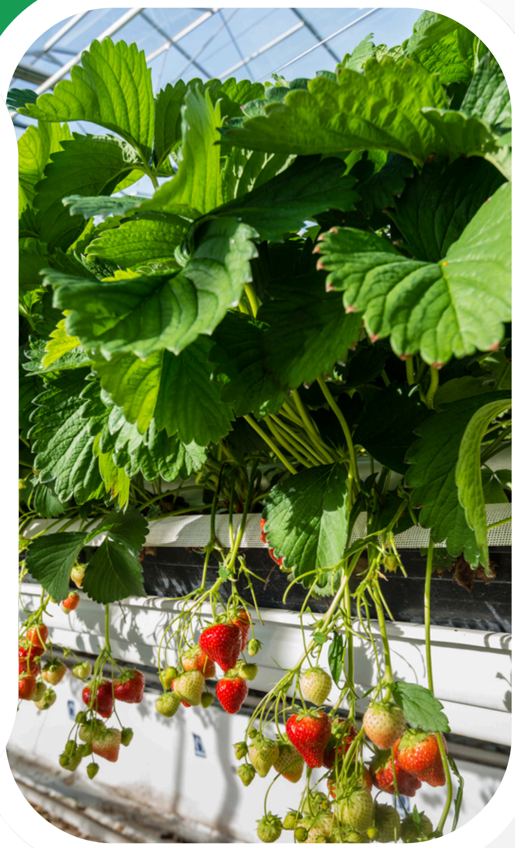
INTERNATIONAL CONGRESS OF HIGH VALUE ADDED AGRICULTURAL PRODUCTS

01-03 DECEMBER 2024 / IĞDIR, TÜRKİYE



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Prof Dr. Mehmet Hakki Alma

Prof.Dr. Sefa Altikat

FULL TEXTS BOOK

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01-03 / DECEMBER / 2024 / IĞDIR, TÜRKİYE

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Prof. Dr. Mehmet Hakkı ALMA

Prof. Dr. Sefa ALTIKAT

Issued: 23.12.2024

ABSTRACT BOOK

ISBN: 978-625-378-039-5

CONGRESS ID

CONGRESS TITLE

INTERNATIONAL CONGRESS OF HIGH VALUE ADDED AGRICULTURAL PRODUCTS

DATE AND PLACE

December 1-3, 2024 – Iğdır, Türkiye

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Total Rejected Papers: 47

Accepted Article (Türkiye): 82

Accepted Article (Other Countries): 91

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INTERNATIONAL CONGRESS OF HIGH VALUE-ADDED AGRICULTURAL PRODUCTS

01-03 / DECEMBER / 2024 / IĞDIR

23.12.2024

REF: Akademik Teşvik

İlgili makama;

Uluslararası Katma Değeri Yüksek Tarımsal Ürünler Kongresi, 1-3 Aralık 2024 tarihleri arasında Iğdır'da 18 farklı ülkenin (Türkiye 82 bildiri- Diğer ülkeler 91 bildiri) akademisyen/araştırmacılarının katılımıyla gerçekleşmiştir

Kongre 16 Ocak 2020 Akademik Teşvik Ödeneği Yönetmeliğine getirilen "Tebliğlerin sunulduğu yurt içinde veya yurt dışındaki etkinliğin uluslararası olarak nitelendirilebilmesi için Türkiye dışında en az beş farklı ülkeden sözlü tebliğ sunan konuşmacının katılım sağlaması ve tebliğlerin yarıdan fazlasının Türkiye dışından katılımcılar tarafından sunulması esastır." değişikliğine uygun düzenlenmiştir.

Bilgilerinize arz edilir,

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Dean of Faculty of Agriculture, Iğdır University
CONGRESS PRESIDENT

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Ziraat Fakültesi Dekanlığı

Sayı : E-23072567-900-155067 12.11.2024
Konu : Kongre Görevlendirme

İLGİLİ MAKAMA

01-03 Aralık 2024 tarihlerinde düzenlenecek olan "INTERNATIONAL CONGRESS OF HIGH VALUE ADDED AGRICULTURAL PRODUCTS" Kongresi düzenleme kuruluna aşağıda unvan ve isimleri yazılı olan öğretim elemanları resmi olarak ve üniversite akademisyen temsilcisi olarak görevlendirilmiştir.

Gereğini bilgilerinize arz/rica ederim.

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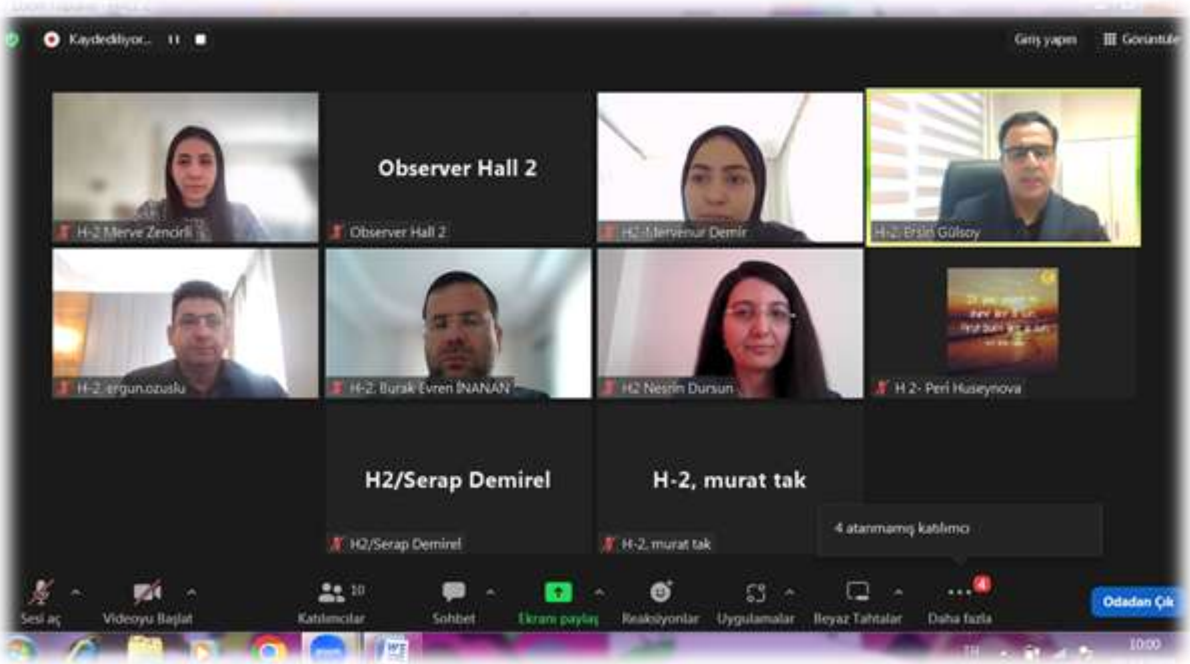

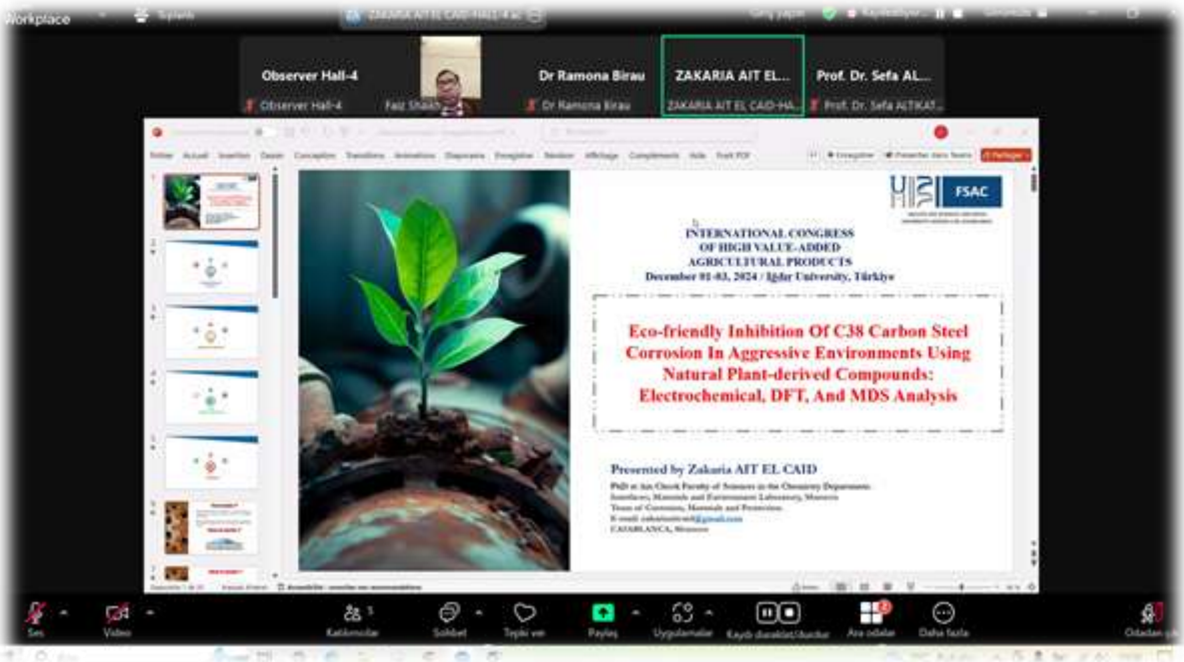

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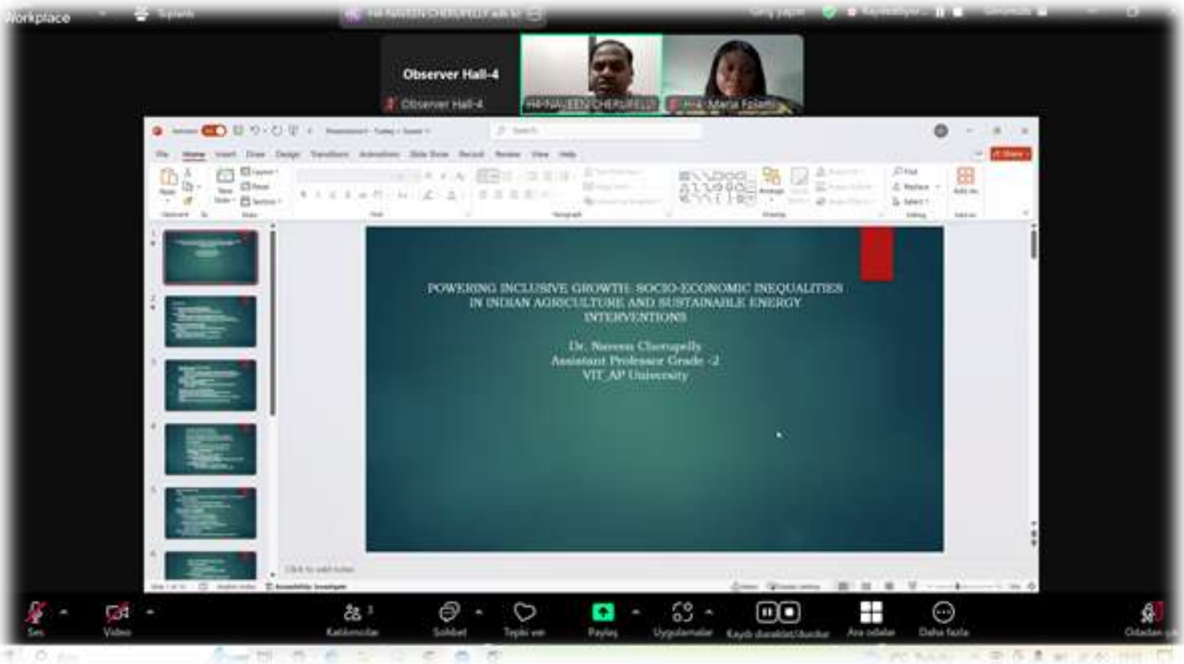

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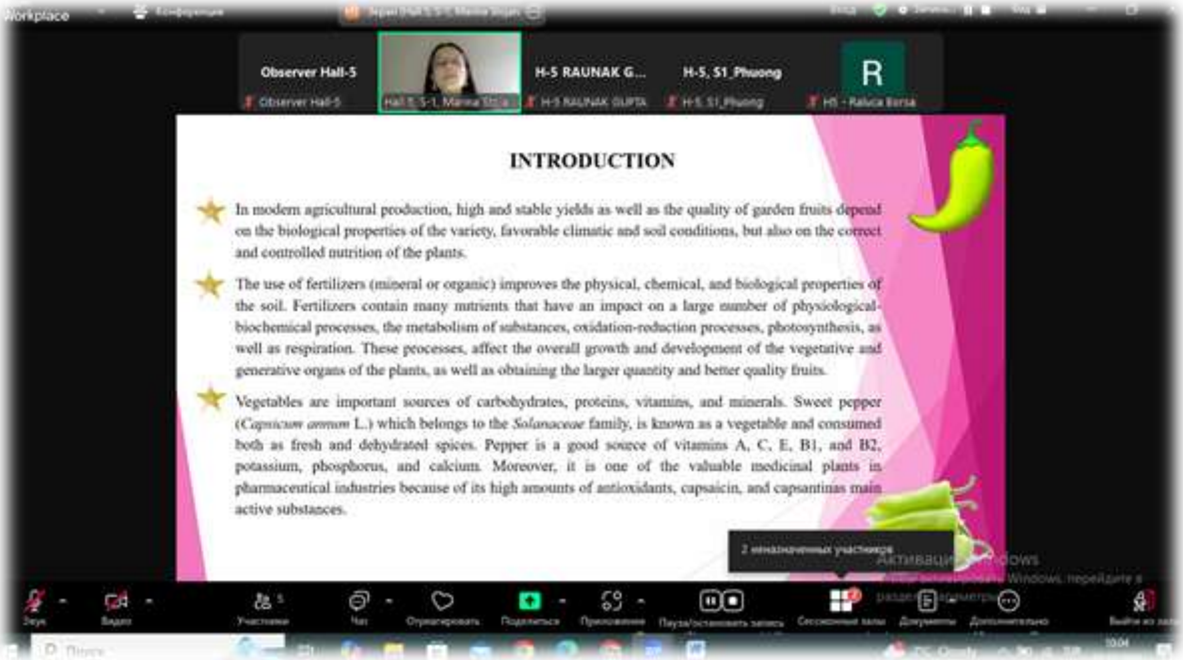

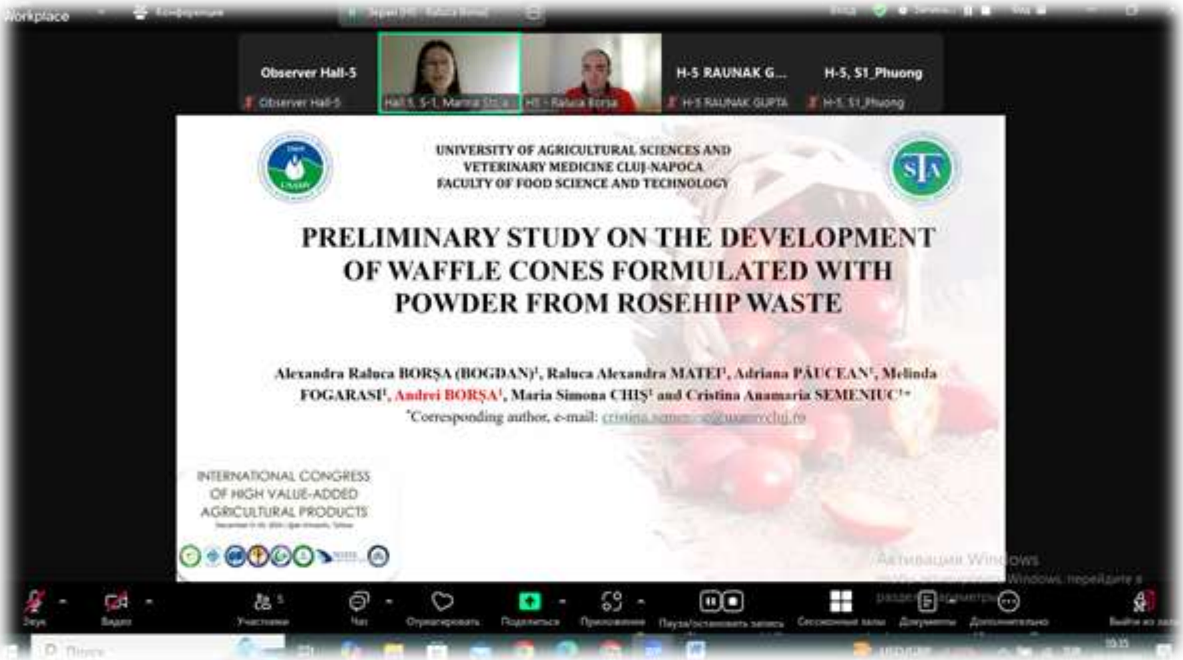

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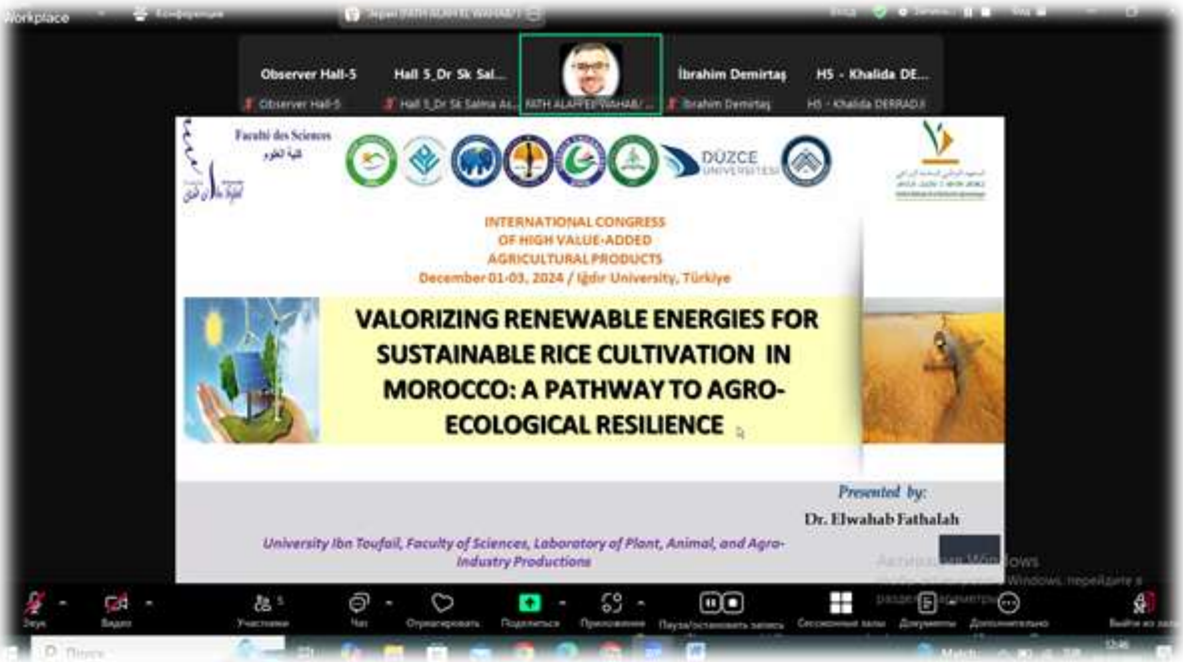

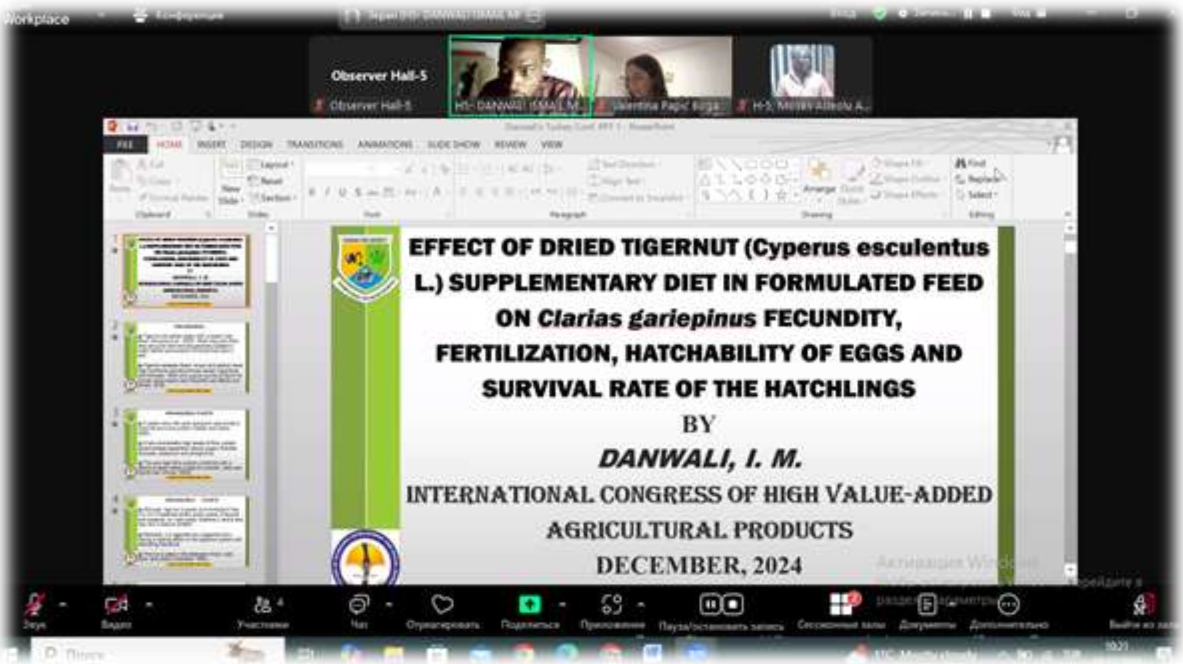

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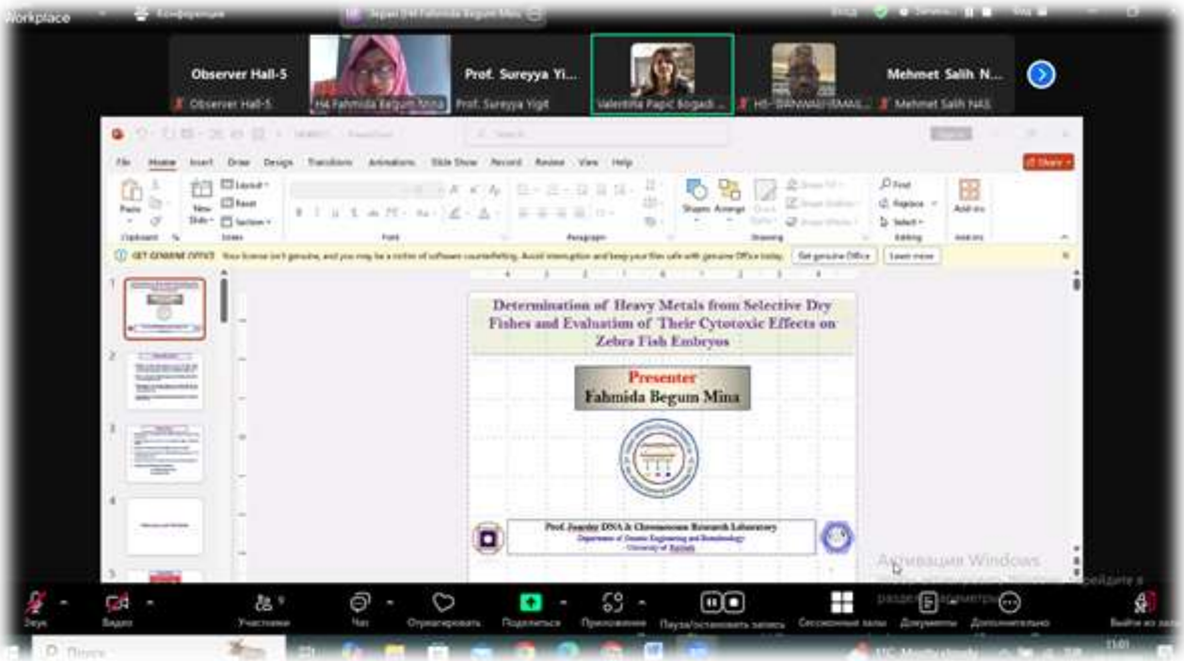

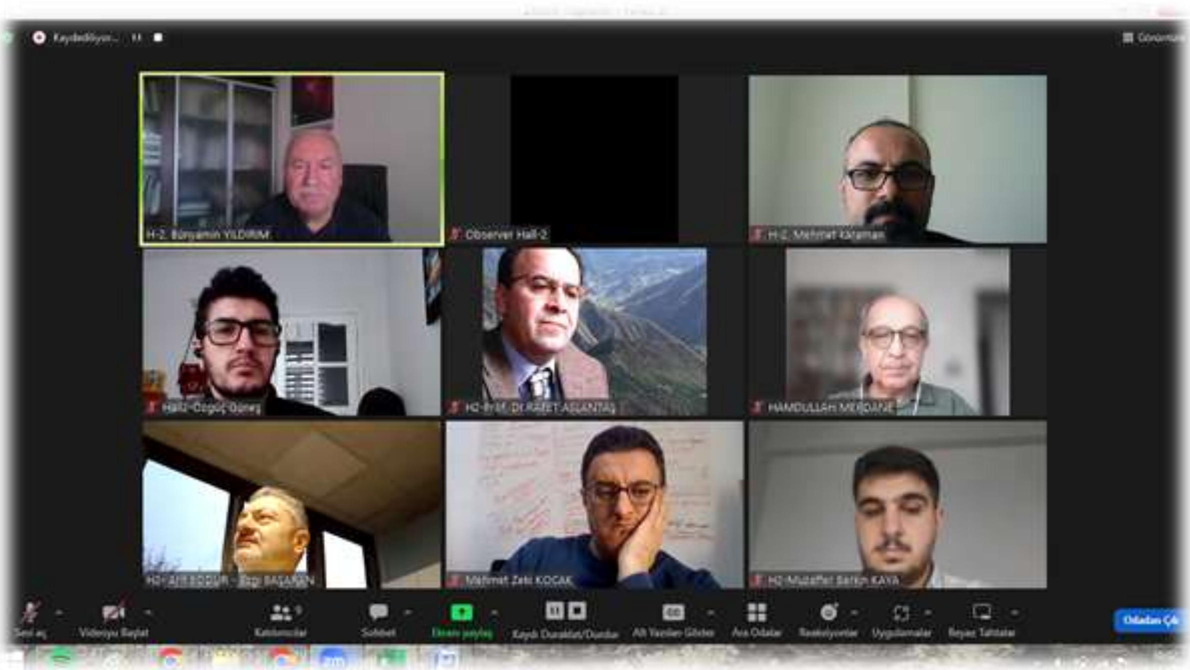

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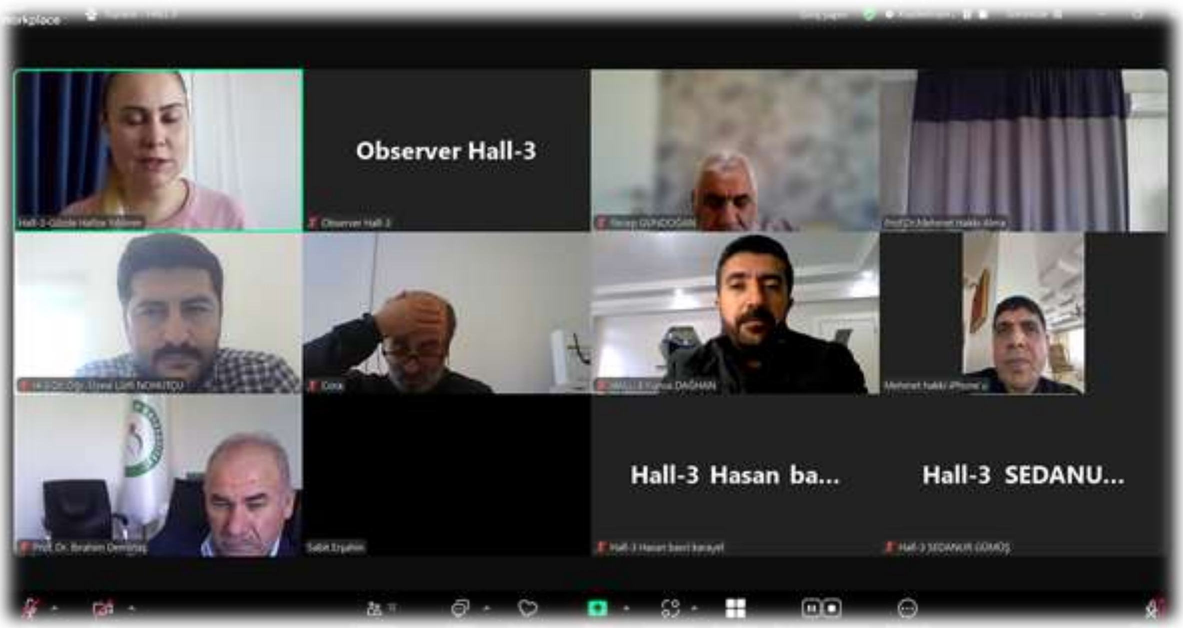

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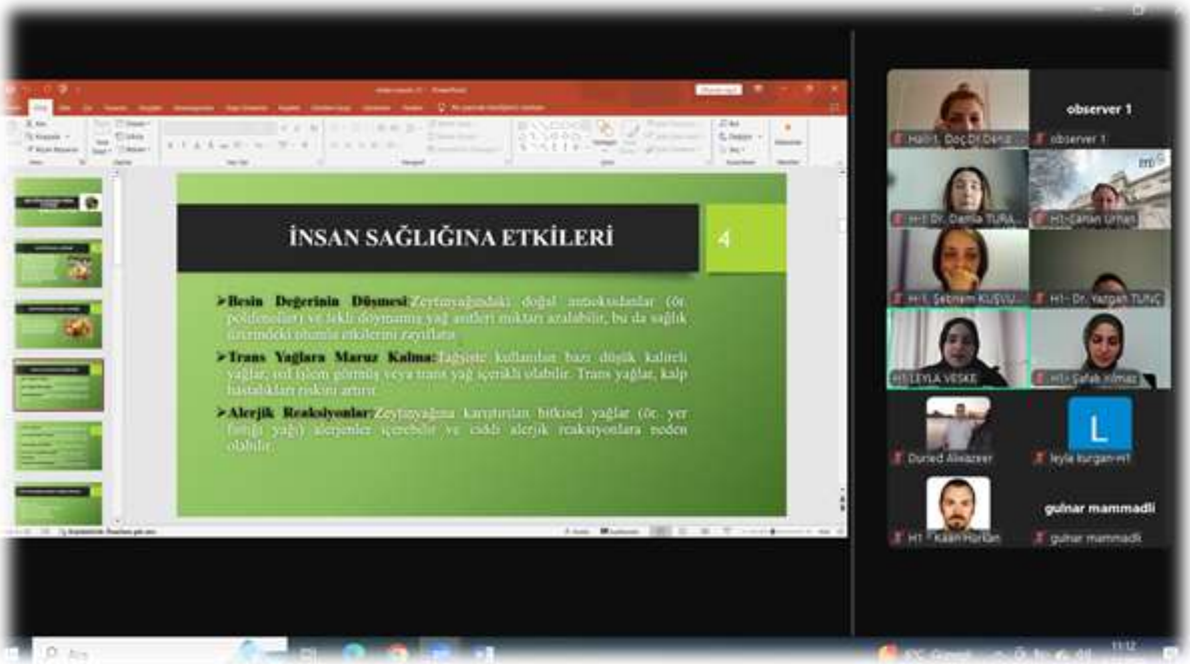

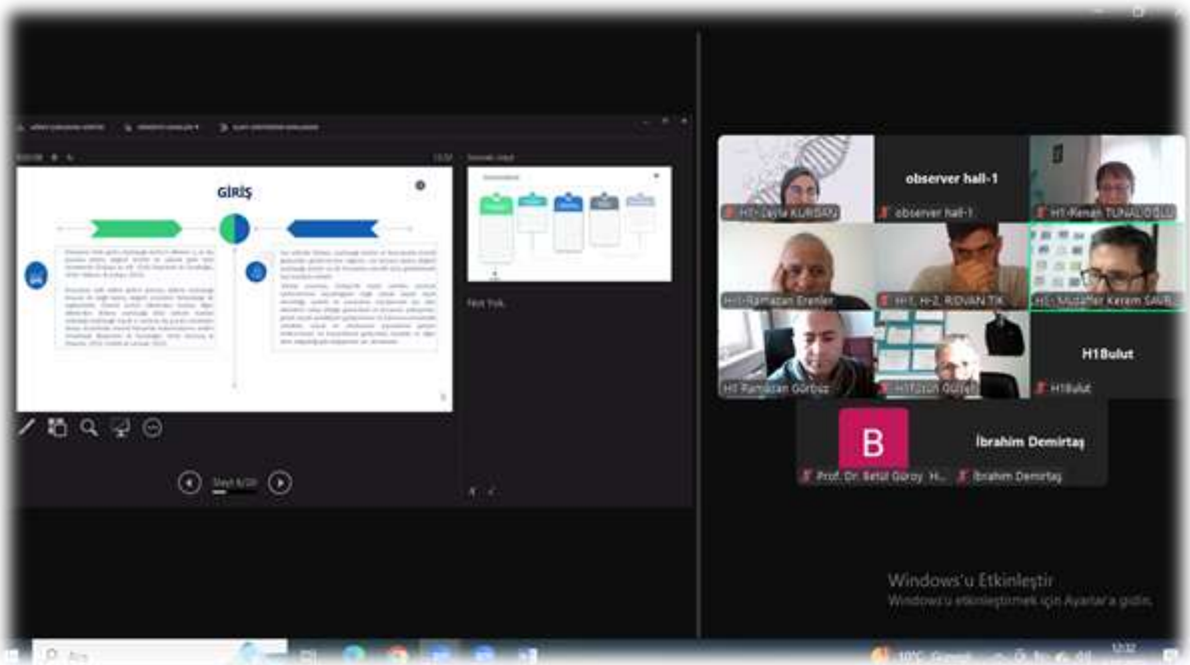

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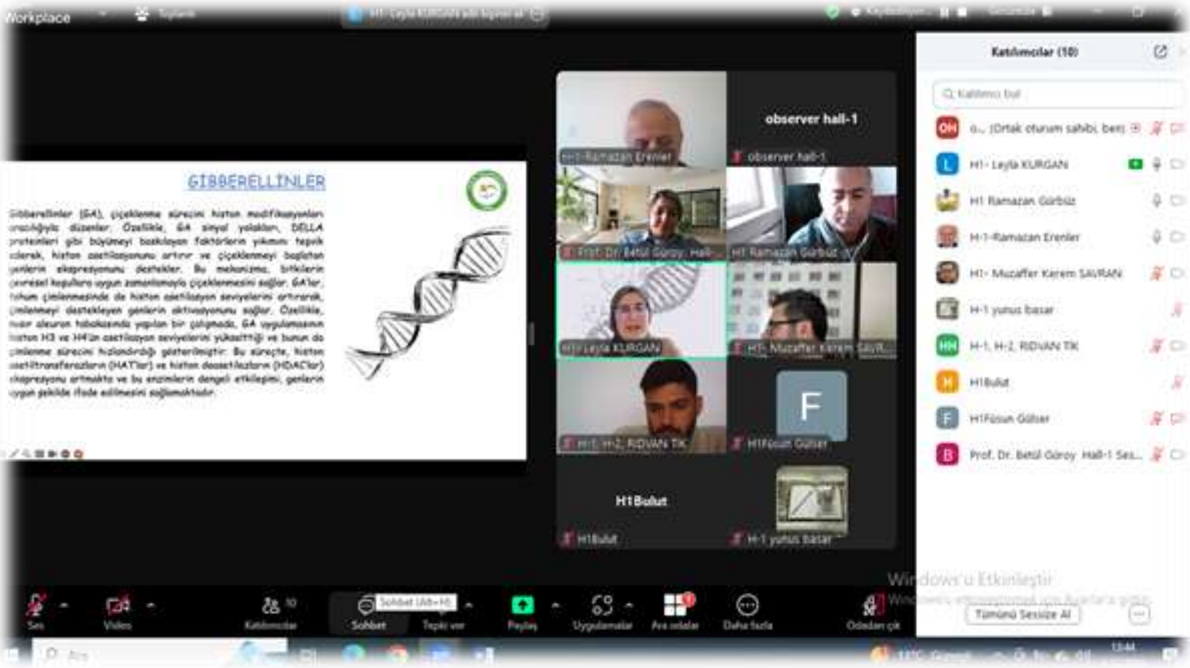

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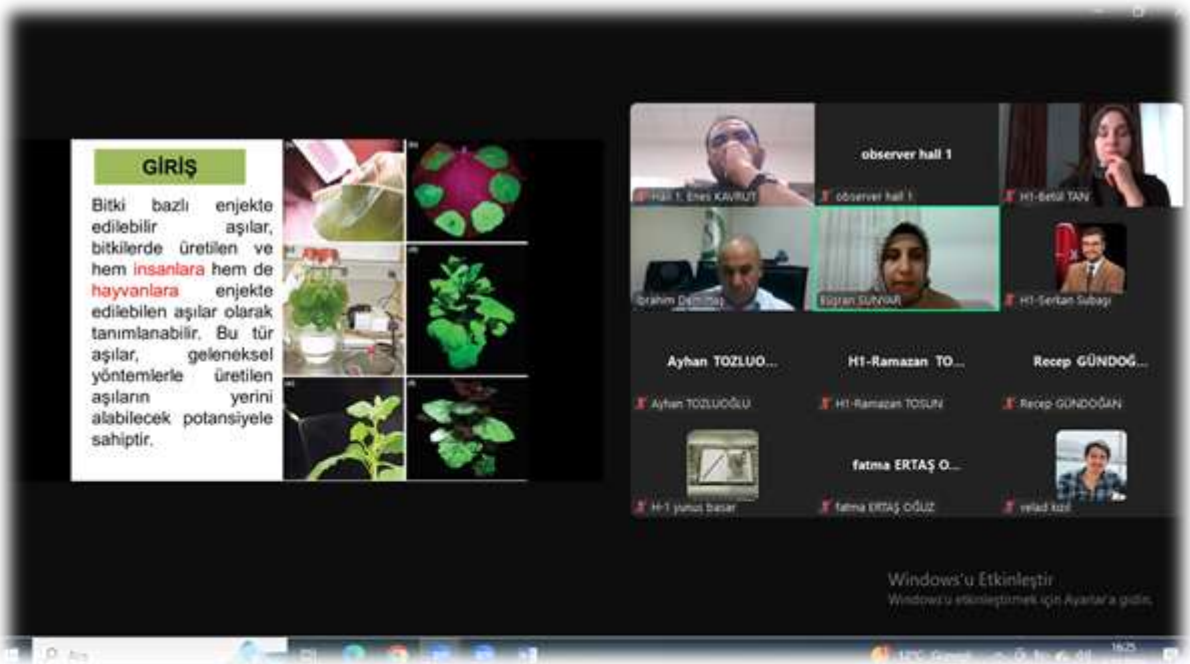

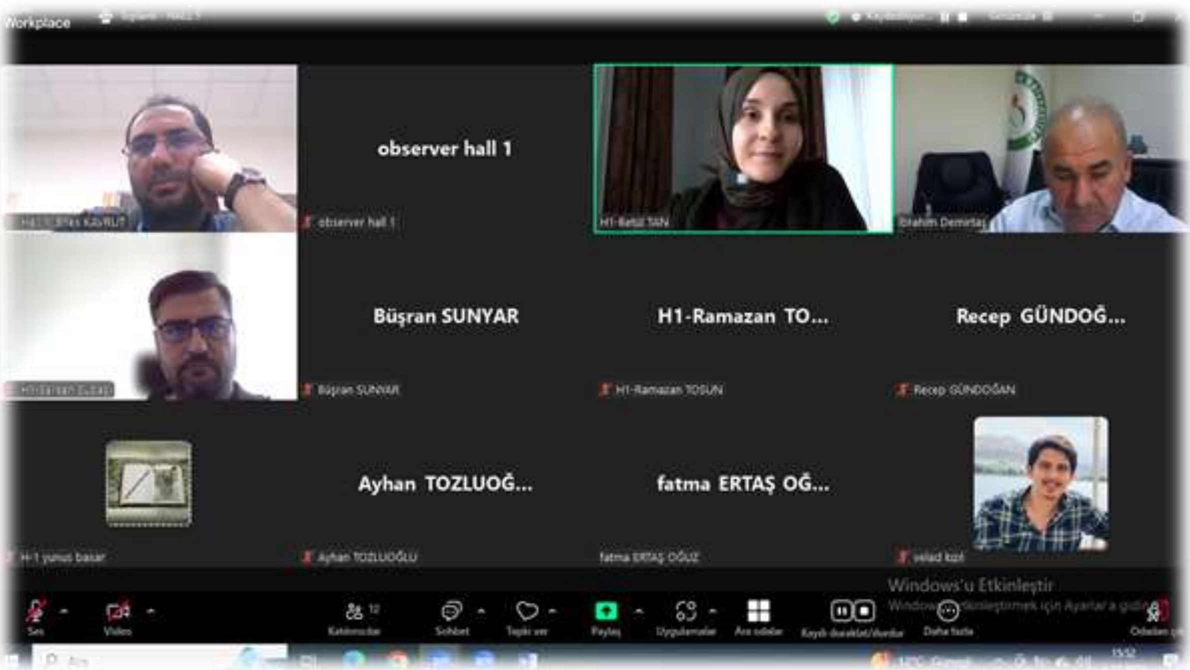

INTERNATIONAL CONGRESS OF HIGH VALUE-ADDED AGRICULTURAL PRODUCTS

December 01-03, 2024 / Iğdır University, Türkiye

DÜZCE ÜNİVERSİTESİ

CONGRESS PROGRAM

ONLINE

Meeting ID: 897 0755 8402
Passcode: 010203

Participant Countries (18)

TÜRKİYE, ROMANIA, PAKISTAN, CANADA, NORTH MACEDONIA, EAST SARAJEVO, SERBIA, RUSSIA, MOROCCO, EAST SARAJEVO, AZERBAIJAN, VIETNAM, INDONESIA, ETHIOPIA,BOSNIA AND HERCEGOVINA, CROATIA, GEORGIA, BANGLADESH

Önemli, Dikkatle Okuyunuz Lütfen

- Kongremizde Yazım Kurallarına uygun gönderilmiş ve bilim kurulundan geçen bildiriler için online (video konferans sistemi üzerinden) sunum imkanı sağlanmıştır.
- Online sunum yapabilmek için https://zoom.us/join sitesi üzerinden giriş yaparak "Meeting ID or Personal Link Name" yerine ID numarasını girerek oturuma katılabilirsiniz.
- Zoom uygulaması ücretsizdir ve hesap oluşturmaya gerek yoktur.
- Zoom uygulaması kaydolmadan kullanılabilir.
- Uygulama tablet, telefon ve PC'lerde çalışıyor.
- Her oturumdaki sunucular, sunum saatinden 5 dk öncesinde oturuma bağlanmış olmaları gerekmektedir.
- Tüm kongre katılımcıları canlı bağlanarak tüm oturumları dinleyebilir.
- Moderatör – oturumdaki sunum ve bilimsel tartışma (soru-cevap) kısmından sorumludur.

Dikkat Edilmesi Gerekenler - TEKNİK BİLGİLER

- Bilgisayarınızda mikrofon olduğuna ve çalıştığına emin olun.
- Zoom'da ekran paylaşma özelliğini kullanabilmelisiniz.
- Kabul edilen bildiri sahiplerinin mail adreslerine Zoom uygulamasında oluşturduğumuz oturuma ait ID numarası gönderilecektir.
- Katılım belgeleri kongre sonunda tarafınıza pdf olarak gönderilecektir.
- Kongre programında yer ve saat değişikliği gibi talepler dikkate alınmayacaktır.

Important, Please Read Carefully

- To be able to attend a meeting online, login via https://zoom.us/join site, enter ID "Meeting ID or Personal Link Name" and solidify the session.
- The Zoom application is free and no need to create an account.
- The Zoom application can be used without registration.
- The application works on tablets, phones and PCs.
- The participant must be connected to the session 5 minutes before the presentation time.
- All congress participants can connect live and listen to all sessions.
- Moderator is responsible for the presentation and scientific discussion (question-answer) section of the session.

Points to Take into Consideration - TECHNICAL INFORMATION

- Make sure your computer has a microphone and is working.
- You should be able to use screen sharing feature in Zoom.
- Attendance certificates will be sent to you as pdf at the end of the congress.
- Requests such as change of place and time will not be taken into consideration in the congress program.

***

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Before you login to Zoom please indicate your hall number, name and surname

exp. H-5, Radmila Janičić

-Opening Ceremony-

Date: 01.11.2024

Time: 09:30-10:00

Meeting ID: 897 0755 8402 / Passcode: 010203

Prof. Dr. Sefa ALTIKAT

Dean of the Faculty of Agriculture, Iğdır University

HEAD OF CONGRESS

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Prof. Dr. Mehmet Hakkı ALMA

Rector of Iğdır University

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ONLINE PRESENTATIONS

01.12.2024 / HALL-1 / SESSION-1

ANKARA LOCAL TIME: 10 00 - 12 00

HEAD OF SESSION: Prof. Dr. Şebnem KUŞVURAN

AUTHORS	AFFILIATION	TOPIC TITLE
Assoc. Prof. Dr. Deniz ŞAHİN Orhan YILMAZ Mustafa BAYSAL	*National Defense University TÜRKİYE* *Rebuplic of Turkey Ministry of Educatican, Ankara TÜRKİYE* *National Defense University TÜRKİYE*	THE POSSIBLE EFFECTS OF HEAVY METALS IN HONEY BEE ON HUMAN HEALTH
Prof. Dr. Harun ÇİFTÇİ Prof. Dr. Şebnem KUŞVURAN	*Çankırı Karatekin University TÜRKİYE*	SALT-BASED STRATEGIC FOOD AND AGRICULTURAL PRODUCTS
Prof. Dr. Şebnem KUŞVURAN Dr. Damla TURAN BÜYÜKDİNÇ	*Çankırı Karatekin University TÜRKİYE* *Recep Tayyip Erdoğan University TÜRKİYE*	EFFECT OF NANO-SILICON APPLICATIONS ON PEPPER GROWN UNDER DEFICIT IRRIGATION CONDITIONS
Dr. Yazgan TUNÇ Agr. Eng. Cafer İŞLEK Agr. Eng. Eray KOCA Agr. Eng. Göksel GÜNDÜR	*Ministry of Agriculture and Forestry, General Directorate of Agricultural Research and Policies Hatay TÜRKİYE* *Kahramanmaraş Sütçü İmam University TÜRKİYE*	NOVEL TECHNIQUES IN NUTRITION AND FOOD SCIENCE: A COMPREHENSIVE REVIEW ON THE ROLE OF OLIVES
Dr. Canan URHAN	*Istanbul Technical University TÜRKİYE*	SWOT ANALYSIS OF ACORN AS FOOD WITHIN A PESTEL FRAMEWORK IN TURKEY: A STAKEHOLDER PERSPECTIVE
Prof. Dr. Duried Alwazeer Şafak Yılmaz	*Iğdır University TÜRKİYE*	FUNCTIONAL FOODS: A KEY TO HEALTH AND ECONOMIC GROWTH
Leyla VESKE Kaan HÜRKAN	*Iğdır University TÜRKİYE*	FOOD ADULTERATION IN OLIVE OIL: DETECTION METHODS, ECONOMIC AND HEALTH IMPACTS

All participants must join the conference 10 minutes before the session time.
Every presentation should last not longer than 10-12 minutes.
Kindly keep your cameras on till the end of the session.

ONLINE PRESENTATIONS

01.12.2024 / HALL-2 / SESSION-1

ANKARA LOCAL TIME: 10 [00] - 12 [00]

HEAD OF SESSION: Prof. Dr. Ahmet Zafer TEL

AUTHORS	AFFILIATION	TOPIC TITLE
Merve ZENCİRLİ Hatice Sena OLCAY Meral YILDIRIM-YALÇIN	*İstanbul Aydın University TÜRKİYE*	ENRICHMENT OF DURUM WHEAT PASTA WITH JERUSALEM ARTICHOKE AND PURPLE BASIL
Nesrin DURSUN	*Ardahan University TÜRKİYE*	INVESTIGATION OF BIOHYDROGEN PRODUCTION POTENTIAL OF WOOD SAWDUST WASTE
Dr. Mustafa AKÇAY	*Kafkas University TÜRKİYE*	EFFECTS OF Ag_2S NANOPARTICLES ON CRESS (Lepidium sativum L.) PLANTS IN VIVO CONDITIONS
Mustafa USTA Abdullah GÜLLER Serap DEMİREL	*Van Yüzüncü Yıl University TÜRKİYE* *Bingöl University TÜRKİYE* *Van Yüzüncü Yıl University TÜRKİYE*	CLADISTIC ANALYSIS of TURKISH DENİZLİ CUCUMIS MELO ALPHAENDORNAVIRUS (CmEV) ISOLATES FROM MELON (Cucumis melo L.)
Assoc. Prof. Dr. Burak Evren İNANAN Prof. Dr. Mustafa ÖZ	*Aksaray University TÜRKİYE*	USE OF FISH SPERMATOZOA IN THE ASSESSMENT OF TOXIC EFFECTS OF PESTICIDES IN AQUATIC ECOSYSTEMS
Assoc. Prof. Dr. Ersin GÜLSOY Mervenur DEMİR	*Iğdır University TÜRKİYE*	SUSTAINABILITY AND WASTE MANAGEMENT IN NUTS PRODUCTION
Murat TAK Prof. Dr. Ahmet Zafer TEL	*Iğdır University TÜRKİYE*	DETERMINATION OF AKDAĞ (ADIYAMAN/MALATYA) HABITAT DIVERSITY ACCORDING TO EUNIS HABITAT CLASSIFICATION SYSTEM
Ergün ÖZUSLU Prof. Dr. Ahmet Zafer TEL	*Gaziantep Islam Science and Technology University TÜRKİYE* *Iğdır University TÜRKİYE*	WILD PISTACHIO SPECIES DISTRIBUTED IN GAZİANTEP (TÜRKİYE) AND THEIR TAXONOMIC CHARACTERISTICS
Peri HUSEYNOVA	*Nakhchivan State University AZERBAIJAN*	METHODS TO EFFECTIVELY PROTECT THE APRICOT TREE FROM FREEZING DURING THE FLOWERING PERIOD

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ONLINE PRESENTATIONS

01.12.2024 / HALL-3 / SESSION-1

ANKARA LOCAL TIME: 10 00 - 12 00

HEAD OF SESSION: Prof. Dr. Murat TUNÇTÜRK

AUTHORS	AFFILIATION	TOPIC TITLE
Assoc. Prof. Dr. Hasan Basri KARAYEL	*Kütahya Dumlupınar University TÜRKİYE*	AREAS OF USE OF SOME MEDICINAL AND AROMATIC PLANTS FOUND IN THE FLORA OF MURAT MOUNTAIN (KÜTAHYA)
Assoc. Prof. Dr. Hasan Basri KARAYEL	*Kütahya Dumlupınar University TÜRKİYE*	COMPOSITION OF ESSENTIAL OILS OBTAINED FROM THE PLANT (Salvia virgata Jacq.) GROWN IN DIFFERENT ECOLOGIES
Res. Assist. Dr. Gözde Hafize YILDIRIM	*Recep Tayyip Erdoğan University TÜRKİYE*	EFFECTS OF DIGITAL AGRICULTURE TECHNOLOGIES ON YIELD AND QUALITY IN FIELD CROPS
Res. Assist. Dr. Gözde Hafize YILDIRIM	*Recep Tayyip Erdoğan University TÜRKİYE*	USE AND BENEFITS OF BIOFERTILIZERS
Yunus DAĞHAN Abdülmelik ARAS	*Iğdır University TÜRKİYE*	EFFECT OF ELEVATION ON PLANT SECONDARY METABOLITES
Assist. Prof. Dr. Lütfi NOHUTÇU Prof. Dr. Murat TUNÇTÜRK Prof. Dr. Rüveyde TUNÇTÜRK Lect. Dr. Ezelhan ŞELEM Assoc. Prof. Dr. Hüseyin EROĞLU	*Van Yüzüncü Yıl University TÜRKİYE*	MORPHOLOGICAL CHARACTERISTICS AND COLOR VALUES OF Colchicum szovitsii FISCH. ET MEY. AND Colchicum kurdicum (BORNM.) STEF. SPECIES GROWING NATURALLY IN VAN REGION
Prof. Dr. Murat TUNÇTÜRK Assist. Prof. Dr. Lütfi NOHUTÇU Lect. Dr. Ezelhan ŞELEM Prof. Dr. Rüveyde TUNÇTÜRK	*Van Yüzüncü Yıl University TÜRKİYE*	DETERMINATION OF SOME MORPHOLOGICAL, PHYSIOLOGICAL AND COLOR VALUES OF NATURALLY GROWNING DANDELION (Taraxacum montanum) PLANT COLLECTED FROM VAN LAKE AROUND
Assoc. Prof. Dr. İhsan CORA	*Giresun University TÜRKİYE*	OPPORTUNITIES AND THREATS IN HAZELNUT FARMING IN TURKEY

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ONLINE PRESENTATIONS

01.12.2024 / HALL-4 / SESSION-1

ANKARA LOCAL TIME: 10 ^{00} - 12 ^{00}

HEAD OF SESSION: Dr. Faiz Muhammad Shaikh

AUTHORS	AFFILIATION	TOPIC TITLE
Virgil Popescu Ramona Birau	*Craiova University ROMANIA*	WEATHER DERIVATIVES AND THEIR IMPLICATIONS IN THE CONTEXT OF CLIMATE CHANGE
Dr. Faiz Muhammad Shaikh Dr.Liaquat Ali Bhutto Rasool Bux Junejo Muhammad Zafar Wassan Syed Mehtab Ali Shah Eng. Syed Mujeeb Hyder Shah	*Larkano University PAKISTAN* *Agriculture Research SAU-Tando jam PAKISTAN* *Agri.Extension-Government of Sindh PAKISTAN* *Conservator Forest -Larkana PAKISTAN* *Progressive Grower-Saleh Pat PAKISTAN* *Progressive Grower Ontario CANADA*	CLIMATE CHANGE AND PRODUCTION EFFICIENCY OF CHICKPEA KASHMORE-KANDHKOT DISTRICT
Ananda Majumdar	*Alberta University CANADA*	HARNESSING ECOLOGICAL PRINCIPLES FOR SUSTAINABLE AGRICULTURE
Omar BENAMARI Hassan AMHAMDI	*Abdelmalek Essaadi University MOROCCO*	IN VITRO ANTIOXYDANT AND ANTIINFLAMMATORY ACTIVITIES OF VARIOUS EXTRACTS FROM CISTUS LADANIFER L. LEAVES GROWN IN NORTHERN MOROCCO
Shanza Khanum Muhammad Asad Tehseen Fatima	*University of Education PAKISTAN*	THERAPEUTIC POTENTIAL OF SAREEHN (ALBIZIA LEBBECK) SEEDS EXTRACT AGAINST TOXIC EFFECTS OF GRAPHENE NANOSHEETS IN MORI (CIRRHINUS MRIGALA)
Muhammad Amjad Syed Makhdoom Hussain Adan Naeem Eman Naeem Muhammad Mahmood Shoaib Akhtar Muhammad Waseem	*Government College University PAKISTAN*	AGRO-WASTE BIOCHAR CONVERSION INTO A FISH FEED ADDITIVE: ASSESSING ITS EFFECTS ON THE HEALTH AND PERFORMANCE OF CYPRINUS CARPIO
Z. AIT EL CAID R. Kellal M. Zertoubi D. Benmessaoud left	*Hassan II University MOROCCO*	ECO-FRIENDLY INHIBITION OF C38 CARBON STEEL CORROSION IN AGGRESSIVE ENVIRONMENTS USING NATURAL PLANT-DERIVED COMPOUNDS: ELECTROCHEMICAL, DFT, AND MDS ANALYSIS
Assist. Prof. Srđan Jovanović Assoc. Prof. Snježana Đokić	*Independent University BOSNIA AND HERCEGOVINA*	AGRICULTURAL COMPANIES THAT APPLY REAL MARKETING IN THEIR BUSINESS BASED ON FINANCIAL MANAGEMENT BASED ON INFORMATION ON FINANCIAL STATEMENTS
Zineb El Hamri Ibrahim Maouhoubi	*Moulay Ismail University MOROCCO*	EFFECT OF WALNUT SHELL POWDER ON THE CHARACTERISTICS OF POLYPROPYLENE-BASED COMPOSITES
Assist. Prof. Srđan Jovanović Assoc. Prof. Snježana Đokić	*Independent University BOSNIA AND HERCEGOVINA*	PROMOTION OF ENTREPRENEURSHIP DEVELOPMENT AND MARKETING IN AGRICULTURAL PRODUCTION OF SENSITIVE GROUPS WHO ARE ENGAGED IN DEVELOPING AGRICULTURAL PRODUCTION AS AN EXAMPLE OF THE REPUBLIC OF SERBIA

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ONLINE PRESENTATIONS

01.12.2024 / HALL-5 / SESSION-1

ANKARA LOCAL TIME: 10 ^{00} - 12 ^{00}

HEAD OF SESSION: Prof. Dr. Marina Todor STOJANOVA

AUTHORS	AFFILIATION	TOPIC TITLE
Prof. Dr. Marina Todor STOJANOVA Acad. Prof. Dr. Dragutin A. DJUKIC Dr. Monika STOJANOVA Prof. Dr. Ivana BOSKOVIC	*Ss. Cyril and Methodius University NORTH MACEDONIA Kragujevac University SERBIA Association for Scientific-research, Educational and Cultural Activities NORTH MACEDONIA East Sarajevo University EAST SARAJEVO*	EFFECT OF FOLIAR CALCIUM AMPLIFIERS ON THE CHEMICAL COMPOSITION OF SWEET PEPPER
Prof. Dr. Dragutin A. DJUKIC Prof. Dr. Leka MANDIC Dr. Monika STOJANOVA Prof. Dr. Marina T. STOJANOVA Prof. Dr. Alexander M. SEMENOV Prof. Dr. Vesna DJUROVIC Prof. Dr. Ivana BOSKOVIC	*Kragujevac University SERBIA Association for Scientific-research, Educational and Cultural Activities NORTH MACEDONIA M.V. Lomonosov Moscow State University RUSSIA Cyril and Methodius University NORTH MACEDONIA Kragujevac University SERBIA East Sarajevo University EAST SARAJEVO*	DYNAMIC NITROGEN BALANCE IN THE EARTH'S PEDOSPHERE AND ATMOSPHERE
Assoc. Dr. Ivana BOSKOVIC Prof. Dr. Dragutin DJUKIC Dr. Monika STOJANOVA Prof. Dr. Marina Todor STOJANOVA Dr. Marijana PESAKOVIC	*Kragujevac University SERBIA Association for Scientific-research, Educational and Cultural Activities NORTH MACEDONIA Ss. Cyril and Methodius University NORTH MACEDONIA Fruit Research Institute Čačak SERBIA*	BIOLOGICALLY ACTIVE PLANT COMPOUNDS AND THEIR MECHANISMS OF ACTION: REWIEV
Nguyen Thi Huynh Phuong Nguyen Trong Nhan Nguyễn Trung Hieu	*Hue University VIETNAM Can Tho University VIETNAM Tour guide in Can Tho city VIETNAM*	A STUDY OF THE FACTORS INFLUENCING AGRITOURISM DEVELOPMENT AT BAO GIA FARM, HAU GIANG PROVINCE, VIETNAM
Alexandra Raluca BORŞA (BOGDAN) Raluca Alexandra MATEI Adriana PĂUCEAN Melinda FOGARASI Andrei BORŞA Maria Simona CHIŞ Cristina Anamaria SEMENIUC	*University of Agricultural Sciences and Veterinary Medicine of Cluj-Napoca ROMANIA*	PRELIMINARY STUDY ON THE DEVELOPMENT OF WAFFLE CONES FORMULATED WITH POWDER FROM ROSEHIP WASTE
Zineb El Hamri Ibrahim Maouhoubi Assia Belhassan	*Moulay Ismail University MOROCCO*	PHYSICAL, MECHANICAL, AND THERMAL PROPERTIES OF POLYPROPYLENE COMPOSITES INCORPORATING WALNUT SHELL POWDER
RAUNAK GUPTA	*Vellore Institute of Technology INDIA*	AI-BASED MULTISPECTRAL IMAGING SYSTEM FOR PRECISION AGRICULTURE: TACKLING SOIL HEALTH, PESTS, AND CROP STRESS
Dio Samudra	*UIN KH.Abdurrahman Wahid Pekalongan INDONESIA*	QUALITY MANAGEMENT IN FISH PROCESSING AGRO-INDUSTRIES SURABAYA

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ONLINE PRESENTATIONS

01.12.2024 / HALL-1 / SESSION-2

ANKARA LOCAL TIME: 12 30 - 14 30

HEAD OF SESSION: Prof. Dr. Ramazan ERENLER

AUTHORS	AFFILIATION	TOPIC TITLE
Muzaffer Kerem SAVRAN Ferit ÇOBANOĞLU Renan TUNALIOĞLU	*Ministry of Agriculture and Forestry İzmir TÜRKİYE* *Aydın Adnan Menderes University TÜRKİYE*	VALUE ADDED OLIVE OIL PRODUCTION AND EXPORT OPPORTUNITIES: PROBLEMS AND SUGGESTIONS
Prof. Dr. Ramazan ERENLER	*Iğdır University TÜRKİYE*	QUANTITATIVE ANALYSIS OF BIOACTIVE COMPOUNS IN ROBINIA PSEUDOACACIA STEM AND ANTIOXIDANT EFFECTS
Prof. Dr. Betül GÜROY	*Yalova University TÜRKİYE*	STRATEGIC IMPORTANCE OF BLUE-GREEN ALGAE (CYANOBACTERIA) "SPIRULINA" AND GREEN ALGAE (CHLOROPHYTA) "ULVA" AS AQUATIC AGRICULTURE PRODUCTS
Bulut SARĞIN Siyami KARACA Füsun GÜLSER	*Van Yüzüncü Yıl University TÜRKİYE*	MICROPLASTIC CONTAMINATION AND SOIL HEALTH
Siyami KARACA Füsun GÜLSER Bulut SARĞIN	*Van Yüzüncü Yıl University TÜRKİYE*	THE INTERACTION BETWEEN SOIL MANAGEMENT AND CARBON FOOTPRINT
Leyla KURGAN Assoc. Prof. Dr. Adnan AYDIN	*Iğdır University TÜRKİYE*	THE RELATIONSHIP OF PLANT GROWTH REGULATORS WITH EPIGENETICS
Res. Assist. Rıdvan TİK Assoc. Prof. Dr. Ramazan GÜRBÜZ	*Iğdır University TÜRKİYE*	WHEN BEAUTY TURNS BEAST: ORNAMENTAL PLANTS THAT BECOME WEEDS
Assoc. Prof. Dr. Ramazan GÜRBÜZ Dr.Harun ALPTEKİN	*Iğdır University TÜRKİYE*	THE ROLE OF NANOTECHNOLOGY IN HERBICIDE DEVELOPMENT: MECHANISMS, FORMULATIONS, AND ECOLOGICAL IMPACTS

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ONLINE PRESENTATIONS

01.12.2024 / HALL-2 / SESSION-2

ANKARA LOCAL TIME: 12 30 - 14 30

HEAD OF SESSION: Prof. Dr. Sefa ALTIKAT

AUTHORS	AFFILIATION	TOPIC TITLE
Alperay ALTIKAT Prof. Dr. Mehmet Hakkı ALMA	*Iğdır University TÜRKİYE*	BIOCHAR USE AS A SEED COATING MATERIAL
Alperay ALTIKAT Prof. Dr. Mehmet Hakkı ALMA	*Iğdır University TÜRKİYE*	BIOGAS AND BIOMASS: A REVIEW ON RENEWABLE ENERGY SOURCES
Prof. Dr. Duried Alwazeer Berrak Iğdır	*Iğdır University TÜRKİYE*	BIOHYDROGEN PRODUCTION FROM AGRICULTURAL AND FOOD WASTE
Prof. Dr. Duried Alwazeer Tunahan ENGİN	*Iğdır University TÜRKİYE*	USE OF A HYDROGEN EXTRACTION METHOD FOR THE EXTRACTION OF PHYTOCHEMICALS
Prof. Dr. Sefa ALTIKAT	*Iğdır University TÜRKİYE*	REDUCING CARBON FOOTPRINT IN VERTICAL FARMING AND HYDROPONIC SYSTEMS
Prof. Dr. Sefa ALTIKAT	*Iğdır University TÜRKİYE*	SELECTION AND OPTIMISATION OF HYPERSPECTRAL AND MULTISPECTRAL BANDS IN AGRICULTURAL RESEARCH
Hilal DEMİR Prof. Dr. Kürşat DEMİRYÜREK Assoc. Prof. Dr. Nur İlkay ABACI Res. Assist. Ahmet Yesevi KOÇYİĞİT	*Ondokuz Mayıs University TÜRKİYE*	RENEWABLE ENERGY IN AGRICULTURE: A SYSTEMATIC REVIEW OF INNOVATIONS AND APPLICATIONS
Res. Assist. Rıdvan TİK Assoc. Prof. Dr. Tuncay KAYA	*Iğdır University TÜRKİYE*	POSSIBILITIES OF USING RENEWABLE ENERGY SOURCES IN LANDSCAPE STUDIES

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ONLINE PRESENTATIONS

01.12.2024 / HALL-3 / SESSION-2

ANKARA LOCAL TIME: 12 30 - 14 30

HEAD OF SESSION: Prof. Dr. Bahri KARLI

AUTHORS	AFFILIATION	TOPIC TITLE
Lect. Dr. Emirhan ÖZDEMİR Lect. Rüştü ÇALLI Assoc. Prof. Dr. Aliihsan ŞEKERTEKİN	*Iğdır University TÜRKİYE*	ANALYZING CROP DEVELOPMENT USING SENTINEL-2 BASED NDVI TIME SERIES
Lect. Rüştü ÇALLI Lect. Dr. Emirhan ÖZDEMİR Assoc. Prof. Dr. Aliihsan ŞEKERTEKİN	*Iğdır University TÜRKİYE*	DEVELOPING A BASIC QGIS-BASED AGRICULTURAL MANAGEMENT SYSTEM: INTEGRATING PARCEL, IRRIGATION, AND SATELLITE DATA LAYERS
Res. Assist. Dr. Ayşe KARADAĞ GÜRSOY Res. Assist. Bektaş KADAKOĞLU Prof. Dr. Bahri KARLI	*Iğdır University TÜRKİYE*	DEVELOPMENT OF APRICOT PRODUCTION IN TÜRKİYE: THE CASE OF IĞDIR PROVINCE
Res. Assist. Bektaş KADAKOĞLU Res. Assist. Dr. Ayşe KARADAĞ GÜRSOY Prof. Dr. Bahri KARLI	*Iğdır University TÜRKİYE*	STRUCTURAL ANALYSIS OF GOAT BREEDING IN TÜRKİYE
Taner İŞEVİ Prof. Dr. Ergin ÖZTÜRK	*Ministry of Agriculture and Forestry, Ordu TÜRKİYE* *Ondokuz Mayıs University TÜRKİYE*	NUTRITIONAL CONTENT AND BIOACTIVE COMPOUNDS OF WALNUT GREEN HUSK AND LEAVES: THEIR APPLICATIONS AND POTENTIAL USE IN ANIMAL NUTRITION
Sedanur GÜMÜŞ Assist. Prof. Dr. Barış EREN Assoc. Prof. Dr. Adnan AYDIN	*Iğdır University TÜRKİYE*	EVALUATION OF NEW MARKERS THAT CAN BE USED IN BLACK CUMIN PLANT
Dilay ÖZUYAR Assoc. Prof. Dr. Emir Zafer HOŞGÜN	*Eskisehir Technical University TÜRKİYE*	CHOLINE CHLORIDE/FORMIC ACID DEEP EUTECTIC SOLVENT SYSTEM FOR THE PRETREATMENT OF SUNFLOWER STALKS TO ENHANCE THE ENZYMATIC HYDROLYSIS YIELD
Mine ATAKUL Prof. Dr. Levent ÜNLÜ	*Selçuk University TÜRKİYE*	POPULATION DEVELOPMENT AND PARASITISM RATE OF SUNN PEST (Eurygaster spp.) AND WHEAT BUG(Aelia spp.) IN TRITICALE PLANT

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ONLINE PRESENTATIONS

01.12.2024 / HALL-4 / SESSION-2

ANKARA LOCAL TIME: 12 30 - 14 30

HEAD OF SESSION: Dr. Naveen Cherupelly

AUTHORS	AFFILIATION	TOPIC TITLE
Ahmed Attahiru Yusuf Haruna Abubakar Umar Birnin-Yauri Garba G. Jibo Adamu Almustapha Aliero	*Kebbi State University of Science and Technology NIGERIA*	QUALITATIVE PHYTOCHEMICAL ANALYSIS AND ANTIFUNGAL ACTIVITY OF AQUEOUS CRUDE LEAVES EXTRACT OF ACACIA NILOTICA
Ahmed Attahiru Yusuf Haruna Abubakar Umar Birnin-Yauri Garba G. Jibo	*Kebbi State University of Science and Technology NIGERIA*	ASSESSMENT OF ANTIFUNGAL ACTIVITY OF AQUEOUS FRACTIONS OF ACACIA NILOTICA LEAVES
Geeta Shinde Sakshi Ingale Chetana Shewale Aman Upaganlawar Chandrashekhar Upasani	*SNJBs Shriman Sureshdada Jain College of Pharmacy INDIA*	NEPHROPROTECTIVE ACTIVITY OF KUDZU ROOT EXTRACT IN STREPTOZOTOCIN INDUCED DIABETIC NEPHROPATHY IN RATS
Diayi V.N. Akinlabi A. K. Falope F.Y. Mosaku A.M. Oladipo G.O. Falana B.M.	*Federal University of Agriculture NIGERIA Bells University of Technology NIGERIA Federal University of Agriculture NIGERIA D.S. Adegbenro ICT Polytechnic NIGERIA National Biotechnology Research and Development Agency NIGERIA*	EFFECT OF CARBONIZATION OF WALNUT SHELL ON THE PHYSICO-MECHANICAL PROPERTIES OF NATURAL RUBBER
Sudhanshu Kumar Jha	*VIT Bhopal University INDIA*	CROP PREDICTION USING MACHINE LEARNING
CHANDRU E. SARAVANAN R.SRINIVASAN	*Bharath Institute of Higher Education and Research INDIA*	LEMON OIL
Dr. Naveen Cherupelly	*VIT-AP University INDIA*	POWERING INCLUSIVE GROWTH: SOCIO-ECONOMIC INEQUALITIES IN INDIAN AGRICULTURE AND SUSTAINABLE ENERGY INTERVENTIONS
FOLAMI, Maria	*Lagos State University NIGERIA*	CLIMATE CHANGE AND URBAN FARMING IN OJO LOCAL GOVERNMENT AREA, LAGOS STATE, NIGERIA: ADAPTING AND MITIGATING CLIMATE CHANGE IMPACTS

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ONLINE PRESENTATIONS

01.12.2024 / HALL-5 / SESSION-2

ANKARA LOCAL TIME: 12 30 - 14 30

HEAD OF SESSION: Assoc. Prof. Dr. Shaik Salma Asiya Begum

AUTHORS	AFFILIATION	TOPIC TITLE
Dr. Mamoon Ur Rasheed Sabila Arooj Dr. Haroon Rashid Dr. Shafa Iman	*Government College University PAKISTAN*	GC-MS ANALYSIS, ANTI-DIABETIC, AND CYTOTOXIC EVALUATION OF PHLOMIS STEWARTII PLANT PHYTOCHEMICALS ON CIGARETTE SMOKE INHALATION AND ALLOXAN-INDUCED DIABETES IN WISTAR RATS
Sarah Abou el anouar Mohammed Bergui Boutaina Louafi Naoufal Ahidar Amine Salhi Meryem Benjelloun	*Sidi Mohamed Ben Abdellah University MOROCCO Abdelmalek Essaadi University MOROCCO Sidi Mohamed Ben Abdellah University MOROCCO*	ETHNOBOTANICAL STUDY OF CISTUS MONSPELIENSIS AND ITS USAGE FOR DIFFERENT PURPOSES IN THE RIF REGION (NORTHERN MOROCCO)
Dr. Elwahab Fathalah Prof. Benramel Mostafa Dr. Sedki Mohamed Prof. Ziri Rabea	*Ibn Toufail University MOROCCO Ibn Toufail University MOROCCO Regional Center of Agricultural Research of Kenitra MOROCCO Ibn Toufail University MOROCCO*	VALORIZING RENEWABLE ENERGIES FOR SUSTAINABLE RICE CULTIVATION IN MOROCCO: A PATHWAY TO AGRO-ECOLOGICAL RESILIENCE
Assoc. Prof. Dr. Shaik Salma Asiya Begum Shaik Tanveer Fathe Ahamed	*Lakireddy Bali Reddy College of Engineering INDIA Northern Tools and Equipment, Senior Front-End Developer INDIA*	GSAtt-CMNetV3: POTATO LEAF DISEASE CLASSIFICATION USING OSPREY OPTIMIZATION
Bashir, M.B. Fatima, A.B Faruk, A.U.	*Ahmadu Bello University NIGERIA*	SKILLS REQUIRED IN POULTRY PRODUCTION FOR ECONOMIC SUCCESS AMONG YOUTHS IN DANKO WASAGU LOCAL GOVERNMENT OF KEBBI STATE, NIGERIA
IS Liman A Mann LA Fadipe WN Adamu	*Federal University of Technology NIGERIA The Federal Polytechnic NIGERIA*	EVALUATION OF HYPOGLYCEMIC POTENTIAL OF THE METHANOL EXTRACT OF THE GYMNEMA SYLVESTRE PLANT IN WISTER ALBINO RATS
Khalida DERRADJI Leila SMAIL	*Ibn Khaldoun University of Tiaret ALGERIA*	SOIL MICROORGANISMS BIOTECHNOLOGY, A USEFUL INNOVATION FOR BIOLOGICAL AGRICULTURE AND ENVIRONMENT

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ONLINE PRESENTATIONS

01.12.2024 / HALL-1 / SESSION-3

ANKARA LOCAL TIME: 15 00 - 17 00

HEAD OF SESSION: Prof. Dr. İbrahim DEMİRTAŞ

AUTHORS	AFFILIATION	TOPIC TITLE
Assoc. Prof. Dr. Ali İhsan ATALAY Assist. Prof. Dr. Ramazan TOSUN	*Iğdır University TÜRKİYE*	INVESTIGATION OF ALTERNATIVE FEED SOURCES TO CORN AND SOYBEAN MEALS IN BROILER FEEDING
Assist. Prof. Dr. Ramazan TOSUN Assoc. Prof. Dr. Ali İhsan ATALAY	*Iğdır University TÜRKİYE*	POSSIBILITY OF USING LUPIN AS AN ALTERNATIVE PROTEIN SOURCE IN POULTRY NUTRITION
Prof. Dr. Duried Alwazeer Enes KAVRUT	*Iğdır University TÜRKİYE*	USE OF VALUE-ADDED PRODUCTS FOR SUSTAINABLE CUISINE
Prof. Dr. Duried Alwazeer Betül TAN	*Iğdır University TÜRKİYE*	AN EMERGING TECHNIQUE IN DRYING HIGH VALUE-ADDED PRODUCTS: REDUCING ATMOSPHERE DRYING
Prof. Dr. Serkan SUBAŞI Prof. Dr. Ayhan TOZLUOĞLU Ali Murat SÜRÜCÜ Çağrı AGİN	*Düzce University TÜRKİYE* *Düzce University TÜRKİYE* *Unigen Construction Materials Inc. Düzce TÜRKİYE* *Fiber Chemistry Inc. İstanbul TÜRKİYE*	UTILIZATION OF NANOCELLULOSE IN CALCIUM SULFATE BASED COMPOSITE PRODUCTION
Prof. Dr. Ayhan TOZLUOĞLU Prof. Dr. Serkan SUBAŞI Ali Murat SÜRÜCÜ Ahmet GÜRKAN UMUCU	*Düzce University TÜRKİYE* *Düzce University TÜRKİYE* *Unigen Construction Materials Inc. Düzce TÜRKİYE*	EFFECT OF FDM-IMPREGNATED HEMP FIBERS ON PHYSICAL, MECHANICAL AND THERMAL PROPERTIES IN CALCIUM SULFATE MATRIX COMPOSITES
Büşran SUNYAR Prof. Dr. Mehmet Hakki ALMA Velad KIZIL Prof. Dr. İbrahim DEMİRTAŞ Fatma ERTAŞ OĞUZ	*Iğdır University TÜRKİYE*	A BIBLIOMETRIC ANALYSIS ON HERB-BASED INJECTABLE VACCINES
Velad KIZIL Prof. Dr. İbrahim DEMİRTAŞ Büşran SUNYAR Prof. Dr. Mehmet Hakki ALMA Fatma ERTAŞ OĞUZ	*Iğdır University TÜRKİYE*	A BIBLIOMETRIC ANALYSIS ON TRANSGENIC PLANT-BASED EDIBLE VACCINES

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ONLINE PRESENTATIONS

01.12.2024 / HALL-2 / SESSION-3

ANKARA LOCAL TIME: 15 00 - 17 00

HEAD OF SESSION: Prof. Dr. Sabit ERŞAHİN

AUTHORS	AFFILIATION	TOPIC TITLE
Nisanur YAKUT Fatma KIZILER Assoc. Prof. Dr. Emrah KUŞ	*Iğdır University TÜRKİYE* *Siirt University TÜRKİYE* *Iğdır University TÜRKİYE*	A STUDY ON THE USE OF ELECTROSHOCK TECHNIQUES FOR WEED CONTROL
Mehdi GÜVEN Nisanur YAKUT Assoc. Prof. Dr. Emrah KUŞ	*Iğdır University TÜRKİYE*	EFFECTS OF USING SEED TUBE ON SEED DISTRIBUTION UNIFORMITY IN SINGLE SEED PLANTERS
Assoc. Prof. Dr. Emrah KUŞ	*Iğdır University TÜRKİYE*	CURRENT IMPROVEMENTS AND DEVELOPMENTS IN THE SEED PLANTERS
Lect. Dr. Azime SUBAŞI	*Düzce University TÜRKİYE*	INVESTIGATION OF THE USABILITY OF HEMP FIBERS AS REINFORCEMENT MATERIAL IN PHOTOCURED POLYMER COMPOSITES
Sabit ERŞAHIN Mücahit KARAOĞLU Faruk TOHUMCU Serdar SARI Seda AKBAY TOHUMCU	*Iğdır University TÜRKİYE*	USE OF GYPSUM MIXED IRRIGATION WATER TO IMPROVE SALINE-ALKALI SOILS
Şaika Gül İLİKSİZ Assoc. Prof. Dr. Emine KAYA ALTOP	*Ondokuz Mayıs University TÜRKİYE*	DETERMINATION OF THE GENETIC DIVERSITY OF AVENA FATUA (L), A PROBLEM IN WHEAT GROWING AREAS
Prof. Dr. Duried Alwazeer Ayhan ÇİĞDEM	*Iğdır University TÜRKİYE*	MOLECULAR HYDROGEN AS A REGULATOR IN PLANT GROWTH

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ONLINE PRESENTATIONS

01.12.2024 / HALL-3 / SESSION-3

ANKARA LOCAL TIME: 15 ^{00} - 17 ^{00}

HEAD OF SESSION: Assoc. Prof. Dr. Abdul Qadeer Khan

AUTHORS	AFFILIATION	TOPIC TITLE
Yadessa Melaku Abera Kalbessa	*Adama Science and Technology University ETHIOPIA*	ANTIBACTERIAL AND ANTIOXIDANT COMPOUNDS FROM THE ROOT BARKS OF GNIDIA INVOLUCRATA
Ms. Vaibhavi V. Meshram Dr. Mrs. Alpana J. Asnani	*Priyadarshini J. L. College of Pharmacy INDIA*	FORMULATION AND ASSESSMENT OF HERBAL LOTION FORMULATED WITH LEUCAS ASPERA LEAF EXTRACT
Assoc. Prof. Dr. Abdul Qadeer Khan	*Azad Jammu University PAKISTAN*	BIFURCATIONS OF A TWO-DIMENSIONAL DISCRETE TIME PLANT-HERBIVORE SYSTEM
Okoro, John Chukwuma Ugwu, Johnmartins Ifeanyi	*Nigeria University NIGERIA*	HERBICIDE INFORMATION NEEDS OF FARMERS IN ENUGU STATE, NIGERIA
Zineb El Hamri M. Alami M. Assouag	*Moulay Ismail University MOROCCO*	INFLUENCE OF WALNUT SHELL POWDERS ON THE MORPHOLOGY, THERMAL, AND MECHANICAL PROPERTIES OF POLY(LACTIC ACID)
Rachid Flouchi Marwa Chraibi Karim Fahsi Ibrahim Touzani Kawtar Fikri-Benbrahim	*Sidi Mohamed Ben Abdellah University MOROCCO*	PHYTOCHEMISTRY AND ANTIMICROBIAL ACTIVITY OF RUTA MONTANA ESSENTIAL OIL AGAINST NOSOCOMIAL BACTERIA
Omowaye O.S A.A. Abdul-Rahman AbukaV.A Oche Josephen Otorkpa Dakun Yacop G.I.Ogu G.Odewale Attah Friday Olubiyo C.K E.Okolo	*Federal University Lokoja NIGERIA* *Open University NIGERIA* *Federal University Lokoja NIGERIA* *Federal University of Technology NIGERIA* *Kogi State University NIGERIA* *Federal University Lokoja NIGERIA*	In-vitro EVALUATION OF DIFFERENT EXTRACTS OF Telfeiria occidentalis ON Trypanosoma brucei brucei INDUCED MICE
Liman, I. S. Jiya, F. Adamu, W. N.	*The Federal Polytechnic NIGERIA*	PHYTOCHEMICAL AND IN-VIVO ANTIDIABETIC STUDIES OF THE ACTIVITY OF MOMORDICA CHARANTIA L. SEED

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ONLINE PRESENTATIONS

01.12.2024 / HALL-4 / SESSION-3

ANKARA LOCAL TIME: 15 ^{00} - 17 ^{00}

HEAD OF SESSION: Assist. Prof. Samira N. H. Al-Hassoon

AUTHORS	AFFILIATION	TOPIC TITLE
Attah Friday Moses E. Abalaka Daniyan S. Yahaya Abdulsalami Halimat Umar M. Bello Muhammad F. Enagi	*Federal University of Technology NIGERIA*	PHYTOCHEMICAL ANALYSIS AND IN-SILICO EVALUATION OF DRUG-LIKENESS OF ETHANOLIC EXTRACT OF MITRACARPUS SCABER
Dhivya C R Arunkumar	*Tamil Nadu Agricultural University INDIA*	BLOCKCHAIN TECHNOLOGY IN AGRICULTURE FOR SCIENTIFIC RESEARCH
Nutan V. Sadgir Rahul A. Yelave Bapu S.Jagdale	*Loknete Vyankatrao Hiray Arts, Science and Commerce College Panchavati INDIA*	SYNTHESIS, CHARACTERIZATION, AND ANTIMICROBIAL ACTIVITY OF (E)-1-(BENZO[D][1,3]DIOXOL-5-YL)-3-(HETEROARYLARYL) PROP-2-EN-1-ONE DERIVATIVE"
Othmane Roby Rafik Saddik Said Tighadouini Aziz Aboulmouhajir	*Hassan II University MOROCCO*	SYNTHESIS, CHARACTERIZATION, ANTIMICROBIAL ACTIVITY EVALUATION, AND IN-SILICO PREDICTION OF NEW IMIDAZOPYRIDINE DERIVATIVES
Mohammed, U. Umar, I.S. Ubandoma, G.A. Ahmad, B.S.	*Ibrahim Badamasi Babangida University NIGERIA* *Federal University of Technology NIGERIA* *Ibrahim Badamasi Babangida University NIGERIA* *National Cereal Research Institute Badeggi NIGERIA*	ANALYSIS AND LIVELIHOOD BENEFITS OF BEANS CAKE (AKARA) PROCESSING IN OFFA LGA OF KWARA STATE. NIGERIA
ANUSHYA DR.SARAVANAN M.MONICA G.ASMA S.SHERLIN KUSHI SINGH	*Bharath Institute of Higher Education and Research INDIA*	THUTHI LEAF
S. Sherlin sheeba K. Sneha A. Ashwini G.Asma begum D. Anushya	*Bharath Institute of Higher Education and Research INDIA*	A SHORT REVIEW ON ALOE VERA

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ONLINE PRESENTATIONS

01.12.2024 / HALL-5 / SESSION-3

ANKARA LOCAL TIME: 15 ^{00} - 17 ^{00}

HEAD OF SESSION: Dr. R. Saravanan

AUTHORS	AFFILIATION	TOPIC TITLE
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Ajesh Chauhan Shivam Rajput	*Hindu College of Pharmacy INDIA*	ROLE OF ARTIFICIAL INTELLIGENCE IN VETERINARY DISEASES MANAGEMENT
Abderrahmane Ziari Abderrahmane Medjerab	*Huari Bumedyen University of Science and Technology ALGERIA*	IMPACT OF CLIMATE CHANGE ON WATER RESOURCES IN NORTHEASTERN ALGERIA
Nadagouda Kalyani Chyaraju Balasai Yalakacharla Narasimha Devara Guru Venkata Prasad Dasari Rahul Gandhi Bommepalli Pradeep Reddy	*G. Pulla Reddy Engineering College INDIA*	APPLICATION OF REMOTE SENSING METHODS IN AGRICULTURE
Oderinde A.A. Okoye, C. I. Hanis, B. Adeyemi, M. A. Muhammad, N. O. Olukotun, G.B.	*National Biotechnology Research and Development Agency NIGERIA*	IMPROVEMENT OF THE NUTRITIONAL VALUES OF FERMENTED LOCUST BEAN/SOYA BEAN SEEDS USING CONSORTIUM OF TWO BACILLUS STRAINS
K.R.Padma K.R.Don	*Women's University INDIA Bharath Institute of Higher Education and Research INDIA*	PLANT-BASED BRAIN THERAPIES: CHALLENGES AND FUTURE PROSPECTS ALONG WITH MOLECULAR MECHANISM AIDED IN COGNITIVE PROTECTION
K. Pushpa raj R. Selva Kumar Dr.R. Srinivasan	*Bharath Institute of Higher Education and Research INDIA*	A REVIEW ON MEDICINAL ROLE OF PITHECELLOBIUM DULCE
Dr. R. Saravanan	*Bharath Institute of Higher Education and Research INDIA*	SYNTHESIS AND EVALUATION OF SILVER NANOPARTICLES FROM ETHANOLIC LEAF EXTRACT OF TRIDAX PROCUMBENS. L
Adeniyi, B.M Kyenge B.A Adah C.A Abel O.O Ibitoye O Ogungbemi K Balogun D.A Alejo, A.O Abdulbaki, M. K Solomon-I,O.M Ajala O.V Akeju B.M	*Benue State University NIGERIA*	BIOPESTICIDAL EFFICACY OF Heliotropium indicum LEAF EXTRACTS IN POSTHARVEST PEST CONTROL OF STORED GRAINS
Chaymae GHAFFOULI Khaoula FAIZ Adil ROUKBANI Bouchra LOUASTE	*Sidi Mohammed Ben Abdellah University MOROCCO*	CONSUMERS' WILLINGNESS AND ACCEPTANCE OF FOOD PRODUCTS WITH NATURAL PRESERVATIVES: A MOROCCAN PERSPECTIVE

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ONLINE PRESENTATIONS

02.12.2024 / HALL-1 / SESSION-1

ANKARA LOCAL TIME: 10 00 - 12 00

HEAD OF SESSION: Prof. Dr. Celalettin GÖZÜAÇIK

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Prof. Dr. Celalettin GÖZÜAÇIK Hakan HEKİMHAN	*Iğdır University TÜRKİYE* *Ege Agricultural Research Institute, İzmir TÜRKİYE*	THE EFFICACY OF BEAUVERIA BASSIANA AND NEEM AZAL T/S ON HYPERA POSTICA (GYLLENHAL) IN FIELD CONDITIONS
Prof. Dr. Nurhan KESKİN Prof. Dr. Birhan KUNTER Assoc. Prof. Dr. Özkan KAYA M.Sc. Ali KILINÇ Agr. Eng. Melehat DURMAZ UYGUN	*Van Yüzüncü Yıl University TÜRKİYE* *Ankara University TÜRKİYE* *Erzincan Horticultural Research Institute TÜRKİYE* *GAP International Agricultural Research and Training Center, Diyarbakır TÜRKİYE* *Van Yüzüncü Yıl University TÜRKİYE*	GRAPE POMACE: VALUE ADDED RECYCLING PRODUCT FOR SUSTAINABLE VITICULTURE
Mihriban BATUK Prof. Dr. Nurhan KESKİN Assoc. Prof. Dr. Fadime ATEŞ Prof. Dr. Birhan KUNTER	*Van Yüzüncü Yıl University TÜRKİYE* *Van Yüzüncü Yıl University TÜRKİYE* *Manisa Viticulture Research Institute TÜRKİYE* *Ankara University TÜRKİYE*	A HIGH VALUE GRAPE VARIETY IN TURKISH VITICULTURE: "SULTANİ ÇEKİRDEKSİZ"
Dr. Sinem GÜLER Prof. Dr. Birhan KUNTER Prof. Dr. Nurhan KESKİN	*Ministry of Agriculture and Forestry General Directorate of Agricultural Research and Policies, Ankara TÜRKİYE* *Ankara University TÜRKİYE* *Van Yüzüncü Yıl University TÜRKİYE*	VALUE ADDED IN GRAPES: PRODUCT EVALUATION METHODS AND GLOBAL COMPETITIVENESS
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ONLINE PRESENTATIONS

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ANKARA LOCAL TIME: 10 00 - 12 00

HEAD OF SESSION: Prof. Dr. Bünyamin YILDIRIM

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Assoc. Prof. Dr. Mehmet KARAMAN	*Muş Alparslan University TÜRKİYE*	SELECTION OF BREAD WHEAT GENOTYPES IN TERMS OF THOUSAND GRAIN WEIGHT UNDER MULTIPLE ENVIRONMENTS WITH GGE BIPLOT ANALYSIS

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ONLINE PRESENTATIONS

02.12.2024 / HALL-3 / SESSION-1

ANKARA LOCAL TIME: 10 [00] - 12 [00]

HEAD OF SESSION: Prof. Dr. İbrahim DEMİRTAŞ

AUTHORS	AFFILIATION	TOPIC TITLE
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Prof. Dr. İbrahim DEMİRTAŞ	*Iğdır University TÜRKİYE*	OBTAINING BIOACTIVE COMPOUNDS FROM GREEN EXTRACTION METHOD USING SUPERCRITICAL CO_2 EXTRACTION TECHNIQUES
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Prof. Dr. Recep GÜNOĞAN Prof. Dr. Hikmet GÜNAL	*Harran University TÜRKİYE*	IMPACTS OF AGROVOLTAIC SYSTEMS ON SOIL ECOSYSTEMS IN SEMI-ARID REGIONS

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ANKARA LOCAL TIME: 10 ^{00} - 12 ^{00}

HEAD OF SESSION: Dr. C. Vijai

AUTHORS	AFFILIATION	TOPIC TITLE
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Faisal Nazir	*Agriculture University PAKISTAN*	PRODUCTION AND CHARACTERIZATION OF CARBON NANOTUBES FROM BIOCHAR UNDER MICROWAVE IRRADIATION
Maria Fareed Siddiqui Hammad Ur Rehman Umar Raees	*Lahore University PAKISTAN Pakistan Council of Research in Water Resources PAKISTAN*	GENETIC MANIPULATION AND THE ASSOCIATED HAZARDS OF GENETICALLY MODIFIED AGRICULTURAL PRODUCTS
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Assoc. Prof. Dr. Sagaya Aurelia	*CHRIST University INDIA*	AI-DRIVEN AGRICULTURAL SENSORS AND CROP YIELD PREDICTION SYSTEMS IN INDIA
MOHANAPRIYA. P. Assoc. Prof. Dr. CHAMUNDEESWARI. M.	*St. Joseph's College of Engineering INDIA*	RHIZOSPHERE MEDIATED ELECTROGENESIS FOR HARNESSING BIO- ENERGY THROUGH CO_2 SEQUESTRATION- A POWER SOURCE FOR RURAL DEVELOPMENT
VIGNESH K Dr. K. SELVAM ARSHA G	*Palar Agricultural College INDIA*	INVITRO EFFICACY OF COPPER NANOPARTICLES AGAINST RICE SHEATH BLIGHT CAUSED BY Rhizoctonia solani
VIGNESH K Dr. K. SELVAM ARSHA G	*Palar Agricultural College INDIA*	INVITRO EFFICACY OF COPPER NANOPARTICLES AGAINST RICE BLAST CAUSED BY Pyricularia oryzae
Khaoula FAIZ Chaymae GHAFFOULI Adil ROUKBANI Mohammed BENLMLIH Bouchra LOUASTÉ	*Sidi Mohammed Ben Abedllah University MOROCCO*	UNVEILING THE MOLECULAR COMPOSITION AND BIOLOGICAL PROPERTIES OF OLIVE BY-PRODUCT

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HEAD OF SESSION: Prof. Dr. Süreyya Yiğit

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Valentina Papić Bogadi Ph.D. Bernardica Črep, bacc.ing.agr.	*Križevci University CROATIA*	THE IMPORTANCE OF KNOWING A FOREIGN LANGUAGE FOR SPECIFIC PURPOSES IN THE AGRICULTURAL SECTOR
Prof. Dr. Süreyya Yiğit	*New Vision University GEORGIA*	WHAT ARE THE CHALLENGES FACING EUROPEAN AGRICULTURE
I. M. Danwali S. A. Okunsebor R. Mohammed	*Nasarawa State University NIGERIA*	EFFECT OF DRIED TIGERNUT (Cyperus esulentus L.) SUPPLEMENTARY DIET IN FORMULATED FEED ON Clarias gariepinus FECUNDITY, FERTILIZATION, HATCHABILITY OF EGGS AND SURVIVAL RATE OF THE HATCHLINGS
P. Pooja Dr. R. Saravanan	*Bharath Institute of Higher Education and Research INDIA*	ROLE OF VETERINARY PHARMACISTS IN ANIMAL HEALTHCARE
Oluwadamilola Peace AGOI Moses Adeolu AGOI Oluwanifemi Opeyemi AGOI	*Federal University of Agriculture Abeokuta NIGERIA Lagos State University of Education NIGERIA Obafemi Awolowo University NIGERIA*	EVALUATING THE EFFICACY OF TECHNOLOGY IN THE ASSESSMENT OF THE CORRELATION BETWEEN SEED COLORATION AND FUNGAL INFECTION ON SESAME PLANT
Dr. Rekha Suman Abhilasha	*Himachal Pradesh University INDIA*	FROM CHILLING HOURS TO RISING TEMPERATURES: UNDERSTANDING CLIMATE CHANGE'S IMPACT ON APPLE CULTIVATION IN HIMACHAL PRADESH'
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ONLINE PRESENTATIONS

02.12.2024 / HALL-6 / SESSION-1

ANKARA LOCAL TIME: 10 ^{00} - 12 ^{00}

HEAD OF SESSION: Ehizogie Joyce FALODUN

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Ehizogie Joyce FALODUN Anthony EDIALE	*University of Benin NIGERIA*	PERFORMANCE OF TIGER NUT (*Cyperus esculentus* L.) AS INFLUENCED BY ROW SPACING AND FERTILIZER APPLICATION IN A NIGERIAN RAIN FOREST
Nesrine Benkhaira Naoufal El Hachlafi Saad Ibnsouda Koraichi Kawtar Fikri-Benbrahim	*Sidi Mohamed Ben Abdellah University MOROCCO*	PHYTOCHEMICAL COMPOSITION AND BIOACTIVE PROPERTIES OF *Clinopodium nepeta* ESSENTIAL OIL: ANTIOXIDANT, ANTIMICROBIAL, AND ANTIDIABETIC POTENTIAL
Said Babou Miloud Chakit Radia El Gui Abdelhalem Mesfioui Youssef Sqalli-Houssaini	*Ibn Tofail University MOROCCO*	TOXICITY ASSESSMENT OF ETHANOLIC EXTRACT OF ROSMARINUS OFFICINALIS LEAVES IN FEMALE WISTAR RATS
Said Babou Miloud Chakit Abdelhalem Mesfioui Youssef Sqalli Houssaini	*Ibn Tofail University MOROCCO*	ANTILIPIDEMIC AND NEPHRO-HEPATOPROTECTIVE ACTIVITIES OF ROSMARINUS OFFICINALIS ETHANOLIC EXTRACT IN WISTAR RATS
Dr. BRAKNI Oumaima Dr. BIBIMOUNE Imene Prof. KERBOUA ZIARI Yasmina	*University of Science and Technology Houari Boumediene ALGERIA*	ADVANCED COMPUTATIONAL FLUID DYNAMICS ANALYSIS OF FLOW FIELD CHANNEL DESIGN
M'hamed Majji Abdelhak Talha Ouiam Chetto Rachid Benkirane Hamid Benyahia	*National Institute for Agricultural Research (INRA) MOROCCO* *Ibn Tofail University MOROCCO*	SCREENING OF NEW HYBRID CITRUS ROOTSTOCKS FOR SALINITY AT EARLY SEEDLING STAGES UNDER GREENHOUSE CONDITIONS
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Zineb ELABOUDI Samira EL AOUIDI Radouan SAADI Azzouz BENKDAD Zineb EL Mouridi Abdelmourhit LAISSAOUI Abdelaziz MADINZI Salah SOUABI	*Hassan II University MOROCCO* *Centre National de l'Energie, des Sciences et des Techniques Nucléaires MOROCCO* *Centre National de l'Energie, des Sciences et des Techniques Nucléaires MOROCCO* *Centre National de l'Energie, des Sciences et des Techniques Nucléaires MOROCCO* *National Institute of Agronomic Research (INRA) MOROCCO* *Centre National de l'Energie, des Sciences et des Techniques Nucléaires MOROCCO* *Hassan II University MOROCCO* *Hassan II University MOROCCO*	RADIONUCLIDE'S SOIL-PLANT TRANSFER FACTORS IN MEKNES SEMI-ARID AREA, MOROCCO

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CONTENTS

REDUCING CARBON FOOTPRINT IN VERTICAL FARMING AND HYDROPONIC SYSTEMS

Prof. Dr. Sefa ALTIKAT
Igdir University Agriculture Faculty Department of the Biosystems Engineering

ABSTRACT
The growing global population, projected to reach 9.7 billion by 2050, underscores the urgency for sustainable food production systems. Vertical farming and hydroponic systems offer innovative solutions to food security challenges by minimizing environmental impacts. These systems optimize resource use, reduce land dependency, and limit agrochemical application, presenting a viable alternative to traditional agriculture. This article aims to evaluate the sustainability potential of these technologies and identify strategies to address their challenges, particularly energy demands and carbon footprints. Vertical farming employs controlled environments with energy-efficient LED lighting, while hydroponics replaces soil with nutrient-rich solutions. A life cycle analysis (LCA) was utilized to examine energy consumption, carbon emissions, and resource efficiencies in these systems. Key methods included implementing renewable energy sources, dynamic sensing technologies for real-time monitoring, and closed-loop nutrient recycling systems. Vertical farming enables year-round crop production with significantly reduced water usage and minimal nutrient runoff. Hydroponic systems prevent soil degradation and conserve up to 90% more water than traditional methods. High energy demands, particularly for lighting and climate control, were highlighted as critical barriers. The carbon footprint of vertical farming remains a challenge due to reliance on non-renewable energy sources. While vertical farming and hydroponic systems present transformative potential for sustainable agriculture, energy efficiency remains a critical limitation. The integration of renewable energy systems could mitigate carbon emissions and operational costs. Dynamic sensing technologies and closed-loop systems enhance resource efficiency, but scalability and cost barriers must be addressed. Additionally, urban implementation reduces transportation emissions, bolstering localized food security. Future research should explore improving carbon sequestration through plant trait optimization and developing economic models to make these systems more accessible. Vertical farming and hydroponics represent innovative pathways to sustainable agriculture, offering solutions to pressing global food security challenges. With advancements in renewable energy integration, dynamic monitoring systems, and enhanced plant-based research, these technologies can substantially reduce global carbon emissions while meeting future food demands. To achieve their full potential, interdisciplinary efforts in research, policy, and economic modeling are essential for widespread adoption.
Keywords: Vertical farming, hydroponic systems, carbon footprint, water conservation, renewable energy, sustainable agriculture.

INTRODUCTION
Vertical farming is a unique method of cultivating vegetables in a controlled climate environment, particularly in an urban setting. In addition to its unique approach in utilizing the indoor environment for crop production, vertical farming is believed to handle food security problems associated with increasing population and depleting arable lands, reduce

over-reliance on imported farm produce, and contribute significantly to national growth through the provision of jobs. However, several concerns have been raised regarding the environmental impacts of operating a vertical farm. These impacts have to do with the increasing energy consumption, the greenhouse gas emissions associated with such a high energy consumption, which contribute not only to peak oil demand but also of the growing concern for environmental sustainability (Khan et al.,2020).

Vertical farming or hydroponic systems are cropping systems where plants are placed on trays or stacked in a vertical configuration in growth areas and are fed a nutrient-rich water solution. These cropping systems minimize their carbon footprint since the rates of water recycling, water use, and nutrient use are very high compared to traditional systems. Besides, these systems can produce multiple harvests per unit area annually. However, technological advances in growth medium and lighting technologies are still the focus of short- and long-term studies for these cropping systems. These advances aim to select technologies that can reduce operating costs while maintaining a low level of carbon footprint (Blom et al.2022). With the increased demand by society for research on crops produced in these systems with uniform quality and lower operating costs, there are several strategies that can be used to reduce the carbon footprint in production system aspects, such as operation models, growing conditions, growth substrates, nutrient and water management, seedling production, and irrigation support as detailed in the following sections. The choice of plant varieties is also a factor that determines success in the production system, especially for those that can be grown together to take advantage of the use of the same environment (Casey et al.2022).

The food and agriculture industry contributes to global warming in different aspects. It is commonly acknowledged that the food and agriculture sector alone accounts for as much as half of the global greenhouse gas emissions. Other sectors, such as transportation and power generation, are also involved. In the food and agriculture sector, nearly one-third of it comes directly from the five sub-sectors of livestock, rice cultivation, waste incineration, miscellaneous soil treatments, and synthetic fertilizers (Gołasa et al.2021).

Food waste itself contributes to global warming as well. It is estimated that it costs at least one percent of the national GDP to manage it. In the following paragraphs, we give further explanations on how the greenhouse gas emissions relate to the well-known carbon footprint. It is mainly because of three factors. First, one-third is generated through the methane emissions occurring during the waste incineration or in the field of rice paddies. Second, more than one-third is generated through livestock because the digestive system of livestock produces a lot of methane gas. Third, more than twenty percent comes from other sources, such as energy use for the food chain or fuel combustion for equipment used in agriculture (Munir and Fadhilah2023). The electricity, heating, and vehicle fuels consumed in the process are derived from coal, natural gas, and petroleum that are burned. In fact, nearly half of the energy used by the food chain comes from petroleum fuel (Mahapatra et al., 2021).

CARBON FOOTPRINT IN AGRICULTURE

Agriculture accounts for one-third of human-induced global warming. From a business sector point of view, agriculture generates more greenhouse gases than any other business sector, resulting from the vast array of processes such as paddy rice cultivation, energy used for fertilizer, and the production and application of inorganic fertilizers. It is laid down in agricultural literature that nitrogen cycle processes are major sources of nitrous oxide. By their complete life cycle evaluation, agricultural products are similar in approach to livestock and forestry, and they identify that agriculture projects significantly influence the emission factor calculations (Shivanna, 2022). In practice, the agricultural GHG emissions are calculated based on deployments of livestock production data. The co-benefits include potential large reductions of methane and ammonia, which drastically improve air quality, thereby addressing relevant policies and targets, and finally climate protection. Mitigating farming environmental footprint can put agriculture on the right path if the right pocket of climate finance is available to support investments in green agriculture (Panchasara et al., 2021).

Understanding Carbon Footprint

Carbon footprint is a measure of the effect of a specific activity or a particular system on the environment, in terms of the amount of greenhouse gases it generates. In this day and age, effective methods of developing crops have become essential due to expanding cities and depleted arable land. With the increase in natural disasters due to climate change, it is necessary to develop crops that are resistant to adverse weather, with the ability to be produced in a short period of time regardless of the season. Urban agriculture that produces vegetables, such as leaves, roots, or tubers in an environmentally controlled facility, also known as a city farm, outdoor farm, or plantation, is one possible solution. It is seen as responsible urban environmental conservation, with the potential for long-term vision and innovation-based economic development. The most representative of these are the soilless culture systems: hydroponics and vertical farming (Tawiah et al., 2021).

Professional vertical farms are, in principle, plant factories in which direct or indirect artificial light grows in wide-rack multi-storied construction using air flow-based cultivation technology rather than soil, making it the most water-efficient form of urban agricultural technology. As urban agriculture may have urban and metropolitan as well as regional or rural meanings, vertical farming refers to urban agriculture and rural-oriented high-tech farming that produces crops in super-high-rise buildings where air quality, light, and temperature can be adjusted using high technology (Chatterjee et al.2020). However, in recent research, Plant Factories with Artificial Light have started to take the place of vertical farming. Even though PFAL has been developed as an extreme form of urban agriculture, they only use roof areas in urban spaces and indoor spaces in remote cities, which are obvious differences from professional vertical farms that use super-high-rise buildings. Unlike views of typical standards, previous studies claim that it is possible to export high-value crops from PFAL to objective farms or third markets and measure carbon footprints, which normalizes all the boundary conditions of different product systems. With prior research done, it is now plausible to study the carbon footprint under the field of vertical conditions (Van Gerrewey et al., 2021).

Factors Contributing to Carbon Footprint in Agriculture

Vertical farming and hydroponic production systems with energy-efficient designs have the potential to produce healthier food with smaller carbon footprints. Energy-efficient production system designs are therefore essential. The objective of this literature review is to identify the factors that contribute to the carbon footprint in agriculture in order to provide guidance for further reducing the carbon footprint of products from greenhouse, vertical farming, and hydroponic systems. Reducing the embedded energy or changing the energy sources to use more low-carbon energy is the most important task for reducing the carbon footprint of greenhouse, vertical farming, and hydroponic systems (Kumar et al.2021). This paper also introduces the heat recovery or exchange devices that take advantage of the potential for energy savings, which entails reducing the amount of traditional energy used in these systems and specifies further methods for energy reductions in greenhouses, vertical farming, and hydroponic systems (Jurga et al., 2020). Under the rapidly changing environments of growing operations and the general operating systems for fresh, herb, and vegetable production in controlled plant production with natural or artificial lighting, this study identifies the significant factors that contribute to the carbon footprint in agriculture and discusses the relationship between embedded energy and carbon footprint, the advantages and disadvantages of renewable energy, and the necessity for reducing carbon intensity from agricultural sectors. While the electrification of the production system is the first step for reducing embedded energy, we conclude that the necessary further reduction of transportation and other indirect energy sectors associated with energy consumption in controlled plant production can be achieved by promoting the adoption of self-sustaining technology and adapting an industry viewpoint of efficient and low-carbon emissions (Bogdanov et al., 2021).

BENEFITS OF VERTICAL FARMING AND HYDROPONICS

Arguably, the most important benefit of farming with these methods – and the single most important means of helping to abate carbon dioxide by photosynthesis – is that these methods grow plants faster. They also grow a large range of food crops nearly anywhere – even in one-story buildings. This means that the opportunity to use such systems regardless of climatic conditions is possible. The employment of vertical farming and hydroponics to grow food increases local food production. In locations as well as everyone, such systems not only supply nutritious food but also offer emergency food supply to those in need. It helps to build up multiple centers of food security in nearly every building in every city. With the added benefit of having a secure, safe food supply, each city block can gain a local, resilient food supply that minimizes the environmental impacts of importing food. And if combined with solar panel power and rainwater capture, they are sustainable (Ghosh et al., 2022).

CARBON FOOTPRINT ASSESSMENT METHODS

The growing conditions within a Controlled Environment Agriculture system are typically monopolistic and highly controlled, maximizing heat, light, and water supplies with little regard for the larger environmental costs. The expense of consuming more electrical energy has a double negative impact on the environment: consumption directly from the power grid and a higher carbon footprint for the system’s products. Over one third of the carbon contribution of a vertical farm was derived from electricity consumption (Jin et al.2023). Any electrical contribution is a direct reason to engineer a lower kW container, select more efficient electrical equipment, turn the electrical components on and off as quickly as maintainable, isolate and not heat-expel the vertical farm system, insulate to retain generated heat, or enable the use of heat draw energy when it is easily possible. Significant energy commitments for maintaining a suitable microclimate of temperature and humidity resulted in the second highest expenditure. The remarkable wide range of treatment was due to the different vegetables requiring growth under different thermal constraints, in some cases of several degrees apart. These were not implemented by the application and operation of a flexible system that would be able to reduce and adjust the electricity consumption and carbon footprint of the microclimate. It was as simple as that; basically, the entire, thus monopolistic system was kept at the most demanding growth specification appropriate. Carbon offset repaid the emissions of all physical emissions of the vertical farm. Offset finance might be combined into early subsidies from carbon. This is part of the last, strongly suggested life cycle evaluation (Panchalingam et al., 2024).

Life Cycle Assessment (LCA)

The rate of global urbanization is increasing. About 60% of the world's population is expected to be living in urban areas by 2030. There is also a land-form issue. A substantial percentage of the world's land is classified as erratic and unproductive at the global level, which is insufficient for food production. With the increasing population and the decreasing arable

land areas, alternative solutions should be taken into consideration (Jarzebski et al.2021). Vertical farming is defined as a type of indoor cultivation practice in which plant growth is controlled through the employment of regulated indoor environmental conditions. Since the method is based on controlled environment approaches according to external factors, all environmental factors that limit plant growth in field conditions can be provided through vertical farming. For example, plants are irrigated with a nutrient solution, and water consumption is decreased remarkably. Furthermore, plants could be grown independently from seasonal changes, outdoor weather, and climate conditions, and unproductive land could be utilized in a productive way. List the strengths and weaknesses of vertical farming (Chowdhury et al.2020).
There are two main issues with regard to the practice. The first problem is the high cost of indoor farming. The second issue is the negative environmental effects of indirect energy consumption. Currently, vertical farms are not more economical than habitually used greenhouses due to their high energy consumption, but there are many studies dealing with this problem, so the economic feasibility can increase. On the other hand, indirect energy sources, especially non-renewable energy, are widely employed for vertical farming, but a decrease in carbon footprint alongside the conservation of the greenhouse concept is aimed at through energy management strategies (Majeed et al.,2023).

Carbon Accounting Tools

The term carbon footprint and its measurement are somewhat controversial. Rather than black and white, the topic of carbon footprints is more of a shade of gray. What more people are realizing and indeed experiencing is that heat, carbon dioxide, and other greenhouse gases are bad for our planet. This realization is experienced by a wide range of stakeholders, like families, high-level government officials, and even CEOs. One of the more realistic benefits of understanding and calculating one’s carbon footprint is in understanding how to reduce their greenhouse gas impacts using carbon neutrality and offsets (Sovacool et al.2021).
Carbon accounting tools generally have limited application and practicality for part of the agricultural community. For example, to calculate the carbon footprint of a farm, it is necessary to measure or monitor many carbon releases from the farm in order to estimate the total amount of carbon released into the atmosphere. At each level of farm information, the components of carbon inputs and outputs need to be estimated. Given the complex nature of farming, the spatial and temporal effects often pose challenges to translate scientific calculations to carbon footprints. However, not many calculate the carbon footprint of the plant food sector. Still, not many research studies outline or quantify the carbon implications of land use transition to alternative uses in the absence of actual farming activities (Sovacool et al.2021).

ENERGY EFFICIENCY IN VERTICAL FARMING AND HYDROPONICS

Energy demand is a major economic expense associated with vertical farming and hydroponic systems. In order to improve the competitiveness of the produced crops, it is necessary to incorporate the use of energy-efficient consumption practices, reducing the carbon footprint of the process. Along with the reduction in semi-constant energy demand, specific strategies aimed at promoting the rational use and management of light for the energy balance of plants due to the photosynthetic reactions are discussed in the following section.

LED Systems Based on PFAL Systems

For more than twenty years now, the integration of LED technology in Plant Factory with Artificial Lighting systems has been explored. The introduction of Blue LED marked a significant development, and commercial research in veggie production PFAL began in 2011. Many studies have been carried out to determine the possible effects of LED light on plant growth. Satisfactory results for plant growth are limited to Red/Far-Red and Red/Blue. It is well established that green, the middle peak of the photosynthetic response function, is not effectively used in both algae, cyanobacteria, and higher plants, while the risk due to a massive presence in advanced cities ruins the effect of light pollution (Karanisa et al.2022).

CO_2 Level Effect on Energy Consumption

The conventional growing conditions used in climate-controlled environments, such as greenhouses, growth chambers, and indoor vertical farms, assume uniform aerial CO_2 levels according to the light conditions and plant CO_2 consumption. The vertical farm design consists of several levels, with lighting schedules that adapt to plant growth. To ensure a uniform distribution of aerial CO_2 levels, the greenhouse frequently circulates the crop air with external replacement. In growth chambers, individual isolated smaller spaces are often filled with high CO_2 levels. These uniform aerial CO_2 management systems, combined with the increase in plant consumption, control photosynthesis stomata and limit energy efficiency. The intercellular CO_2 concentration decreases, resulting in a decrease in photosynthesis and long exposure time to high light without food optimization. Effective management of focal CO_2 levels within the leaf repair environment, such as dynamic and heterogeneous control depending on light and patient coverage, can further improve lighting energy consumption and photosynthetic efficiency in vertical farms. Considering these results and the approach to lighting schedules, they should be further optimized to expand vertically or horizontally (Aliero et al.2021).

CHALLENGES AND LIMITATIONS

Despite all the advantages mentioned above, a combination of a few critical challenges needs to be overcome before the hydroponic urban vertical sealed factory-like farming model might meet the enthusiastic advocacy of some researchers. We briefly introduce these limitations as an incentive toward offering our proposed future R&D technology challenges needed to overcome them. In preparing this list, note that the specifics of a challenge we miss might not have suggested its importance to us simply because we are focusing on the technology of mass-produced sealed vertical farming model with hydroponic urban vertical factory innovations primarily in mind. Even if there are no challenges like climate, economic, legal, medical, political, regulatory, social, or strategic issues (Mir et al.2022).

Technological challenges at the present growth problem of hydroponic vertical farming: The water sensor problem; The fully automated tomato-picking robot problem; The tomato/location sensor problem; The precise weighing of all parts of a single 1 kg tomato problem. Lower production cost: The new UFDN problem; The new UV LU panel edge connection to manage thermal stress transfer in vertical construction; Harvesting the light of the leftover solar spectrum; The organic waste disposal problem. Quantifying the CO_2 footprint, with all conceptual corporate R&D interactions as a mixed data problem. Each of these hydroponic-based farming problems is fascinating and crucial, and acts just as a start in pointing out the environmental issues that still need much attention (Vollmer et al., 2022).

Economic Viability

The growing and innovative applications of hydroponic systems and vertical farming present a potential solution to meeting consumer demands for fresh and pesticide-free products at either regular or counter-seasonal availability of supply. However, a consideration of carbon footprints is also required, and both vertical farming and other controlled environment agriculture systems rely largely on non-renewable fuel and fire use for heating, cooling, ventilation, and lighting, thus also increasing their carbon footprints. Strategies for reducing energy-related carbon footprints and including assessment costs are discussed. Energy loads from each source of crop management are highlighted, together with the role of carbon trading that can help generate significant additional revenues to growers and other stakeholders. This is concluded by suggestions for further work to reduce both real and virtual carbon footprints (Pomoni et al., 2023). With the exception of marginal locations and with high construction and operational costs, economic returns from vertical farming and hydroponic systems can be significant. Other potential options are increasingly recognized as retrofitting existing buildings and utilizing disused urban space, with recycling of available materials and components, where partial operational commitments by communities and neighborhood stakeholder groups can yield multiple economic, societal, and visual benefits, including a reduction in greenhouse gas emissions. By optimizing choices to meet locally specific opportunities, limitations, and successful experiences, economic interpretation areas of vertical farming and hydroponic systems sustainability are characterized, economies for both capital and operational financial accounting, life cycle investment appraisal, with financial payback periods that may be initially unattractive, matching urban planning and procurement policies relying on regulation, incentives, and education that support commercial investment robustness and adaptation (Mir et al.2022).

FUTURE DIRECTIONS AND EMERGING TECHNOLOGIES

We have identified numerous areas in which investments and technologies may allow vertical farms, and ultimately broad agriculture systems, to reduce their carbon footprint. These technologies include improved operational strategies, energy-efficient lighting and heating, deeper heat exchange with localized sources, and carbon capture and use technologies. Additionally, our data assessment methodology identifies areas where remaining uncertainty in lifecycle placement can be significantly improved by additional research. We note several areas of shifts in outcomes due to changes in technological or environmental context. New technologies with low carbon footprint possibilities such as data-based indoor farming management, heat exchange systems utilizing large differences between inside and outside air, and microalgae photobioreactors each introduce new development into the quest for indoor crop production decarbonization (Avgoustaki & Xydis, 2020).

In the environment-tethered context, minimizing the ecosystem services losses that result from cumulative environmental displacement when productive land use is displaced is imperative for ensuring that natural systems can continue to provide humans with food, water, and other life-sustaining elements. Market-based mechanisms such as green bonds and carbon credits with attention to integrity will be part of our carbon-neutral future, targeted to complement in-kind mitigation across these categories. At this early stage of indoor farming’s emergence, we emphasize both the use of data-driven analysis to clear away the fog of uncertainty and the simultaneous deployment of best-known technologies that have demonstrated broad decarbonization of food production not only in indoor farming but in traditional agriculture as well (Lin & Hong, 2022).

CONCLUSION

Vertical farming and hydroponic systems offer innovative pathways to address the intertwined challenges of food security, climate change, and urbanization. By utilizing controlled environments and advanced technologies, these systems achieve remarkable efficiency in water use, nutrient management, and crop productivity. Hydroponic systems conserve up to 90% more water compared to traditional agriculture and prevent soil degradation, while vertical farming enables year-round crop production independent of external climatic conditions. These features position them as pivotal solutions in sustainable agriculture. However, the reliance on energy-intensive operations, particularly for artificial lighting and climate control, poses significant challenges in terms of carbon footprint and operational costs.

To unlock their full potential, several strategies must be prioritized. Integrating renewable energy sources such as solar and wind power into vertical farming and hydroponic systems can significantly mitigate greenhouse gas emissions. Advances in energy-efficient lighting, including LED technologies optimized for plant growth, and the adoption of closed-loop nutrient and water recycling systems further enhance sustainability. Moreover, employing dynamic sensing technologies and artificial intelligence for real-time monitoring and system optimization can improve resource use efficiency while reducing operational expenses. These innovations, combined with urban implementation of such systems, reduce transportation emissions and strengthen localized food supply chains.

Despite their transformative potential, these systems face critical economic and scalability barriers. High initial investment costs and reliance on non-renewable energy sources hinder widespread adoption. Policymakers, researchers, and industry stakeholders must collaborate to develop economic models that ensure affordability, incentivize renewable energy integration, and create supportive regulatory frameworks. Retrofitting existing urban infrastructures and utilizing underused spaces for vertical farming can also reduce costs while enhancing urban sustainability.

Future research directions should focus on enhancing energy efficiency, improving carbon sequestration capabilities, and developing crop varieties optimized for controlled environments. Exploring innovative technologies such as heat exchange systems, carbon capture and utilization (CCU) technologies, and data-driven precision farming approaches will be crucial. Additionally, expanding the use of market-based mechanisms like green bonds and carbon credits can provide financial incentives for sustainable practices in vertical farming and hydroponics.

In conclusion, vertical farming and hydroponic systems exemplify the potential of science and technology to revolutionize agriculture and reduce its environmental footprint. However, achieving their widespread adoption and realizing their full benefits require an interdisciplinary approach that integrates advancements in engineering, economic incentives, and policy frameworks. By addressing these challenges, these systems can play a central role in building a sustainable and resilient global food production system for future generations.

REFERENCES

Aliero, M. S., Qureshi, K. N., Pasha, M. F., & Jeon, G. (2021). Smart home energy management systems in Internet of Things networks for green cities demands and services. *Environmental Technology & Innovation, 22,* 101443. https://doi.org/10.1016/j.eti.2021.101443

Avgoustaki, D. D., & Xydis, G. (2020). Indoor vertical farming in the urban nexus context: Business growth and resource savings. *Sustainability, 12(19),* 8125. https://doi.org/10.3390/su12198125

Blom, T., Jenkins, A., Pulselli, R. M., & Van den Dobbelsteen, A. A. J. F. (2022). The embodied carbon emissions of lettuce production in vertical farming, greenhouse horticulture, and open-field farming in the Netherlands. *Journal of Cleaner Production, 377,* 134443. https://doi.org/10.1016/j.jclepro.2022.134443

Bogdanov, D., Gulagi, A., Fasihi, M., & Breyer, C. (2021). Full energy sector transition towards 100% renewable energy supply: Integrating power, heat, transport and industry sectors including desalination. *Applied Energy, 283,* 116107. https://doi.org/10.1016/j.apenergy.2020.116107

Casey, L., Freeman, B., Francis, K., Brychkova, G., McKeown, P., Spillane, C., ... & Styles, D. (2022). Comparative environmental footprints of lettuce supplied by hydroponic controlled-environment agriculture and field-based supply chains. *Journal of Cleaner Production, 369,* 133214. https://doi.org/10.1016/j.jclepro.2022.133214

Chatterjee, A., Debnath, S., & Pal, H. (2020). Implication of urban agriculture and vertical farming for future sustainability. In *Urban Horticulture—Necessity of the Future.* IntechOpen. https://doi.org/10.5772/intechopen.92214

Chowdhury, M. E., Khandakar, A., Ahmed, S., Al-Khuzaei, F., Hamdalla, J., Haque, F., ... & Al-Emadi, N. (2020). Design, construction and testing of IoT-based automated indoor vertical hydroponics farming test-bed in Qatar. *Sensors, 20(19),* 5637. https://doi.org/10.3390/s20195637

Ghosh, S., Sarkar, T., Das, A., & Chakraborty, R. (2022). Natural colorants from plant pigments and their encapsulation: An emerging window for the food industry. *LWT, 154,* 112653. https://doi.org/10.1016/j.lwt.2021.112653

Gołasa, P., Wysokiński, M., Bieńkowska-Gołasa, W., Gradziuk, P., Golonko, M., Gradziuk, B., ... & Gromada, A. (2021). Sources of greenhouse gas emissions in agriculture, with particular emphasis on emissions from energy used. *Energies, 14(13),* 3784. https://doi.org/10.3390/en14133784

Jarzebski, M. P., Elmqvist, T., Gasparatos, A., Fukushi, K., Eckersten, S., Haase, D., ... & Pu, J. (2021). Ageing and population shrinking: Implications for sustainability in the urban century. *NPJ Urban Sustainability, 1(1),* 17. https://doi.org/10.1038/s42949-021-00017-5

Jin, W., Formiga Lopez, D., Heuvelink, E., & Marcelis, L. F. (2023). Light use efficiency of lettuce cultivation in vertical farms compared with greenhouse and field. *Food and Energy Security, 12(1),* e391. https://doi.org/10.1002/fes3.391

Jurga, A., Pacak, A., Pandelidis, D., & Kaźmierczak, B. (2020). A long-term analysis of the possibility of water recovery for hydroponic lettuce irrigation in an indoor vertical farm. Part 2: Rainwater harvesting. *Applied Sciences, 10(18),* 6207. https://doi.org/10.3390/app10186207

Karanisa, T., Achour, Y., Ouammi, A., & Sayadi, S. (2022). Smart greenhouses as the path towards precision agriculture in the food-energy-water nexus: Case study of Qatar. *Environment Systems and Decisions, 42(4),* 521–546. https://doi.org/10.1007/s10669-022-09838-8

Khan, M. M., Akram, M. T., Janke, R., Qadri, R. W. K., Al-Sadi, A. M., & Farooque, A. A. (2020). Urban horticulture for food secure cities through and beyond COVID-19. *Sustainability, 12(22),* 9592. https://doi.org/10.3390/su12229592

Kumar, R., Mishra, J. S., Mondal, S., Meena, R. S., Sundaram, P. K., Bhatt, B. P., ... & Raman, R. K. (2021). Designing an ecofriendly and carbon-cum-energy efficient production system for the diverse agroecosystem of South Asia. *Energy, 214,* 118860. https://doi.org/10.1016/j.energy.2020.118860

Lin, L., & Hong, Y. (2022). Developing a green bonds market: Lessons from China. European Business Organization Law Review, 23(2),289–311. (https://doi.org/10.1007/s40804-022-00239-y)

Mahapatra, S., Kumar, D., Singh, B., & Sachan, P. K. (2021). Biofuels and their sources of production: A review on cleaner sustainable alternative against conventional fuel, in the framework of the food and energy nexus. *Energy Nexus, 4,* 100037. https://doi.org/10.1016/j.nexus.2021.100037

Majeed, Y., Khan, M. U., Waseem, M., Zahid, U., Mahmood, F., Majeed, F., ... & Raza, A. (2023). Renewable energy as an alternative source for energy management in agriculture. *Energy Reports, 10,* 344–359. https://doi.org/10.1016/j.egyr.2022.12.090

Mir, M. S., Naikoo, N. B., Kanth, R. H., Bahar, F. A., Bhat, M. A., Nazir, A., ... & Ahngar, T. A. (2022). Vertical farming: The future of agriculture: A review. *The Pharma Innovation Journal, 11(2),* 1175–1195. https://www.thepharmajournal.com

Munir, A., & Fadhilah. (2023, January). Climate change and food insecurities: The importance of food loss and waste reduction in Indonesia. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1134, No. 1, p. 012040). IOP Publishing. https://doi.org/10.1088/1755-1315/1134/1/012040

Panchalingam, K., Rasheed, E. O., & Rotimi, J. O. B. (2024). Cost-related drivers and barriers of Passivhaus: A systematic literature review. *Sustainability, 16(1),* 123–134. https://doi.org/10.3390/su16010123

Panchasara, H., Samrat, N. H., & Islam, N. (2021). Greenhouse gas emissions trends and mitigation measures in Australian agriculture sector—A review. *Agriculture, 11(7),* 582.https://doi.org/10.3390/agriculture11070582

Pomoni, D. I., Koukou, M. K., Vrachopoulos, M. G., & Vasiliadis, L. (2023). A review of hydroponics and conventional agriculture based on energy and water consumption, environmental impact, and land use. *Energies, 16(1),* 345. https://doi.org/10.3390/en16010345

Shivanna, K. R. (2022). Climate change and its impact on biodiversity and human welfare. *Proceedings of the Indian National Science Academy, 88(3),* 325–339. https://doi.org/10.1007/s43538-021-00018-y

FUNGI ASSOCIATED WITH ANTHRACNOSE DISEASE OF MANGO LEAVES (MANGIFERA INDICA)

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ABSTRACT
The aim of this study was to identify fungal organisms associated with Anthracnose disease of mango leaves in Lokoja, Kogi state. Anthracnose infected mango leaves were sampled from a total of 10 different mango trees within Lokoja. The infected leaves samples were immediately taken to the laboratory for direct isolation, characterization, and identification of fungal isolates. An average total of 102.6 fungal colonies were obtained from the anthracnose infected mango leaves. Based on similarity of morphological features (colony colour, texture, presence of septate mycelia or not, spore shape, and number of septa), fungal colonies were grouped into 4 species and were identified as Aspergillus niger, A. fumigatus, A. flavus, and Penicillium spp. Findings of this study have indicated that Aspergillus niger is the predominant fungal species responsible for anthracnose disease of mango leaves within Lokoja, Kogi state.

INTRODUCTION
Mango (Mangifera indica L.) is among the fruit plants rich in vitamin C that is grown throughout the humid region of Southern Nigeria. It is an important fruit crop in most tropical regions of the world and most eaten in the developed countries (Diedhiou et al., 2007; Crane and Campbell, 1994). It plays an important part in the diet and cuisine of many diverse cultures. In India alone report shows that there are over 1000 varieties of mango, which is a testament of their value to humankind. Mangos belong to the genus Mangifera of the family Anacardiaceae, The genus Mangifera contains several species that bear edible fruit and Most of the fruits trees that are commonly known as mangos belong to the species Mangifera indica (Rawal et al., 2009). Mango has become naturalized and adapted throughout the tropics and subtropics. Much of the spread and naturalization has occurred in conjunction with the spread of human populations. Mango is a common garden tree throughout the tropics, when Ripe, this delicious dessert fruit is particularly high in vitamin A (Amusa, et al., 2010). The fruit is also eaten green, processed into pickles, pulps, jams, and chutneys, and is frozen or dried. The fruit is also an important source of sustenance for birds, bats, insects, and mammals. Mangos are well adapted to cultivation and have been grown commercially for sscenturies. Today, mangos are recognized and eaten throughout the world and are regarded as one of the most popular and esteemed tropical fruits. The leaves of Mangifera indica in recent years, has received attention by pharmaceutical, cosmetic and food industries. Mango leaves have a high content of natural antioxidants they are also a rich source of phenolic compounds with strong antioxidant power, particularly mangiferin, a special xanthone commonly known as “super-

antioxidant" (Massibo et al., 2008). Mango leaves contains a lot of beneficial chemical compounds to remedy various diseases, most importantly as diabetes, diarrhea, asthma, kidney scabies, respiratory problems and urinary disorder. Mango leaves are very healthy to consume, they're tender and can be eaten but one of the most common method of consuming mango leaves is by boiling as Tea.

Mango like all other field crops is affected by certain pest and diseases. Anthracnose disease is presently recognized as the most important field and post-harvest disease of mango worldwide (Ploetz and Prakash, 1997). It is the major disease limiting fruit production in all countries where mangoes are grown, especially where high humidity prevails during the cropping season. The post-harvest phase is the most damaging and economically significant phase of the disease worldwide (M.R. Humauan et al., 2008). It directly affects the marketable fruit rendering it worthless. This phase is directly linked to the field phase where initial infection usually starts on young twigs and leaves and spreads to the flowers, causing blossom blight and destroying the inflorescences and even preventing fruit set (Diedhiou et al., 2007).

The main causative agent of Anthracnose disease is known as Colletotrichum gloeosporioides Penz. C.gloeosporioides as a causal agent of anthracnose of mango was first reported in south western Nigeria. These pathogens invade inflorescences, fruit, leaves and stems of mango. Anthracnose disease appears as irregular-shaped and black necrotic spots on both surfaces of the mango leaf making severely affected leaves to curl. On mango, anthracnose disease symptoms occur on leaves, twigs, petioles, flower clusters (panicles), and fruits. On leaves, lesions start as small, angular, brown to black spots that can enlarge to form extensive dead areas. Lesions often coalesce to form large necrotic areas, frequently along the leaf margins. Lesions develop primarily on young tissue and conidia are formed and can be observed in lesions of all ages, while in older leaves, lesions do not develop, but latent infections are formed and the fungus remains dormant until the tissue senesces, Growth then resumes and fruiting structures are produced in the necrotic tissue. The lesions may drop out of leaves during dry weather.

MATERIALS AND METHODS

This study was carried out in Lokoja, Kogi State. Lokoja town is located on the west bank of River Niger; opposite the mouth of the Benue River. The original site of Lokoja, is a 1,349-foot-(411-metre-) high.

2.1 Preparation of Potato Dextrose Culture media

Potato dextrose agar (PDA) was used for isolation. The Culture media was prepared according to manufacturer's specification (at 39 gL^{-1}) autoclaved at 121°C for 15 min (15psi). Then, 0.1% of chloramphenicol was added to the sterilized media just before pouring into petri dishes to prevent bacterial growth (Wang et al. 2019).

SAMPLE PROCESSING

Collection of sample

A total of 10 Mango trees were visited at random within Lokoja, Kogi state. Infected mango leaves were identified and collected into closed paper envelops and taken to the Biological laboratory for analysis. Two leaves were taken per Mango tree for fungal isolation and identification and the leaves were sorted into envelops according to different locations as identified. The Envelops were identified (i.e., numbered serially 1-10) and the Locations were also stated on each envelop. The sample locations are Old polyquaters (OPQ), Lokongoma (LKM), Ganaja (GNJ), Fehintolu (FHL), Wada estate (WDE), Phase II (PH2), Gadumo (GDM), Felele (FEL), Adankolo (ADL) and Crusher (CRS) respectively.

Sample processing

At the laboratory, all 10 locations of the mango leaves obtained were sorted separately. Samples of infected leaves showing symptoms of anthracnose were washed with tap water to remove dirt and dust from the surface. The leaves were excised into small or tiny pieces using a sterilized razor blade and were immersed in 10ml of sterilized distilled water for 24hrs; with periodic shaking; during which the microorganisms are detached inside. The leaves were then removed with sterilized forceps. Then, 0.5ml of turbid water containing the microorganisms was then inoculated using a sterile syringe into ten plates well labeled, containing already prepared Potato dextrose agar (PDA) for fungal growth and was incubated for 6 days at room temperature (25±3^{0}C).

Enumeration and Isolation of the fungi

After incubation for a period of 144hr (6 days) on PDA, plates were inspected to observe fungal growth and were counted using counting chamber.

Sub culturing/purification of isolates

Distinct representative fungal colonies observed were sub-cultured into freshly prepared PDA media plate with the help of a sterile inoculating loop to obtain pure culture isolates of the fungi. The subculture was left for another 144hr of incubation after inoculation. The Plates were observed and stored for identification. Transfer of pure colonies to freshly prepared PDA media was done and kept at room temperature (25±3^{0}C) during identification to keep strains viable and maintain pure cultures at all times for correct identification of fungi.

Identification of fungi

Pure cultures obtained were identified based on morphological features; the fungi were characterized and identified on the bases of their colonial and microscopic characteristics. The cellular morphology of isolated fungi was studied by Lactophenol cotton blue staining (Cappuccino and Sherman, 2005).

RESULTS

Frequency of occurrence of fungal colonies after six days incubation.

After six days of incubation, fungal colonies from infected mango leaves varied in their cultural characteristics on PDA media in terms of color and texture. Some visible color colonies were observed on the plates and are shown in Table 1.

Characterization of fungal isolates from infected mango leaves.

The morphological characteristics of fungal isolates from infected leaves samples collected from 10 locations within Lokoja Kogi State (Old polyquarters, Lokongoma, Ganaja, Fehintolu, Wada estate, PhaseII, Gadumo, Adankolo, Crusher) are shown in Table 2. The macroscopic and microscopic characterization revealed the presence of Aspergillus niger, Aspergillus flavus, Aspergillus fumigatus, Penicillium spp.

Distribution of anthracnose fungal isolate in each sample location.

The fungal isolated from the samples gotten from the 10 locations within Lokoja (Old-Polyquarters, Lokongoma, Ganaja, Fehintolu, Wada estate, PhaseII, Gadumo, Adankolo, Crusher) is shown in Table 3. From the results, Aspergillus flavus was present in Ganaja, Wada estate, and Phase II and absent in 7 other locations. Penicillium spp. was present in 6 locations and absent in Old-Polyquarters, Lokongoma, Fehintolu, and Gadumo. Aspergillus fumigatus was present in 7 locations and absent in Lokongoma, Felele, and Crusher. Aspergillus niger was present in 9 locations and absent in Felele.

Table1 Frequency of occurrence of fungal colonies after six days incubation.

Visible colours of colonies	Average numbers of colonies		
Yellow	0.5		
Green	5.7		
White	35.2		
Black	61.2		
Total	**102.6**		

Table 2 Characterization of fungal isolates from infected mango leaves.

S/N	Macroscopic features	Microscopic features	Probable Isolates
1.	Black powdery growth	Simple upright conidiophore terminating in globose conidia head.	Aspergillus niger
2.	Brown powdery colony growth	Non-branched conidiophores	Aspergillus flavus
3.	Green color growth	columnar and uniseriate conidial heads	Aspergillus fumigatus
4.	White cotton-like in texture at the bottom of the plate	Smooth hyaline with chains of single celled conidia produced in basipetal succession and form a specialized conidiogenous cell called phialide.	Penicillium spp

Table3 Distribution of anthracnose fungal isolates in each sample location

Isolates	OPQ	LKM	GNJ	FHL	WDE	PH2	GDM	FEL	ADL	CRS
Aspergillus niger	+	+	+	+	+	+	+	_	+	+
Aspergillus flavus	_	_	+	_	+	+	_	_	_	_
Aspergillus fumigatus	+	_	+	+	+	+	+	_	+	_
Penicillium spp	_	_	+	_	+	+	_	+	+	+

Key –absence
+presence

Discussion

This study aimed to isolate, identify, and characterize the fungal organisms causing anthracnose disease on mango leaves (Mangifera indica).

Fungal Analysis

After six days of incubation, the average number of fungal colonies was:

Yellow leaves: 0.5
Green leaves: 5.7
White leaves: 35.2
Black leaves: 61.2
Fungal Isolates

A total of four fungi were isolated from infected mango leaves collected from ten locations within Lokoja, Kogi State:

Aspergillus niger
A. flavus
A. fumigatus
Penicillium spp.
Among these, Aspergillus niger was the most prevalent, found in all locations except Felele.

Prevalence of Anthracnose
The results indicate that anthracnose disease is widespread in all surveyed mango-growing areas of Lokoja.

Comparison with Previous Studies
Similar to a study conducted in Bangladesh by Farhana et al. (2018), Aspergillus niger, A. flavus, A. fumigatus, and Penicillium spp. were identified as major causative agents of mango anthracnose.
Our findings also align with Zainab et al. (2006) in Sokoto State, who identified A. niger and A. fumigatus as causative agents of mango leaf anthracnose.

Conclusion

Anthracnose disease was found to be prevalent in all surveyed mango-growing areas of Lokoja, Kogi State. This study identified Aspergillus niger as the primary fungal pathogen responsible for the disease, posing a significant threat to mango production. To effectively manage anthracnose and minimize economic losses, a comprehensive approach is necessary. This includes understanding the disease cycle, exploring alternative management practices like hot water treatment, bio-agents, botanicals, and mineral treatments, and considering the environmental impact of chemical fungicides.

Acknowledgement

Ethical Approval
All authors hereby declare that “Principles of laboratory animal care” (NIH publication No. 85- 23, revised 1985) were followed, as well as specific national laws where applicable. All experiments have been examined and approved by the appropriate ethics committee.

Competing Interests

Authors have declared that no competing interests exist.

References

Abdul Rehman, A. U. Malik, H. Ali, M. W. Alam, & B. Sarfraz. (2015). Preharvest factors influencing the postharvest disease development and fruit quality of mango. Journal of Environmental and Agricultural Sciences, 3, 42-47.

Aishatu, H., Gali, A. I., & Mahmud, Y. J. (2020). Identification and Pathogenicity of Organisms Associated with Anthracnose Disease of Mango in Yola, Adamawa State, Nigeria. Asian Plant Research Journal, 10, 97-34.

Akem, C. N. (2006). Mango anthracnose disease: Present status and future research priorities. Plant Pathology Journal, 5(3), 266-273.

Akhtar, K. P., Khan, I., Khar, I. A., & Khan, S. M. (1998). Studies on the incident and pathogenesis of Colletotrichum gloeosporioides causing anthracnose of mango and chemical control. Pak. J. Phytopathol., 10, 42-44.

Amusa, N. A. (2010). Man and microbes in a continuous battle. An Inaugural Lecture Delivered in the Faculty of Science, Olabisi Onabanjo University, Ago-Iwoye, Nigeria.

Arauz, L. F. (2000). Mango anthracnose: Economic impact and current options for integrated management. Plant Dis., 84(6), 600-611.

Aslam Memon, M. Y. Khan Marri, & A. M. Khushk. (2013). Estimation of mango Post Harvest Losses in Sindh. Life Sci. Int. J., 7(1), 2827-2832.

Awa, O. C., Samuel, O., Oworu, O. O., & Sosanya, O. (2012). First Report of Fruit for Anthracnose in Mango caused by C. gloeosporioides in Southern Nigeria. International Journal of Scientific & Technology Research, 1, 30-34.

Bhuvaneswari, V., & Subba Rao, M. (2001). Evaluation of Trichoderma viride antagonistic to post-harvest pathogens on mango. Indian Phytopathology, 54(4), 493-494.

Castaner, M., Gill, M. I., & Artes, F. (1997). Organic acids as browning inhibitors on harvested “Baby” lettuce and endive. Z. Lebensm. Unters. Forsch., 205, 375-379.

Chowdhury, M. N., & Rahim, M. A. (2009). Integrated crop management to control anthracnose (Colletotrichum gloeosporioides) of mango. Journal of Agriculture & Rural Development, 115-120.

Chowdhury, M. N. A., Rahim, M. A., Khalequzzaman, K. M., Alam, M. J., & Humaun, M. R. (2008). Effect of horticultural practices on incidence of anthracnose on yield and quality of mango. Int. J. Sustain. Crop. Prod., 3, 1-9.

Crane, J. H., Balerdi, C. F., & Maguire, L. (2006). Mango Growing in the Florida Home Landscape. IFAS, Florida, USA.

Crane, J. H., & Campbell, C. W. (1994). The mango fact sheet HS-2: Horticulture sciences. Department of Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, Florida.

Deependra Yadav, K. S. Yadav, & Singh, S. P. (2018). Mango: Taxonomy and botany. Journal of Pharmacognosy and Phytochemistry, 7(2), 3253-3258.

Diedhiou, P. M., Mbaye, N., Dramé, A., & Samb, P. I. (2007). Alteration of post-harvest diseases of mango (Mangifera indica) through production practices and climatic factors. African Journal of Biotechnology, 6(9), 1087-1094.

Dionisio, G. A., & Acda, M. A. (2015). Revisiting the efficacy of hot water treatment in managing anthracnose and stem-end rot diseases of mango. Crop Protection, 67, 96-101.

In-vitro EVALUATION OF DIFFERENT EXTRACTS OF Telfeiria occidentalis ON Trypanosoma brucei brucei INDUCED MICE

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Abstract
Rats infected with Trypanosoma brucei brucei were evaluated in the Advanced Microbiology Laboratory of Federal University Lokoja between 24th June, 2024 to 3rd July, 2024 using various extracts of Telfeiria occidentalis. Twenty-four rats(24) in total were split into six groups of four rats each at random. Following a three-day period of Trypanosoma brucei brucei inoculation and infection, the infected rats were treated with 0.1, 0.01, 0.001mg/ml of methanol Telfeiria occidentalis, n-hexane of Telfeiria occidentalis, petroleum ether of Telfeiria occidentalis, aqueous of Telfeiria occidentalis and albendazole (anti-parasitic drug) respectively for in-vitro evaluation. Group A (positive control) was not infected, group B was not infected but treated, group C was infected and not treated (negative control), group D, E and F was infected and treated with different extracts of Telfeiria occidentalis, albendazole and Tween 80 against the infected blood during in-vitro evaluation. Trypanosoma brucei brucei experimental rats was carried out by injecting 0.2ml of blood containing approximately 1.0 *10^5 Trypanosoma brucei brucei per unit, intraperitoneally into each rat in the infected

group., The anti-trypanosoma effects of TOM, TOA, TOA, TON, Tween 80 and anti-parasitic drug were assessed on Trypanosoma brucei brucei level, haemoglobin, PCV, weight, body temperature. The Trypanosoma brucei brucei count (in-vitro study) was observed to decrease in a concentration dependent on (0.1mg/ml, 0.01mg/ml and 0.001mg/ml) pattern of extracts. In vitro studies on haemoglobin (HB) level, packed cell volume (PCV) and temperature change of the experimental rats, revealed that treatment with TOM and TON among others reversed the abnormalities in HB, PCV, weight and body temperature towards negotiatiable control levels in a fast way especially TOM in in-vitro evaluation compared to others, and the anti-parasitic drug displayed same level of anti-trypanosomal potency in in-vitro experiment with Telfeiria occidentalis methanol. Hence, the usage of TOM could be supported and employed in the treatment of Trypanosomiasis with little or no side effect.
Across all parameters- weight, temperature, hemoglobin levels and packed cell volume-the LSD values indicate that the methanolic extract and the conventional drug Albendazole are more effective in maintaining or restoring normal physiological functions with no significant negative effects (P> 0.05). In contrast, aqueous extracts showed significant negative effects, with the several parameters exceeding the LSD range, indicating statistical significance (P<0.05), which suggests reduced effectiveness and possible toxicity at higher doses.
Key words:Telfeiria occidentalis,Trypanosoma brucei brucei, In-vitro,Mice, Lokoja

Introduction

Recent progress in diagnosis and treatment of Human **African** Trypanosomiasis has made the elimination of this **disease** a realistic target by 2030

Human African trypanosomiasis (HAT), also known as sleeping sickness, is a vector-borne parasitic disease caused by an extracellular protozoa belonging to the genus Trypanosoma, species, brucei. Two subspecies of Trypanosoma brucei are pathogenic for humans: T. b. gambiense and T. b. rhodesiense. These two parasites cause distinct pathologic entities, both of which are included under the general term HAT, but they have to be considered as two separate diseases, with different epidemiological and clinical patterns and different patient management the WHO website, provide detailed judgements on the factors considered in grading these recommendations(WHO 2024). T. b. gambiense infection is found in western and central Africa, and it usually causes a chronic disease named gambiense HAT (Moon et al., 2022). It is an anthroponotic disease with a minor role for animal reservoirs. It is responsible for 98%of the cases of HAT reported in the last decade. T. b. rhodesiense is found in eastern and southern Africa. It is less adapted to human beings and it causes an acute and rapidly progressive disease, known as rhodesiense HAT (Moon et al., 2022). Itis a zoonotic disease, affecting mainly animals (livestock and wildlife), with humans being only accidentally infected. Rhodesiense HAT has an epidemic potential in humans, as it has been responsible for large outbreaks in the past (Lejon et al., 2019).

The classical geographic separation of the two forms of the disease approximately coincides with the Rift Valley, with T b. rhodesiense present at the east of the Rift Valley, while T. b. gambiense is found to the west of the Valley. Due to different factors, the gap between the two forms has been reducing in Northwest Uganda and on the border between the United Republic of Tanzania and the Democratic Republic of Congo, and in the future an overlap of the 2 forms could occur (Cordon-Obras et al., 2010).

HAT clinically evolves in two stages. Initially, there is a first or early stage, where parasites dwell in the lymphatic system and bloodstream (hemo-lymphatic stage) (Borges et al., 2021). After a variable period, which is much shorter in rhodesiense HAT than in gambiense HAT, a late or second stage starts when the trypanosomes cross the blood- brain barrier and invade the central nervous system (meningo encephalitic stage), accompanied by progressive neurological damage (Silva et al., 2022). HAT is considered to be usually fatal if left untreated (WHO 2020), patients progress gradually to a coma, severe organ failure, and eventually death. The clinical presentation of HAT varies in the two forms of the disease. The signs and symptoms are generally the same for both forms, but they differ in terms of their frequency, severity, and kinetic appearance. Rhodesiense HAT is an acute disease that usually progresses to death within 6 months (WHO 2020). Gambiense HAT has a more chronic progressive course with an average duration of almost 3years.

The clinical signs and symptoms are unspecific in both forms of the disease, and their appearance varies between individuals and foci. Intermittent fever, headache, pruritus and other dermatologic problems, lymphadenopathies, weakness, asthenia, anemia, cardiac disorders, endocrine disturbances, musculoskeletal pains, and hepatosplenomegaly are the main signs and symptoms of the first stage (Boulangé et al., 2022). Neuropsychiatric signs and symptoms, including sleep disturbances, are characteristic of second stage (Garrod et al., 2020). However, most of the symptoms of both stages overlap, rendering the distinction between the stages made based on clinical features, unclear. Misdiagnosis with other fever-causing diseases and neuropsychiatric problems is frequent (Zou et al., 2020).

T brucei group trypanosomes are transmitted by tsetse flies. They have a complex life cycle, Vickerman et al., with differentiated biological stages in both the insect vector and the mammalian host. An additional issue with the description of salivarian trypanosomosis lays in the fact that these parasites are pathogenic to most mammals but not to humans and some closely related primates, except for two subspecies of Trypanosoma bruce (Benoit Stijlemans et al., 2024) When entering in the Glossina, the parasites are ingested as bloodstream trypomastigote forms and they move to the midgut. Some species of tsetse are refractory to infection by specific species of trypanosome and even when they are susceptible, the population of parasites in the midgut can be reduced making unsustainable the infection at this point. (Zou et al., 2020). However, some of the trypomastigote forms in the insect's midgut may arrive to differentiate into procyclic forms, which replicate in situ and cross the peritrophic membrane to reach the proventriculus, where they become mesocyclic trypomastigotes and later epimastigote forms (Christie et al., 2022). Then, they migrate via the esophagus, proboscis, and hypopharynx to the salivary gland, where they are able to multiply and some of them can transform into infectious metacyclic forms (Christie et al., 2022). During this migration from the midgut to the salivary glands, the parasite population size experiences a pronounced reduction (Zou et al., 2020). The metacyclic form is the only stage that is infective to vertebrates, and it is characterized by the presence of the variant surface glycoprotein (VSG) coat that will protect the parasite in order to survive on the host. Simarro et al. The whole cycle in the vector takes 18-35 days, and once infected, a tsetse fly remains so for the rest of its life span. Nevertheless, in lab conditions it has been observed that the majority of ingested trypsanosomes fail to develop, and only 2%-5% of the flies ingesting trypanosomes produce metacyclic forms. (Chowdhury et al., 2021).

Metacyclic forms are injected subdermally in the mammalian host during a tsetse fly's blood meal. They proliferate at the site of inoculation and they transform in long slender forms, as they are carried by the draining lymph nodes to the bloodstream where they replicate in the blood-stream, the parasite can be found in its proliferative, long, slender bloodstream trypomastigote form, which is adapted to maintain the parasite in mammalian blood, or as the non-proliferative, short, stumpy bloodstream trypomastigote form, which is adapted to differentiate into the replicative procyclic form in the tsetse fly, and thus to ensure transmission. (Geiger et al., 2022). There are also intermediate forms, which are transitional, as they are between the slender and stumpy forms. The bloodstream forms can enter into

different body fluids, including lymph and cerebrospinal fluid, and they can also cross the placenta (Geiger et al., 2022).
Literature abounds on the medicinal activities of Telfairia occidentalis both in traditional medicine and treated animal models (Ebong et al., 2021). T. occidentalis is an important vegetable and medicinal plant in tropical and subtropical countries in Africa; it is widely used as food and in folk medicine in a different culture (Ebong et al., 2019). T. occidentalis is known commonly as fluted pumpkin (in Ibibio it is called nkong ubong and in Igbo it is called Ugu) and it is a popular vegetable all over Nigeria, especially in the Eastern part of the country (Ebong et al., 2019).
Lastly Anti- trypanosomal effect of different extracts of ugu leaf (Telfairia occidentalis) on Trypanosoma brucei brucei induced mice, Studies have shown that both the ethanol root extract and aqueous leaf extract of T. occidentalis possess anti trypanosomal activity (Ebong et al., 2019). This suggests that Phytomedicine is gradually staging a comeback particularly in the developing countries where the cost of orthodox treatment is skyrocketing as a result of dwindling economy (Ebong et al., 2019).

GC-MS Analysis: The plant extract be taken to Abuja for GCMS analysis to evaluate the potential antimicrobial activity.

Plant Extract Sterility

The extract sterility was confirmed using the standard laboratory procedure. Boerhavia erecta fruit extract was incubated on sterile nutrient agar and incubated at 37 ℃ for 24 hours. Absence of microbial growth on the extract after incubation proved the extract sterility.

Test organism and Experimental Animals: Trypaosoma brucei brucei was obtained from Nigeria institute for trypanonosomiasis Evom, Jos and transported by infecting the donor mice and maintained the parasite up to the actual procedure of the study.
Mice of both sex and pellet diet was purchased. The animals were kept in cages and housed with a typical animal house under a natural 12/12h light-dark cycle at room temperature and maintained on a pellet diet and free access to water. Before the experiment, they were acclimatized to the test environment for 1 week. The care and handling of mice was per international guidelines for the use and maintenance of experimental animals.

Experimental Design

Exactly 24 mice of 16 weeks old were chosen randomly into 6 groups with six (4) mice each in group A,B, C,D E and F, .Group A: uninfected un-treated (control), group B uninfected but treated (0.1,0.01 & 0.001 mg/ml bwt TOM), group C infected untreated (Trypanosoma species), group D infected treated (Trypanosoma species), (0.1, 0.01, 0.001 mg/ml bwt TOM) group E infected treated (Trypanosoma species) (0.1, 0.01, 0.001 mg/ml bwt TOM), group F infected treated (Trypanosoma species), (0.1, 0.01, 0.001 mg/ml bwt TOM). Infection of the experimental mice was carried out by injecting 0.1ml of blood containing approximately $1x10^3$ Trypanosome intraperitoneally into each mouse in the infected groups. The experiment lasted for 7 days.

Table 1: Experimental Design

Group	Treatment	No. of Animals	Period
A	Not Infected-Not Treated	4	7 days
B	Not Infected-Treated	4	7 days
C	Infected-Treated	4	7 days
D	Infected-Treated	4	7 days
E	Infected-Treated	4	7 days

Evaluation of in-vitro Activity: Blood sample was gotten from the infected mice at different ml in 3 places, 0.2ml,0.3ml, 0.5ml and placed on 3 different sterile glass slide respectively, smeared and stained with 10% Giemsa stain followed by the extracts with different dosages (-.1mg/ml, 0.01mg/ml,0.001mg/ml) respectively, covered with cover slip and incubated for 10-15 minutes and was focused with 40X and viewed under microscope with 100x obj and all the visible parasites were counted and recorded.

Determination of parasitemia:

On day 3 (72 hours) post-infection a drop of blood was collected from the mice by vein section of the tail and transferred onto the edge of a microscopic slide and drawn evenly across the second slide to create a thin blood film and allowed to dry at room temperature, stained with 10% Giemsa stain for quarter-hour. For every slide, five fields were viewed microscopically with oil immersion (1000 x magnification). The number of PRBCs and uninfected RBCs counted and thus the percent parasitemia was calculated. The weight, temperature and packed cell volume was determined for every group objectically.

Determination of Packed Cell Volume (PCV):

Packed cell volume (PCV) was measured to predict the effectiveness of the test extract and chloroform fraction in preventing hemolysis resulting from increasing parasitemia associated with malaria by using hemoglobin paper. Blood sample is collected from the mice and dropped on the hemoglobin paper, result is determined by comparing the degree of color change. PCV was monitored on the day of treatment initiation, day 3, day 5 and day 7 after treatment.

Determination of Temperature:

Digital thermometer was used to gauge the mice temperatures to evaluate any potential effects of the ugu extract or oil.

Determination of body weight:

The body weight of the experimental animals was recorded throughout the study to assess any changes that may occur due to the administration of the ugu leaf extracts.

Statistical Analysis

Data were expressed as mean ± SEM. Tabulation of information was employed with data obtained from samples. Frequency distribution percentages and bar charts were used to treat the formulated research questions. While descriptive and inferential statistics (Regression analysis) was used to test the relationship between the variables and the effect of the independent on the variables dependent.

RESULTS

Table 2 Showing the different Status of Grouped Rats with Treatment

GROUPS	TREATMENT	BEFORE INFECTION	AFTER INFECTION	AFTER TREATMENT
A	Not infected, not treated	40.1	40.1	42
B	Not Infected, treated	34.1	35.4	38.0
C	Infected, not treated	33.7	32.6	31
D	Infected, treated	35.1	29.6	32.9
E	Infected, Treated	37.2	31.6	34.3
F	Infected, treated	36.0	30.3	32.9

Effects of Methanol and Aqueous Extracts of Telfairia occidentalis on Mean Weight of Mice

Tables 2 shows weight observations of mice made before infection, after infection and after treatment.

Over the course of the investigation, the mice's weights varied in every group. Three days afte r the
injection, mice in the experimental groups began to lose weight. In contrast to the infected unt reated control, there was a relative improvement in body weight following treatment with different extracts of Telfeiria occindentalis. The non
infected, treated control group did not experience any weight loss; instead, their body weight i ncreased over the course of the investigation.

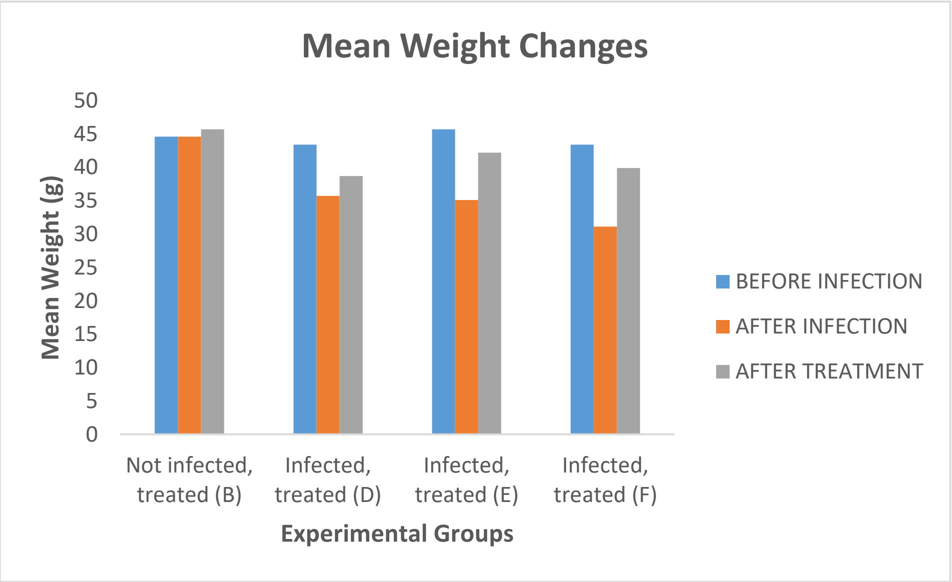

Fig 1: Showing Effect of Different Extracts of Telfeiria occidentalis On Mean Weight of Mice

Table 3 Showing Average Temperature (T ^{O}C) Of Mice throughout Experiment.

GROUPS	TREATMENT	BEFORE INFECTION	AFTER INFECTION	AFTER TREATMENT
A	Not infected, not treated	36.2	37.7^{o}C	36.6^{o}C
B	Not infected, treated	36.4^{o}C	36.9^{o}C	36.7^{o}C
C	Infected, not treated	35.7^{o}C	36.3^{o}C	36.4^{o}C
D	Infected, treated	35.9^{o}C	36.8^{o}C	36.9^{o}C
E	Infected, treated	36.6^{o}C	35.7^{o}C	36.9^{o}C
F	Infected, treated	36.5^{o}C	35.4^{o}C	36.4^{o}C

Effect of Methanol and Aqueous Extracts of T. occidentalis on Mean Temperature of Mice

Fever was observed to occur during the post-infection period, but as the treatment began at day 3 post-infection, temperature fluctuated within the normal range in comparison to the positive control. However, there was increase in temperature above the normal for those mice in the negative control group. There was no significant increase in mean daily temperature of all extract-treated mice.

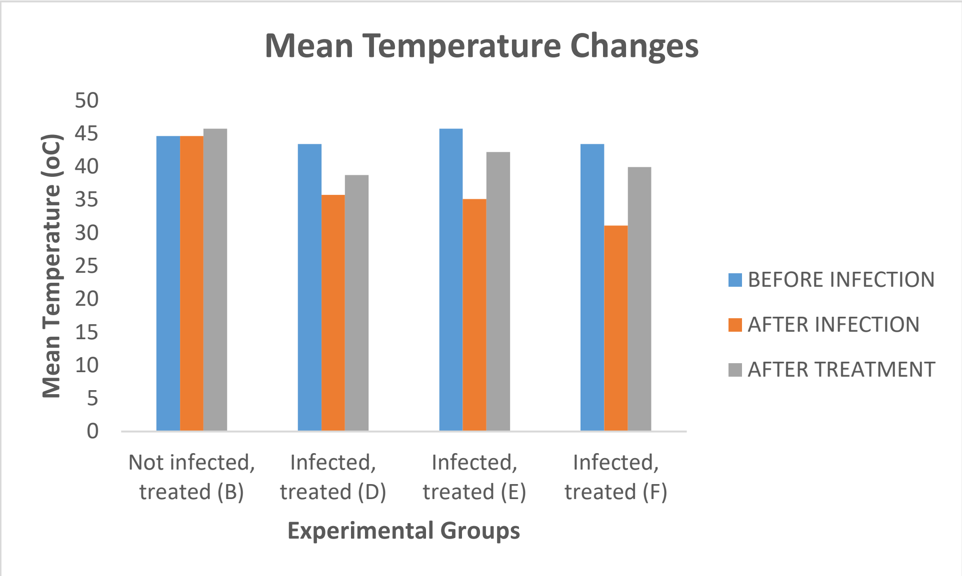

Fig 2: Showing Effect of Different Extracts of Telfeiria occidentalis On Mean Temperature Changes of Mice

Table 4 Showing Average Hemoglobin of Mice throughout Experiment.

GROUPS	TREATMENT	BEFORE INFECTION	AFTER INFECTION	AFTER TREATMENT
A	Not infected, not treated	15.2	15.6	15.6
B	Not infected, treated	14.9	14.9	15.2
C	Infected, not treated	14.9	10.9	8.4
D	Infected, treated	14.5	11.9	12.9
E	Infected, treated	15.2	11.7	14.1
F	Infected, treated	14.5	10.4	13.3

Effect of Methanol and Aqueous Extracts of T. occidentalis on Hemoglobin Level Change of Mice

Hemoglobin levels dropped during the course of infection, but gradually started increasing during treatment with methanol and aqueous extracts of T. occidentalis. After treatment, Hb levels returned back to normal level. This indicates that the treatment might have successfully cleared the infection and the Hb level decline was a temporary response to the infection or treatment. Once the infection was resolved, Hb levels returned to normal.

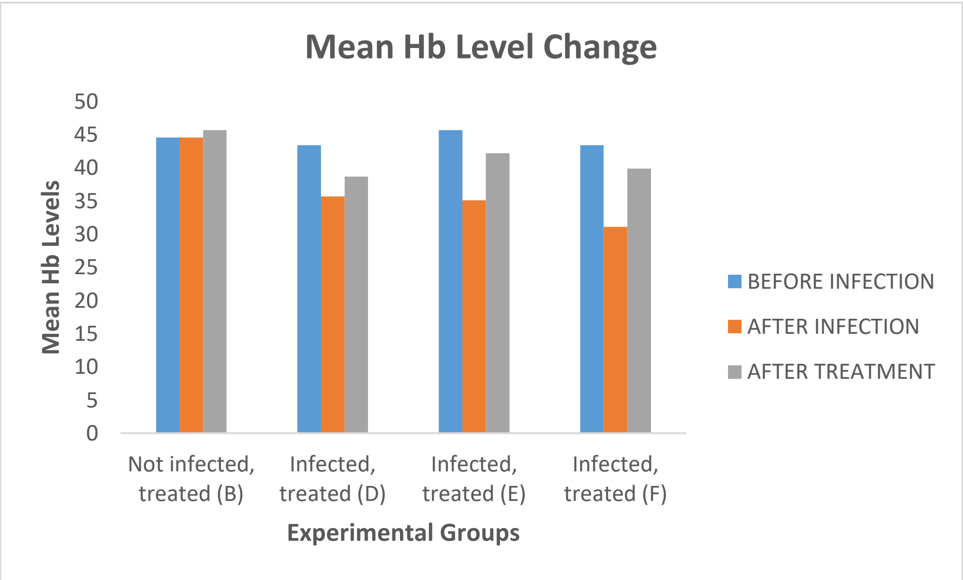

Fig 3: Showing Effect of Different Extracts of Telfeiria occidentalis On Mean Hemoglobin Changes

Table 5. Showing Average Packed Cell Volume of Mice throughout Experiment

GROUPS	TREATMENT	BEFORE INFECTION	AFTER INFECTION	AFTER TREATMENT
A	Not infected, not treated	45.7	46.8	46.8
B	Not infected, treated	44.6	44.6	45.7
C	Infected, not treated	44.6	33.2	28.9
D	Infected, treated	43.4	35.7	38.7
E	Infected, treated	45.7	35.1	42.2
F	Infected, treated	43.4	31.1	39.9

PCV values decreased following 3 days post infection. However, following treatments with the methanol and aqueous T. occidentalis extracts, the PCV values increased. Only the negative control had a further decrease in the mean PCV value.

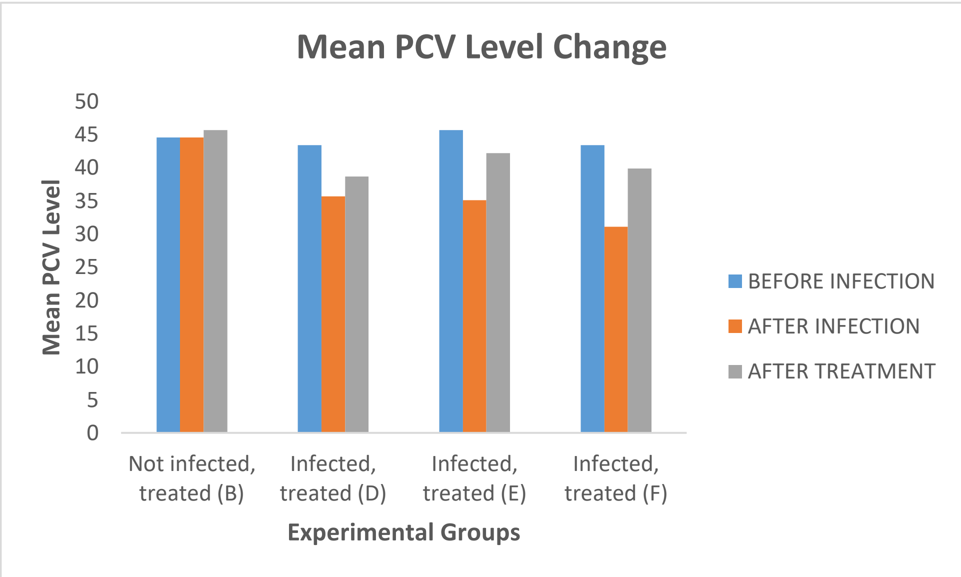

Fig 3. Showing Effect of Different Extracts of Telfeiria occidentalis on Mean Packed Cell Volume

Table 6. Showing Parasitemia of In-Vitro Mice

R1	TOM	TOP	TON	TOA	APD	TWEEN 80
0.1	-	-	-	-	-	12
0.01	-	-	-	4	-	12
0.001	4	4	-	4	-	16
R2						
0.1	-	-	-	-	-	8
0.01	-	4	-	4	4	8
0.01	-	-	4	8	-	12
R3						
0.1	-	-	-	-	-	8
0.01	-	-	-	-	-	16
0.001	-	4	-	4	-	16
R4						
0.1	-	-	-	-	-	12
0.01	-	-	-	4	-	8
0.001	-	4	4	4	-	12

KEY
TOM: Telfeiria Occidentalis methanol extract
TOP: Telfeiria Occidentalis Petroleum Ether Extract
TON: Telfeiria Occidentalis N-Hexane Extract
TOA: Telfeirua Occidentalis Aqueous Extract

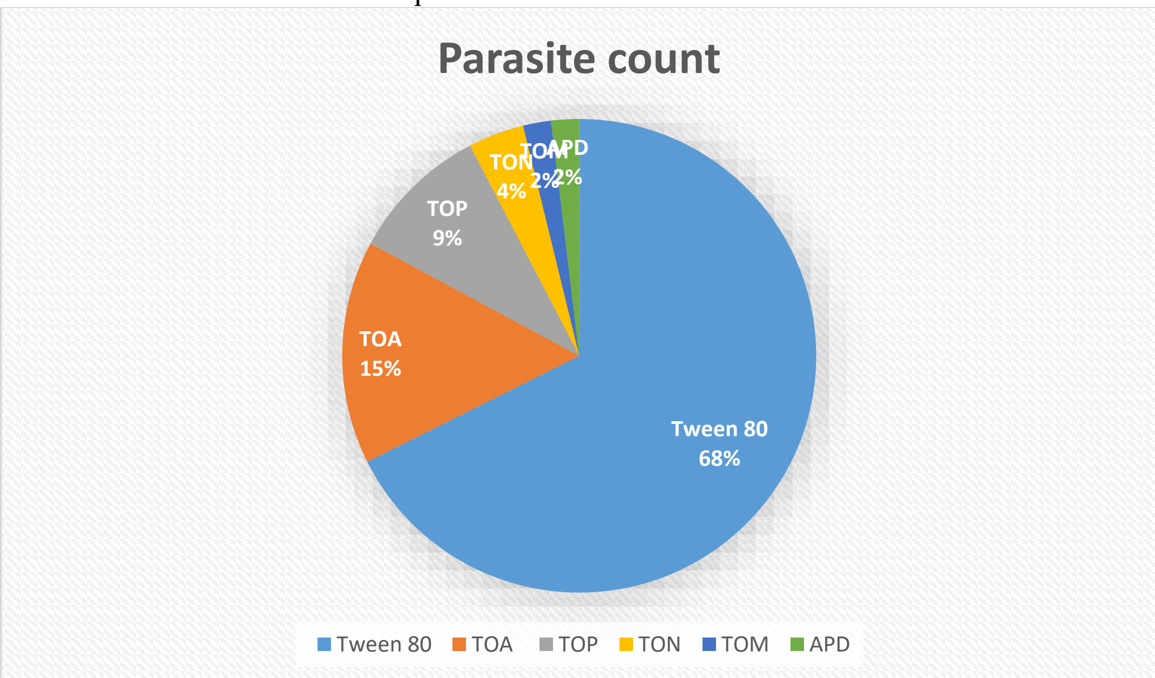

Figure 4. Showing Parasite Count against Different Plant Extracts (parasitemia in vitro)

In-Vitro Results of Parasitemia of Different Extracts of Ugu Leaf (Telfeiria occidentalis).

The least effective treatment against Trypanosoma brucei brucei was found in tween 80 with 68% visible parasite count, the least effective extract was seen in Telfeiria occidentalis aqueous extract with (TOA) 15% visible parasite count (VPC) followed by Telfeiria occidentalis petroleum ether extract (TOP) with 9% visible parasite count (VPC). The most potent extract on Trypanosoma brucei brucei were the methanol and n-hexane extracts with 2% visible parasite count (VPC) and 4% visible parasite count respectively, the anti trypanosoma drug (Abendazole) recorded 2% visible parasite count (VPC).

Fig 1: shows the parasite count against plant extracts (in-vitro parasitemia). The results showed two most important extracts of Telfeiria occidentalis of methanol (TOM) and N-hexane (TON) extract that have significant anti-trypanosomal activity as they significantly reduced parasitemia and improved survival rate that shows their efficacy among others. The anti trypanosomal drug, Abendazole had strong anti trypanosomal activity. Tween 80 had no anti tyrpanosomal activity as it did not show any significant effect on parasitemia or survival rate, aqueous extract weakly reduced parasitemia and did not improve survival rate, petroleum ether extract moderately reduced parasitemia and improved survival rate, hence the least potent extract was seen in aqueous extract (TOA).

Discussion

The need to find novel molecules to treat trypanosomiasis cannot be overstated because the few approved anti-trypanosomal medications have a number of negative side effects, including toxicity and parasite resistance. Because plants are traditionally utilized in North Central Nigeria to treat African trypanosomiasis (Atawodi et al., 2002), they present exciting opportunities for the development of new, affordable, safe anti-trypanosomal medications.

Telfairia occidentalis was subjected to a phytochemical screening in the current study, which showed the presence of several bioactive substances, including tannins, alkaloids, and flavonoids. This is consistent with studies of(Kumar et 2020) that found T. occidentalis methanol extracts included alkaloids, flavonoids, tannins, and saponins. Prior research has demonstrated that flavonoids are potent anti-trypanosomal agents against many species of trypanosomes (Hoet et al., 2004). Medicinal plants can exert their therapeutic effects and act as building blocks for the manufacture of beneficial medications because of the phytochemicals they contain (Abolaji et al., 2007). The T. occidentalis methanol extracts lacked terpenoids and steroids.

Prior to the purchase of experimental animals and test organism, plant extract dosage pattern for Telfeiria occidentalis methanol, petroleum ether, n-hexane, aqueous and conventional drug dosage to be administered prepared in the laboratory by dissolving 0.1, 0.01 and 0.001 of each plant extract and conventional drug in a sterile EDTA bottle containing 5ml, 10ml and 15ml of Tween 80 respectively, and stored in the refrigerator to prevent further attack by microorganisms.

On arrival of experimental animal (mice), the mice were divided into groups according to the experimental design for this research and the body weight of each mouse was taken alongside the hematological parameters such as packed cell volume and hemoglobin levels. The mice were left to acclimatize to the environment for the period of 3 days after which they were infected with the test organism Trypanosoma brucei brucei, 3 days' post infection, treatment commenced, body weight of mice and hematological parameters was taken again.

In this study, the In-Vitro anti-trypanosomal effect of different extracts of Telfeiria occidentalis such as Telfeiria occidentalis of methanol (TOM), of petroleum ether (TOP), of n-hexane (TON), of aqueous (TOA), Tween 80 and conventional drug (Albendazole) were compared and evaluated on hemoglobin (HB), PCV (Packed cell volume), weight and body temperature of Trypanosoma brucei brucei induced mice. The In-vitro Trypanosoma brucei brucei count in this study was observed to decrease in concentration depending on the dosage pattern (0.1mg/ml, 0.01mg/ml, 0.001mg/ml) of TOM, TOP, TON, TOA, TWEEN 80 and anti-parasitic drug (Abendazole) respectively as stated thus; The least effective treatment against Trypanosoma brucei brucei was found in tween 80 with 68% visible parasite count, the least effective extract was seen in Telfeiria occidentalis aqueous extract with (TOA) 15% visible parasite count (VPC) followed by Telfeiria occidentalis petroleum ether extract (TOP) with 9% visible parasite count (VPC). The most potent extract on Trypanosoma brucei brucei were the methanol and n-hexane extracts with 2% visible parasite count (VPC) and 4% visible parasite count respectively, the anti trypanosoma drug (Abendazole) recorded 2% visible parasite count (VPC).

TOM was found to be more effective and consistent in this experiment during the studies among others. TOM could therefore be another potential anti-trypanosomal drug abundant with little or no side effect on mice. This agrees with the work of (kato et al 2012) who earlier recoreded success rate in the efficacy of plant extracts in suppression in in-vivo and in-vitro anti parasitic activities and (Abdullahi et al 2020) who recoreded success in the potency of various methanol plant extracts in in vitro anti trypanosomal activities, a journal of parasitology. TON which is the second most potentb extract showed potential anti trypanosomal activity, likely due to the presence of bioactive compounds such as alkaloids and flavonoids and this is in agreement with the work of (Kumar et al 2021) who recorded that these bioactive compounds have anti trypanosomal potential. TOA tend to perform less against Trypanosoma brucei brucei which may be due to the presence of polar compound that are less effective against the infection (Wang et al 2017) but cannot be totally discarded because it could be potent against other species of Trypanosoma. TOP showed moderate activity, which may be due to the presence of lipophilic compounds (Lee et al 2018). TOM, TON and APD can also be used as promising futuristic anti trypanosomal drug with further studies. However, further purification and characterization of the bioactive compounds are needed to fully understand their potential (Zhang et al 2020). Additionally, in vivo studies are required to evaluate the efficacy and safety of these extracts in treating Trypanosoma brucei brucei infection in mice (Ezeala, et al 2019).

Conclusion

The study investigated the anti trypanosomal effects of different extracts of Telfeiria occidentalis on Trypanosoma brucei brucei induced mice, conducted at the Advanced Microbiology Laboratory of Federal University Lokoja from June 2024 to July 2024. The in-vitro evaluations demonstrated that the methanol and n-hexane extracts of Telfeiria occidentalis showed significant anti trypanosomal activity amongst others with the methanol extract being the most potent, anti-parasitic drug Abendazole also showed strong anti-trypanosomal activity. Specifically, TOM exhibited a concentration-dependent reduction in trypanosome count and effectively normalized hemoglobin (HB) levels, packed cell volume (PCV), weight, and body temperature in infected mice, indicating its potent anti trypanosomal properties.

Recommendations

1. Further research on the methanol and n-hexane extracts to identify and isolate the particular bioactive compounds responsible for their anti-trypanosomal activity.
2. In-vivo studies to evaluate the efficacy and safety of these extracts in treating Trypanosoma brucei brucei infections.
3. Investigation of the mechanism of action of these extracts and compounds to understand how they exert their anti-trypanosomal effects.
4. Evaluation of the potential of these extracts and compounds to treat other parasitic diseases such as malaria, leishmaniasis and other species of Trypanosoma.
5. Comprehensive toxicity studies should be should be conducted to ensure the safety of Telfeiria occidentalis. Long term toxicity evaluation will help in understanding any potential adverse effects and in establishing safe usage guidelines for humans.

REFERENCES

Abolaji, O. A., Adebayo, A. H., & Odesanmi, O. S. (2007). Nutritional qualities of three medicinal plant parts (Xylopia aethiopica, Blighia sapida and Parinari polyandra) commonly used by pregnant women in the western part of Nigeria. Pakistan Journal of Nutrition, 6(6), 665-668.

Abdullahi, A. L., Balogun, E. O., Yusuf, A. B., Adepoju, O. A., Ibrahim, B., Gouegni, F., ... & Nok, A. J. (2020). Blood of African hedgehog Atelerix albiventris contains 115-kDa trypanolytic protein that kills Trypanosoma congolense. Acta Parasitologica, 65, 733-742.

Atawodi, S. E., Ameh, D. A., Ibrahim, S., Andrew, J. N., Nzelibe, H. C., Onyike, E. O., ... & Sallau, A. B. (2002). Indigenous knowledge system for treatment of trypanosomiasis in Kaduna state of Nigeria. Journal of Ethnopharmacology, 79(2), 279-282.

Boulangé, Alain, Veerle Lejon, David Berthier, Sophie Thévenon, Geoffrey Gimonneau, Marc Desquesnes, Samuel Abah et al. "The COMBAT project: controlling and progressively minimizing the burden of vector-borne animal trypanosomosis in Africa." Open Research Europe 2 (2022).

Benoit Stijlemans, Boyoon Choi, Andres Álvarez-Rodríguez, Bo-
kyung Jin, Magdalena Radwanska, Stefan Mage(2024)**The Diagnosis and Treatment of Protozoan Diseases**. Pages 95-148

Borges, R. C., Hohmann, M. S., & Borghi, S. M. (2021). Dendritic cells in COVID-19 immunopathogenesis: insights for a possible role in determining disease outcome. International Reviews of Immunology, 40(1-2), 108-125.

Chowdhury, P., Paul, S. K., Kaisar, S., & Moktadir, M. A. (2021). COVID-19 pandemic related supply chain studies: A systematic review. Transportation Research Part E: Logistics and Transportation Review, 148, 102271.

, C., Garcia-Estebanez, C., Ndong-Mabale, N., Abaga, S., Ndongo-Asumu, P., Benito, A., & Cano, J. (2010). Screening of Trypanosoma brucei gambiense in domestic livestock and tsetse flies from an insular endemic focus (Luba, Equatorial Guinea). PLoS neglected tropical diseases, 4(6), e704.

Ebong, C., Sserwanga, A., Namuganga, J.F., Kapisi, J., Mpimbaza, A., Gonahasa, S., Asua, V., Gudoi, S., Kigozi, R., Tibenderana, J. and Bwanika, J.B., 2021. Efficacy and safety of artemether-lumefantrine and dihydroartemisinin-piperaquine for the treatment of uncomplicated Plasmodium falciparum malaria and prevalence of molecular markers associated with artemisinin and partner drug resistance in Uganda. Malaria Journal, 20(1), p.484.

Ezeala, I. C., Uzor, P. F., Obiora, C. U., Enendu, C. M., Anyadiegwu, C. I., & Nwodo, N. J. (2023). Antimicrobial and antitrypanosomal activities of methanol root extract and fractions of Brenania brieyi (De Wild) Petit (Rubiaceae). African Journal of Pharmaceutical Research and Development, 15(3), 43-52.

Garro d G, Adams ER, Lingley JK, Saldanha I, Torr SJ, Cunningham LJ. (2020). A pilot study demonstrating the identification of Trypanosoma brucei gambiense and T. b. rhodesiense in vectors using a multiplexed high-resolution melt qPCR. PLoS Negl Trop Dis. **14**:e0008308.

Hoet, P. H., Brüske-Hohlfeld, I., & Salata, O. V. (2004). Nanoparticles–known and unknown health risks. Journal of nanobiotechnology, 2, 1-15.

Kumar, M., Joshi, M., Patel, A. K., & Joshi, C. G. (2021). Unravelling the early warning capability of wastewater surveillance for COVID-19: a temporal study on SARS-CoV-2 RNA detection and need for the escalation. Environmental research, 196, 110946.

Lee SJ, Apio RJ, Palmer JJ. (2020). Centering patient expectations of a novel home-based oral drug treatment among t. b. rhodesiense human african trypanosomiasis patients in

Uganda. Trop Med Infect Dis. **5**:16.

Lejon V, Büscher P, NzoumCordon-Obrasbou-Boko R, Bossard G, Jamonneau V, Bucheton B. (2019). The separation of trypanosomes from blood by anion exchange chromatography: from Sheila Lanham's discovery 50 years ago to a gold standard for sleeping sickness diagnosis. PLoS Negl Trop Dis. **13**:e0007051.

Moon S, Janssens I, Kim KH, Stijlemans B, Magez S, Radwanska M. (2022). Detrimental effect of Trypanosoma brucei brucei infection on memory B cells and host ability to recall protective B-cell responses. J Infect Dis. **226**:528–40.

Silva, J. D., Lepore, G., Battelino, T., Arrieta, A., Castañeda, J., Grossman, B., ... & Cohen, O. (2022). Real-world performance of the MiniMed™ 780G system: first report of outcomes from 4120 users. Diabetes Technology & Therapeutics, 24(2), 113-119.

WHO (2024) Guidelines for the treatment of human African trypanosomiasis. Web Annex C. Summary of declared interestsWorld Health Organization, June 28, 2024https://iris.who.int/handle/10665/378081Date accessed: July 2, 2024

Zou Y, Mason MG, Botella JR. (2020). Evaluation and improvement of isothermal amplification methods for point-of-need plant disease diagnostics. PLoS One. **15**:e0235216.

Zhang, J., Lu, H., Zeng, H., Zhang, S., Du, Q., Jiang, T., & Du, B. (2020). The differential psychological distress of populations affected by the COVID-19 pandemic. Brain, behavior, and immunity, 87, 49.

AGRICULTURAL COMPANIES THAT APPLY REAL MARKETING IN THEIR BUSINESS BASED ON FINANCIAL MANAGEMENT BASED ON INFORMATION ON FINANCIAL STATEMENTS

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ABSTRACT:
The development and strengthening of marketing in agriculture can also be observed through the influence of real financial management, which is based on the receipt of real financial reports. In this way, it can contribute to the making of valid management decisions by top management of agricultural enterprises, which, in addition to financial management, also pay attention to marketing.

Thus, agricultural production can be observed through the development of marketing, but also financial management, which is of great importance for a transitional country such as the Republic of Serbia.

Essentially, an increase in real marketing in agricultural production can mean an incentive for the development of already established entrepreneurial initiatives in agriculture.
In addition, the education of agricultural producers and improved management contribute to the growth of agricultural production, greater agricultural production, and the security of food satisfaction for a wide range of people both in wartime and in peacetime.
Keywords: management, accounting, analysis, risk factors, entrepreneurship in agriculture.

INTRODUCTION
The process of introducing and implementing realistic financial reporting should be a continuous process that is important in the functioning of agriculture, while at the same time having a strong influence of marketing in agriculture [1-5].
The goal of marketing in agriculture and its application is to improve managerial decision-making by top management in the processes of managing agricultural enterprises, which is possible with quality financial reporting, that is, with realistic financial management that depends on the work of accounting in the operations of agricultural enterprises [6-9].
In this way, the overall business results visible in financial reports can be improved in the short term and should result in the improvement of overall operations in numerous agricultural enterprises [10-15].
Marketing and realistic financial management enable the improvement of business security of the entire management in the work of agricultural enterprises, which is of great importance in the business of agriculture, processing of primary agricultural production and processing into food for the population and animal nutrition in a country [16-20].

MODELS THAT ILLUSTRATE THE CONNECTION OF MARKETING AND FINANCIAL MANAGEMENT IN TRANSITION COUNTRIES

Models depicting the relationship between marketing and financial management in transition countries are shown in Figures 1-3.

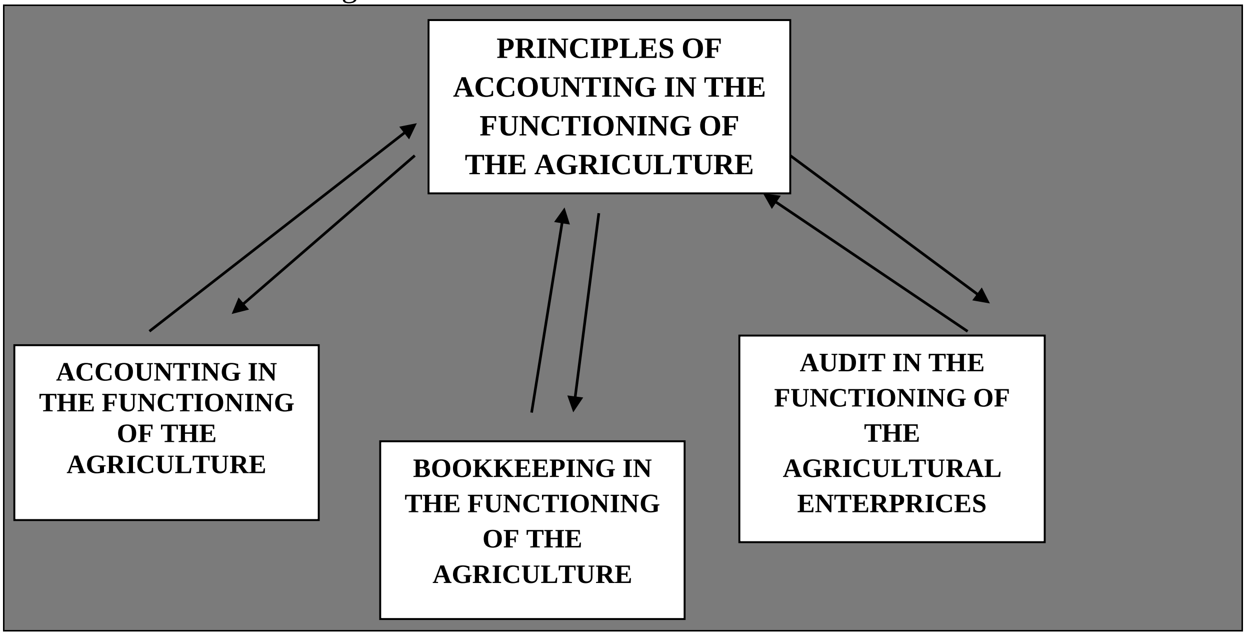

Figure 1: Presentation of the accounting position in the agriculture.

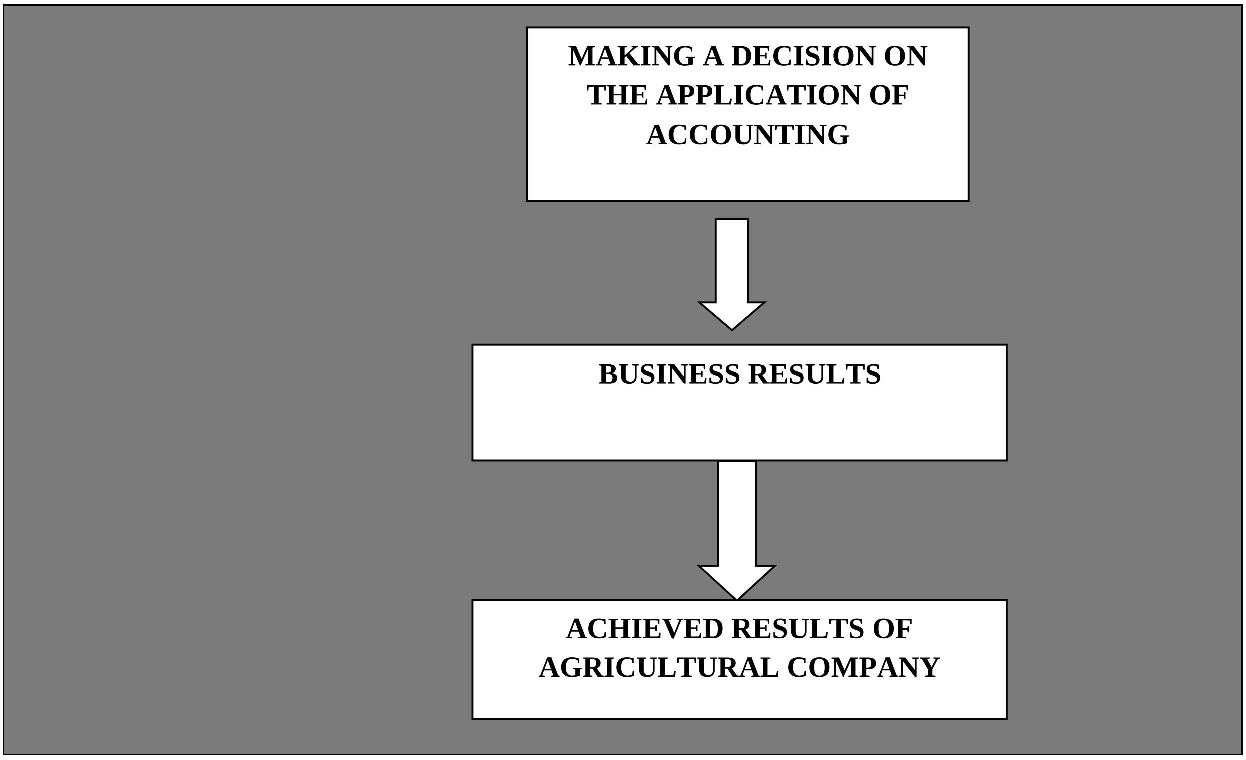

Figure 2: Presentation of accounting decision-making in the agriculture.

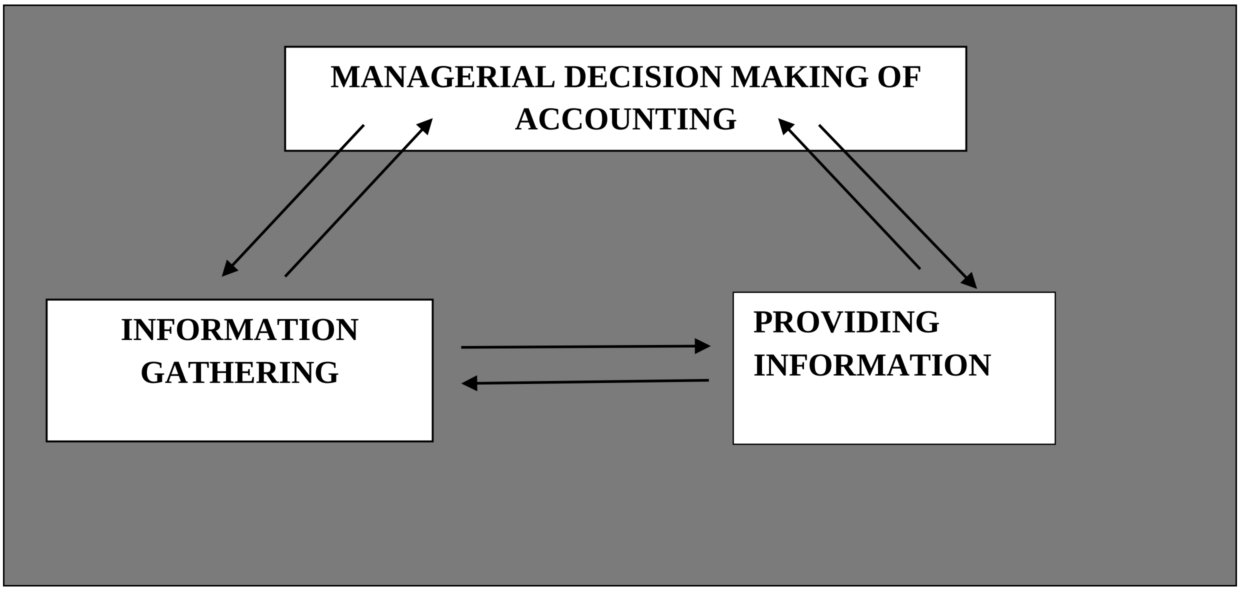

Figure 3: Presentation of marketing in business operations in agriculture.

CONCLUSION

Development and strengthening of agricultural business can be observed with the application of real financial reporting as well as with the application of marketing of agricultural enterprises. This is the basis and presentation of the main conclusions of this study. Real decision-making in the functioning of agricultural work can be observed both through the influence of marketing and financial reports that top managers receive as part of regular reporting. In this way, it can contribute to the opening of new pores in agricultural production for both farmers and small processors in transition countries who strive to increase their production through the application of marketing. A significant increase in the promotion of agricultural production can mean an increase in total agricultural production.

References

[1] Bjelica, B., Bakmaz, O. & Vukasović, D. (2023). The importance of monitoring the realization of income and costs in the management and business of agricultural enterprises in relation to the introduced forms of internal-control mechanisms, Poljoprivredna tehnika, No. 2, 2023., 45 – 51, DOI: 10.5937/PoljTeh2302045B.

[2] Bakmaz, O., Milošević, M. & Marković, N. (2020). Poslovna Ekonomija, Business Economics, Regionalno planiranje-pojam, teorije i modeli, 2: 75-86, doi: 10.5937/poseko18-30482.

[3] Vitomir, J., Laban, B., Bakmaz, O., Nikolić, N., Čolović, M. (2019). Audit as a possible way to improve corporate governance with an overview of possible models of determining the risk interval and some of the basic impact factors identified by top management. Annals of the „Constantin Brâncuşi" University of Târgu Jiu, Economy Series, Issue 2/2019, ISSN 2344 – 3685/ISSN-L 1844 – 7007.

[4] Bakmaz, O., Bjelica, B., Ivić, Lj., Volf, D. & Majstorović, A. (2017). The significance of the audit profession in the financial analysis of agricultural enterprises of the Republic of Serbia. Annals of the „Constantin Brâncuşi" University of Târgu Jiu, Economy Series, pp. 117-123, ISSN 2344 – 3685/ISSN-L1844–7007.

[5] Radović, M., Vitomir, J., Laban, B., Jovin, S., Nastić, S., Popović, V. & Popović S. (2019). Management of joint stock companies and farms by using fair value of agricultural equipment in financial statements on the example of IMT 533 Tractor, Economics of Agriculture, 1: 35-50.[6] Popović, S. (2014). Socio-ekonomski faktori ograničenja razvoja

agrara, monografija, Fimek, Novi Sad.
[7] Popović, S., Novaković, S., Đuranović, D., Mijić, R., Grublješić, Ž, Aničić, J. & Majstorović, A. (2017). Application of international accounting standard-16 in a public company with predominantly agricultural activities, Economic Research-Ekonomska Istraživanja, 30(1):1850–1864.
[8] Popović, S., Tošković, J., Majstorović, A., Brkanlić, S. & Katić, A. (2015). The importance of continuous audit of financial statements of the company of countries joining the EU, Annals of the „Constantin Brâncuşi" University of Târgu Jiu, Economy Series, Special Issue, 241-246.
[9] Radović, M., Vitomir, J. & Popović, S. (2021). Impact of internal control in enterprises founded by local self-government units: the case of Republic of Serbia, Inzinerine Ekonomika-Engineering Economics, 32(1): 82–90.
[10] Bjelica, B., Bakmaz, O., Mijić, R., Popović, S. & Popović, V. (2017). The implementation of heterogeneous risk to the company's operations and transition countries respecting the behavior of agricultural enterprises in the republic of Serbia. Annals of the „Constantin Brâncuşi" University of Târgu Jiu, Economy Series, 3/2017, 207-213, ISSN 2344 – 3685/ISSN-L 1844 –7007.
[11] Arnautović, I., Davidov, T., Nastić, S. & Popović, S. (2022). Značaj donošenja racionalne poslovne odluke top menadžmenta u poljoprivrednim preduzećima u Republici Srbiji, Poljoprivredna tehnika, 1-8.
[12] Majstorović, A. & Popović, S. (2015). Revizija poslovanja poljoprivrednog preduzeća, Računovodstvo, 1: 77-85.
[13] Tamas-Miškin, S., Vitomir, J., Dragosavac, M., Medan, N., Radaković, M., Vitomir, G., Davidov, T. & Popović, S. (2022). The significance of archiving documentation and assessment quality of archiving financial documentation given by top managers, Economics of Agriculture, Year 69, No. 4, 2022, (pp. 949-1252),
[14] Popović, S., Vitomir, J., Tomaš-Miskin, S., Davidov, T., Nastić., S., Popović, V., Popović, D., Vitomir, G. (2021). The importance of a realistically determined amount of tax on property rights relating to the ownership of agricultural land in the Republic of Serbia adopted by tax authorities of local selfgovernment units, Ekonomika poljoprivrede, Economics of agriculture, Vol.LXVIII, 4: 1029-1042.
[15] Popović, D., Vitomir, J., Tomaš-Miskin, S., Davidov, T., Popović, S., Jovanović, M., Aćimić-Remiković, M., Jovanović, S. (2021). Implementation of internal control with reference to the application of it in companies operating on the principles of the green economy. Agriculture & Forestry, Vol. 67 Issue 2: 261-269.
[16] Majstorović, A., Popović, S., Volf, D. (2015). Theory and politics of balance, second amended and supplemented edition, Novi Sad: Feljton.
[17] Popović, S. (2015). Implementacija heterogenih rizika u radu interne revizije, Revizor 69: 7-19.
[18] Bakmaz, O., Bjelica, B. & Vitomir, J. (2023). Application of internal audit in processes of reducing corruption in a transitional economy like the Republic of Serbia, Temel-IJ, 7:1, 36 - 42 https://doi.org/10.52576/TEMEL237.1036b
[19] Bakmaz, O., Bjelica, B. & Vitomir, J. (2023). Application of software solutions in companies that strive to achieve increased financial stability in their regular business, Temel-IJ, 7:1, 13 - 20 https://doi.org/10.52576/TEMEL237.1013b
[20] Bjelica, B., Bakmaz, O, & J. Vitomir, J. (2023). The importance of accounting policy in the context of strengthening financial stability in a company that previously implemented internal audit as a mechanism of regular business decision-making, Temel-IJ, 7:1, 57 - 63 https://doi.org/10.52576/TEMEL237.1013b

AN EVALUATION OF THE DEVELOPMENT OF THE AGRICULTURAL INDUSTRY AND ITS IMPACT ON THE AGRICULTURAL SECTOR

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ABSTRACT
The agricultural industry, particularly export-oriented industries, serves as a crucial lever for the sustainable development of the agricultural sector. Farmers' reliance on fresh consumption markets (such as wholesale markets, local bazaars, and chain stores etc.) is often insufficiently rewarding and contributes only marginally to agricultural advancement.
Establishing agricultural industries in regions where fresh agricultural products are grown or in nearby areas is essential. The objective is to procure fresh agricultural products, which serve as raw materials, at optimal cost and in ideal conditions from regions where they are naturally best suited to grow. Once processed in these facilities, the value of these products increases, their volume generally decreases, making them more suitable for transport to subsequent industrial sectors that use them as raw materials.
Additionally, locating agricultural industries in rural areas fosters social interaction, creates new employment opportunities, and facilitates the emergence of ancillary industries, such as agricultural machinery manufacturing. This, in turn, helps mitigate rural-to-urban migration and the associated challenges.
Moreover, investments in agricultural industries generally offer a shorter payback period compared to other industrial sectors. The capital required to provide employment for one person in the agricultural industry is also significantly lower than in other industries.
Our nearly two decades of experience encompasses various agricultural industry activities, including the processing of vegetable products produced primarily through family farming, such as canning, freezing, drying, and paste production. Drawing on this experience, this paper examines key aspects of agricultural industrial development and presents recommendations for fostering growth in the agricultural sector.
Key Words: Agricultural Industry; Rural Development; Value-added Agricultural Products; Sustainable Agricultural Development; Agricultural Economy

GİRİŞ
Tarımın gelişmesi tarımsal sanayi, özellikle ihracata yönelik tarımsal sanayi ile mümkün olabilir. Çünkü sadece çarşı-pazar, marketler gibi doğrudan tüketiciye yönelik alanlara satacağı ürün, çiftçi için tatmin edici olamamaktadır.
Tarımsal sanayi olarak, doğrudan çiftçinin ürettiği ürünü hammadde olarak temin etmek durumunda olan sanayi dallarından bahsediyoruz. Konserve, salça, Derin dondurma (IQF şoklama), sınai kurutma (dehydrating), faz atlamalı kurutma (freezedrying), konsantre etme, aroma çıkarma, şeker üretimi, un elde etme vs. gibi alanlarda faaliyet gösteren işletmeler tarımsal sanayiye örnek olarak gösterilebilir.

Bu tür işletmelerin hammadde olarak kullanacakları zirai ürünlerin yetiştirildiği yörelerde kurulmaları şarttır. Çünkü tarladan çıkan ürünler çok kısa bir süre sonra bozulmaktadır. Ancak tarımsal sanayi kuruluşlarında işlenen ürünler, uzun süreli depolamaya ve nakliyeye uygun hale gelmektedirler. Tarımsal sanayi işletmelerinin mamul ürünleri, kısmen tüketiciye yönelik olsa da genelde hazır çorba, içecek, hazır gıdalar, bebek maması, soslar vs. gibi nihai sanayi ve pazarlama sektörleri için hammadde niteliğindedir. Bu tür nihai işletmelerin zirai ürünün yetiştiği yerlerde olma zorunluluğu yoktur, ama tarımsal sanayi işletmelerinin yakınında olmaları veya tarımsal sanayi işletmesinin bir yerde entegre tesis olarak bu alanda da faaliyet göstermesinin, nakliye,"just in time" üretim, personeli verimli kullanma, yörede ilave istihdam imkânı gibi ilave pek çok kazanıma yol açacağı açıktır.
Tarladan çıkan ürünü tüketiciye sunmak üzere yapılan depolama, seçme, kalite sınıflarına ayırma, taşıma vs. gibi faaliyetleri ise tarımsal sanayiden saymıyoruz.
Bildirimizdeki düşünce ve önerilerimizin dayanağı, akademik yayınlardan çok, kırsal bölgede kurulu bir tarımsal sanayi firmasında geçen 20yıllık sürede edinilen izlenim ve tecrübeler ile bu firmaya ait birtakım tablolar ve hesaplamalardır. Bunlar geçmişteki iştigalimiz dolayısıyla daha çok nispeten küçük alanlarda, aile tarımı şeklinde üretilen, yüksek birim fiyata haiz sebze türü tarla ürünleri bağlamında olsa da diğer tür zirai ürünler ve bunları işleyen tarımsal sanayi kolları için de büyük ölçüde geçerlidir.

ARAŞTIRMA VE BULGULAR
TARIMSAL SANAYİNİN AVANTAJLARI
Zirai Ürünün Değerlendirilmesi
Doğrudan tüketiciye yönelik zirai ürünlerin fiyatı, çiftçi açısından kimi zaman yüksek de olsa gerek miktarları gerek nitelik sınıfları gerek türleri bir yerde sınırlıdır. Oysa tarımsal sanayi, zirai ürünlere hammadde olarak yüksek miktarlarda ihtiyaç duymakta ve çiftçinin üretimine ilave talep yaratmaktadır. Kanıt olarak geçmişte bünyesinde bulunduğumuz firmayı örnek olarak göstermek yeterli olacaktır: 4-5 milyon dolar kadar cirosu olan, 5 bin nüfuslu bir kasabada kurulu orta boy Kobi niteliğindeki firma, bir sezonda 25 bin tona kadar sebzeyi hammadde olarak işlerdi. Bunun 12 bin tonu (12 milyon kg) kapya türü kırmızı biberdi. Bir insan 2-3 aylık kapya mevsiminde yarım çuval, yani 10-15 kg taze biber yese, bu 1 milyon insanın tüketeceği taze biberin tek başına bir fabrika tarafından tüketilmesi demektir. Bu sayı yakınlardaki iller Çanakkale ve Balıkesir'in toplam nüfusundan daha fazladır. Yani orta boy tek bir tarımsal sanayi kuruluşu, yakındaki şehirlerin taze tüketim ihtiyacı kadar çiftçinin malına ilave talep yaratmaktadır.
Ayrıca tarımsal sanayide tüketicininbeğenmeyeceği nitelik ve türdeki zirai ürünler de değerlendirilebilmektedir. Bir örnek olarak mutfaklarda tüketilen soğan ile sınai kurutmaya uygun soğan farklı türlerde olup,sonuncusunu tüketici tat, aroma, boyut gibi nedenlerle mutfağında tercih etmeyecektir. Veya mutfak tüketimi için düşük kalite olarak kabul edilen ezik, lekeli, güneşte yanmış vs. domates, rahatlıkla salça üretiminde kullanılabilir.
2.1.2.Atıkların Değerlenebilir Nitelikte Olması
Tarımsal sanayinin atıkları çok büyük oranda çekirdek, sap, ıskarta ürün vs. şeklinde olup doğa kaynaklıdır. Dolayısıyla birtakım şartlara uyulduğu sürece çevreye zarar vermezler. Dikkat edilmesi gereken en önemli husus bunların diğer atıklarla temas etmeyecek şekilde elleçlenmeleridir. Bunlar hayvan yemi olarak kullanılabildiklerinden hayvancılar tarafından talep edilmektedir ve firmaya az da olsa ek gelir sağlamaktadırlar. Ve bu gelir, atıkların çevreye zarar vermeden bertarafı için yapılan masrafları fazlasıyla karşılamaktadır.
2.1.3.Çiftçinin Ürününü Doğrudan Alıcı İşletmeye Satması
Tüketiciye yönelik tarımsal ürünler tüketiciye ulaşana kadar çeşitli kademelerde aracıdan geçmektedir. Belli bir sayıda aracı kaçınılmazdır. Çünkü çiftçinin günlük olarak topladığı

ürünü kendi başına uygun şartlarda depolaması, kamyona yükleyip şehirlere ulaştırması, tüketiciye birebir satması, sonra tekrar tarlasına dönüp hasada devam etmesi mümkün değildir. Ama ülkemizde aracı sayısının aşırılığı sıklıkla gözlenmektedir. Bu, çiftçi aleyhine suistimallere zemin hazırlayabilmektedir. Oysa çiftçi, tarlasına yakın tarımsal sanayi işletmelerine malını günlük olarak traktörüyle römork bazında getirebilmekte, nispeten uzak bölgelerde ise sanayi kuruluşları alım merkezleri oluşturarak çiftçinin malını toplayıp işletmeye kamyonlarla sevk etmektedir. Yani arada aracı yoktur, çiftçi doğrudan alıcı işletmeyle muhataptır, alıcının yeri yurdu bellidir. Çiftçi, uzak bölgelerden gelip, çiftçiden malı yüksek fiyata, vadeli aldıktan sonra ortadan kaybolan veya ürünü baştan almayıp çürümesine yakın ölü fiyatına almaya çalışan birtakım kötü niyetli tüccarlara mahkûm değildir.

2.1.4.Yatırımların Daha Kısa Sürede Amortizasyonu

Diğer sanayi dallarıyla karşılaştırıldığında Tarımsal sanayi yatırımlarının amortizasyonu genelde daha kısa zamanda gerçekleşmektedir. Tecrübelerimizin yanısıra bu [6, 7] de de görülmektedir. Üstelik ana kurulum yatırımından sonra zaman içinde yapılan, iyileştirme, revizyon, kısmi kapasite artırımı gibi yatırımların ise bir sezon sonrası yani bir yıl içinde bile kendilerini amorti ettikleri sıklıkla gözlenmiştir. [4, 5]

2.1.5.İstihdam Sağlamanın Maliyetinin Daha Düşük Gerçekleşmesi

Bir kişiye (sürekli) istihdam sağlamanın yatırım maliyeti, tarımsal sanayide diğer sanayi kollarına göre daha düşüktür. Tecrübelerimizle oluşan bu kanaatimiz, kaynakçadaki örneklerle de desteklenmektedir [5, 6, 7]. Gerekli teknoloji birikimi ve bunu uygulayabilecek firmalar yurtiçinde mevcuttur.

2.1.6.Üretim Girdilerinin Ağırlıklı Olarak Yurtiçi Kaynaklı Olması

Tarımsal sanayide mamul ürün girdileri diğer sanayi kollarının aksine çok büyük oranda ithal değil yerli girdilerdir. En önemli girdi hammadde, yani tarladan gelen zirai üründür ki kimi zaman toplam mamul maliyetinin %50- %60'ına kadar çıkabilmektedir [2]. Sadece bu oranlar dahi tarımsal sanayinin, tarımın gelişimine katkısını yansıtmaktadır.

2.1.7. Köylünün Köyünde Kalması

Günümüzde insanların köylerden kentlere göç etmesi nedeniyle köy nüfusunun azalması, hatta köylerin kapanması beraberinde büyük sorunlar doğurmaktadır. Oysa köylü genelde mecbur kalmadıkça köyünü terk etmek istememektedir. Üstelik büyük şehirlerde üniversite bitirmiş gençler dahi, köylerinin yakınlarında meslekleriyle ilgili iş imkanına sahip olduklarında, büyük şehirler yerine köylerinde ve bunun getirdiği rahat ortamda ikamet etmeyi tercih etmektedirler. Bunun bir nedeni de böyle firmalarda yükselmelerinin çok daha kolay olmasıdır. Tabii ki istedikleri anda büyük şehirlere kolay ulaşım imkanına sahip olduklarında yani bir araba sahibi olacak gelire sahip olduklarında. Tecrübelerle sabittir ki, bir tarlası ve bir evi olan bir köylü, ürününü değerlendirebiliyorsa genelde tatmin edici bir refah seviyesine ulaşabilmekte, büyük şehirlere göç ederek köyünün imkanlarını yitirmeyi düşünmemektedir. Bu ancak tarımın ağırlıklı olduğu kırsal bölgelerde kurulu tarımsal sanayiinin sağlayabileceği sosyolojik bir avantajdır. Sadece pazara, taze tüketime yönelik zirai üretimle bunun sağlanması mümkün görünmemektedir.

2.1.8. Sosyalleşme

Tarımsal sanayi kuruluşları, kırsal bölgelerde kuruldukları için büyüklükleri nispetinde sosyalleşmeye vesile olmaktadırlar. "Beyaz yakalı", "mavi yakalı", yönetici konumundaki çalışanlar ve hatta işverenler dahi, yakın çevrenin insanları olup aralarında çok kez akrabalık ilişkileri olduğundan, birbirlerine karşı tavır ve davranışları daha olumlu gelişmektedir. Bu sadece işletme bünyesinde kalmayıp, çalışanlarla, çiftçiler, esnaflar, devlet memurları gibi yöre toplumunun değişik öğeleri arasındaki iletişimi yoğunlaştırarak, sosyal ve kültürel kalkınmaya da katkı sağlamaktadır. Bu tür kuruluşlar, çalışanlar ve yöre insanları tarafından kolaylıkla "memleket varlığı" olarak benimsenmektedirler. Eğer işveren ve yöneticiler tavır ve davranışlarıyla bunu teşvik ederlerse sosyal ortam olumlu yönde şekillenmektedir.

2.2. TARIMSAL SANAYİNİN KENDİNE ÖZGÜ ŞARTLARI

2.2.1.İhracat

Ülkemiz tarımsal sanayi ürünlerinin en büyük alıcılarından Avrupa Birliği'ne çok yakındır ve bu büyük bir ihracat potansiyeli oluşturmaktadır. Diğer yandan tarımsal sanayi ihracatla büyür, ihracatla ayakta durabilir. Sırf yerli pazara mal üretmek, miktar açısından kimi mamuller için yeterli sayılmaz. Ayrıca iç pazardaki aşırı uzun vadeler ve tahsilat problemleri, neticede dış pazarları, tutunulabildiği takdirde daha cazip kılmaktadır.

2.2.2. Rekabet

Tarımsal sanayi ürünleri dış pazarlara açıldığında, kaçınılmaz olarak diğer ülkelerin üreticileriyle rekabet ortamına girilmektedir. Ancak bu rekabet ortamı çoğu kez "haksız rekabet" niteliğinden uzaktır ve doğal kabul edilmelidir. Piyasanın şartları ve taleplerini sağlayan, piyasada "güvenilir" olarak bilinen her firma, dış pazarlarda malına her zaman müşteri bulabilir. Üstelik böyle bir rekabet ortamı hem sanayi kuruluşunun hem de çiftçilerin gelişimini ve istikrarlı bir ürün kalitesini tutturmalarını teşvik etmektedir.

Geçmişte yaşanılan, Çin Halk Cumhuriyeti'nin kurutulmuş sebzede uygulamış olduğu dumping politikası gibi yıkıcı rekabet şartları, istisnai durumlar olarak görülmelidir ve bununla mücadele firmaların boyunu aştığından, ancak devletin ilgili kurumlarının uluslararası kuruluşlar nezdindeki girişimleriyle yürütülebilir.

2.2.3. Kalite

Gerek ürün gerek imalat teknikleri ve şartları, özellikle firma kültürünün "kaliteli" olması, hele Türkiye gibi AB pazarına yakın bir ülkedeki firmalar için, söz konusu rekabet ortamında var olabilmek açısından sorun teşkil etmeyecektir. Burada "Kalite" den bahsettiğimizde süslü laflarla doldurulmuş ciltler dolusu elkitaplarını veya duvarlara sığmayan sertifikaları kastetmiyoruz. Anlaşılır şekilde kaleme alınmış, amaca, işe, firmanın şartlarına uygun; gerçekçi, uygulanabilir, çalışanların gerektiğinde inisiyatif kullanmalarına engel olmayan, imalat akışını zorlaştırmayıp bilakis kolaylaştıran kalite politika ile uygulamalarını kastediyoruz. Bu bağlamda zamanındaki mottomuzu zikretmek isterim: "Kalite, kalitecilere bırakılamayacak kadar ciddi bir iştir"

2.2.4. Mevsimlik Üretim

Tarımsal sanayi diğer sanayi dallarından farklı olarak bütün yıl boyunca değil yılın belli döneminde sezonluk olarak, yani hasat zamanında üretim yapar. Çünkü zirai ürünler yılın belli dönemlerinde yetişir, olgunlaşır, nefasetine erişir ve fiyatları düşer. Diğer sanayi dallarının aksine tarımsal sanayi işletmelerinin bütün yıl boyunca çalışması fizibl ve gerçekçi değildir. Ana hasat sezonu haricinde hammadde olarak temin edilecek zirai ürünlerin (örneğin sera üretimi, soğuk hava depolarında beklemiş vs.) fiyatları oldukça yüksek olup nitelikleri sanayi üretimi açısından istenilen seviyelerde değildir. Tarımsal sanayinin hammaddesi taze ürünün, albenisi değil, doku yapısı, aroması, besin değeri, su içeriği vs. gibi nitelikleri daha önemlidir. Zirai ürün bu niteliklere ana hasat döneminde ulaşır. Bu nedenle tarımsal sanayi işletmeleri, yaptıkları satış bağlantılarının gerektirdiği miktar mamul ürünü, birkaç ay içinde üretmek durumundadırlar. Dolayısıyla işletme kapasitesi buna göre seçilmelidir. Mamul ürün uygun şartlarda depolanarak bütün bir yıl boyunca gerekli ilave işlemlerden geçirilerek (örneğin kurutulmuş sebzede yabancı madde kontrolü vs.) sevkiyata hazır edilir ve müşterinin talebine göre sevk edilir. Bu, kaçınılmaz olarak üretim sezonunda çalışacak geçici mevsimlik işçileri gerekli kılmaktadır.

2.2.5. Sözleşmeli tarım

Tarımsal sanayi ürünleri piyasalarında hele ihraç pazarlarında karşılıklı güven çok önemlidir. Piyasalarda satış bağlantıları miktar ve fiyat yönünden hasat döneminden çok önce, hatta ekim-dikim döneminden dahi önce yapılmaktadır. Ve tarımsal sanayi kuruluşlarının bağlantılarının gereğini yerine getirmeleri beklenir. Aksi takdirde piyasada güvenilirlikleri kaybolur, müşterilerini kaybetme tehlikesi doğar. İşte bu noktada kuruluşun hammaddeyi önceden garantiye alması şarttır. Bunun da çaresi sözleşmeli tarımdır. Buna göre firma çiftçilerle miktar veya ekim alanı ve fiyat yönünden sözleşme yapar ve satışlarını buna göre gerçekleştirir. Bu çiftçi için de garantili satış anlamındadır. Uyanık çiftçi en azından maliyetlerini karşılayacak miktarda sözleşmeli ekim, bir miktar da taze ürün piyasasına yönelik serbest ekim yapar. Çünkü taze ürün piyasasında malın fiyatı günlük olarak değişmekte, kimi zaman üretim maliyetlerinin altında dahi kalmaktadır.

Pratikte her firma çiftçilerle değişik şartlarla sözleşme yapmaktadır. Çiftçi sözleşmeye uymadığı takdirde firma büyük mağduriyet yaşamaktadır. Şöyle ki; sıklıkla rastlandığı üzere, çeşitli gerekçelerle yeterli sözleşme yapmamış bir firma veya farklı bir piyasada (örneğin taze ürün piyasasında) daha yüksek fiyatla satış yapmış bir firma, hasat zamanı hammadde açığını kapatmak için sözleşme yapmış çiftçilere daha yüksek fiyat vererek, sözleşme tarafı firmanın malını kapmaya çalışmaktadır. Hernekadar sözleşmelerde buna karşı birtakım yaptırım hükümleri mevcut olsa da bunların gereğini yerine getirmek oldukça sancılı olmakta ve firmanın gerçek zararını karşılamaktan çok uzaktır. Çünkü hammadde eksikliğinden dolayı ihracat taahhütlerini yerine getirememiş bir firmanın piyasalarda kaybettiği güveni, yitirdiği müşterilerini ve bunun sonuçları hiçbir şekilde tazmin ve telafi edilemez. Bunu tersi, yani firmanın sözleşme konusu hammaddeyi almaktan imtina etmesi çok çok seyrek rastlanan bir durumdur.

Bundan dolayı firmalar kimi zaman, tek tek çiftçiler yerine “komisyoncu “ tabir edilen, birtakım bölgelerde sözü geçen, çiftçilere sözünü dinletebilen simsarlarla sözleşme yapmaya yönelmektedirler. Bu, gereksiz bir aracı olup ilave maliyetler getirmektedir. Üstelik bu kişilerin bir bölümünün ne derece yasal ve ahlaki şartlarda faaliyet gösterdikleri meçhuldür. Önerimiz ilgili bir devlet kuruluşunun örneğin ziraat teşkilatının bu tür sözleşmelerde taraf değil, ama denetleyici, arabulucu, gerektiğinde her iki tarafa da yaptırım uygulayabileceği, sözü dinlenir konumda dahil olmasıdır. Ve her firma/çiftçi için farklı sözleşmeler yerine her iki taraf için dengeli standart sözleşmeleri hayata geçirmesidir.

Sözleşmeli tarımın diğer önemli bir işlevi, tarımın kontrol altında gerçekleşmesidir. Bu bağlamda çiftçiye sürekli danışmanlık desteği verilerek yanlış girdiler, özellikle yanlış ilaç kullanımının önüne geçilebilmektedir. İlaç kalıntısı konusu dış pazarlarda en önemli kriter olup, iç pazarda da ciddi bir halk sağlığı sorunudur.

Sözleşmeli tarım veya çiftçinin ürününün layıkıyla değerlenmesi bağlamında sıklıkla kooperatifçilik gündeme getirilmektedir. Ancak ülkemizde bu tür kooperatiflerin, yöresel kişisel çekişmeler, siyasi mülahazalar, yönetimdekilerin işi bilmemeleri, kötü niyetli kimselerin yönetimde etkin olma çabaları nedeniyle pratikte başarılı olduklarına maalesef pek rastlanamamaktadır.

2.2.6. Sürekli Çalışanlar ve Mevsimlik İşçiler

Mevsimlik üretim nedeniyle tarımsal sanayi işletmeleri sürekli bir çekirdek kadronun yanı sıra, işin emek yoğun niteliğinden dolayı yüksek sayıda sezonluk işçiye ihtiyaç duyarlar. Devamlı kadro, müdür, şef, usta gibi bölgedeki yetişmiş kalifiye elemanlardan oluşur. Bu tür elemanlar, çok kez işletmede stajyer, çırak, mevsimlik işçi, vs. olarak başlayıp zaman içerisinde eğitimleri ve becerileri neticesinde yükselerek bu tür görevleri üstlenmektedirler; yani çekirdekten yetişmedirler. Dolayısıyla tarımsal sanayi işletmeleri kırsal bölge için aynı zamanda bir mesleki eğitim kurumu niteliğindedir.

Geçici işçiler ise üretim mevsimine özgü, genelde fazla kalifikasyon gerektirmeyen faaliyetleri üstlenirler. Bu, bir yerde tarımsal sanayinin bölgeye sağladığı diğer bir avantajdır. Geçici işçilik tabiidir ki, sürekli istihdamın yerini tutmaz. Ama bölgedeki ev kadınlarına, tatile gelen öğrencilere veya düzenli işi olmayanlara, ek gelir imkânı sunmakta, başka işi ve geliri olmayan yöre insanlarının ise en azından şehirlerde olduğu gibi yoksulluğa düşmelerine engel olabilmektedir.

Mevsimlik istihdamın özellikle bölge kadınları açısından dikkatlerden kaçan ilave olumlu etkileri vardır. Mevsimlik işçilik işin doğası gereği büyük çoğunlukla kadınlar tarafından yapılmaktadır. Genelde kırsal bölgelerdeki köy kadınlarının ev işleri, bahçe-tarla işleri, hayvan bakımı, çocuklar, torunlar derken bir işte düzenli çalışmaları pek olası değildir. Dolayısıyla haneye girecek parayı erkek kazanır, para öncelikle erkeğin eline geçer. Çiftçi ailelerinde dahi, kadınlar tarlada çok kez erkeklerden daha çok çalıştığı halde malı fabrikaya veya kabzımala erkek döktüğü için ödeme erkeğe yapılır. Oysa kadın bir veya birkaç aylık fırsat yaratıp mevsimlik işçi olarak çalışma imkanına sahip olursa kazancı doğrudan kendisine ödenir. Kadının eli doğrudan para gördüğünde, keyfince yapmak isteyeceği şahsi harcamalar için erkekten zımnen dahi olsa her seferinde onay beklemeye ihtiyaç görmeyecektir. Bu kadının özgüvenini arttırmakta, ailedeki ve toplumdaki konumunu sağlamlaştırmakta ve göze çarpmayan pek çok olumlu diğer neticeleri beraberinde getirmektedir.

Mevsimlik iş gücü sadece işletmelerin değil çiftçilerin de ihtiyacıdır. Her ne kadar sebze türü tarım ürünleri aile tarımı şeklinde yapılsa da zaman zaman çiftçiler de ilave işgücüne ihtiyaç duymaktadırlar.

Mevsimlik işçilerin yöreden sağlanması esastır. Ancak kırsal bölgelerde ikamet eden nüfusun azalması, düşük maliyetler, muğlak mevzuat dolayısıyla yasal sorumluluklardan kaçınma gibi nedenlerle "dayı başı" tabir edilen simsarlar uzak bölgelerden getirdikleri, yöreye yabancı, hatta kaçak durumdaki insanları istihdam ederek, taşeron statüsünde mevsimlik işçilikleri üstlendikleri görülmektedir. Bu kişilerin ne derece yasal çerçeve içinde çalıştıkları, çalıştırdıklarının kazançlarına ne derece ortak oldukları ne derece insanlık onurunu dikkate aldıkları ve hangi şartlarda barınmalarını sağladıkları soru işaretleridir, fakat normalde görmezden gelinmektedir. Önerimiz devletin ilgili bir kurumunun bu hususta denetleyici olarak devreye girmesi, barınma imkanları yaratması ve devlet otoritesine haiz olması dolayısıyla böylesine faaliyetlerde düzeni sağlamasıdır.

Mevsimlik işçiler konusunun firmalar açısından mevzuat bağlamında tam bir açıklığa kavuşturulması şarttır. Mevsimlik işçilerin sürekli işçilerle aynı mevzuat hükümlerine tabi olması ve işverene aynı meblağlarla mal olması işin doğasına aykırı olup, rekabet ortamında sürdürülebilir değildir. Bu hususta gerçekçi ve açık bir mevzuatın eksikliği, kaçınılmaz olarak gayrı kanuni, gayriahlaki uygulamalara dolayısıyla haksız rekabete yol açar, ülke için böylesine avantajlı bu alana yatırım yapılmasını caydırır. Üstelik mevsimlik işçilerin böylesine talepleri ve sürekli çalışanların sorumluluklarını yüklenmek gibi bir arzuları yoktur. Kanun koyucunun günün şartları değiştikçe, mevsimlik işçilerin ve işletmelerin ihtiyaçlarını dengeli bir şekilde dikkate alıp tarımsal sanayinin dolayısıyla tarımın önünü açması doğru olacaktır.

2.3. TARIMSAL SANAYİNİN BAŞARISINA ETKİ EDEN HARİCİ FAKTÖRLER

2.3.1. Tarla üretim maliyeti

Tarımsal sanayinin başarılı olabilmesi için tarla üretim maliyetlerinin hem çiftçi hem de sanayi kuruluşu açısından uygun seviyelerde gerçekleşmesi gerekir. Çünkü değindiğimiz gibi tarımsal sanayide mamul ürünün birim maliyetindeki en büyük unsur hammadde maliyetidir. Zirai üretim girdilerinin çiftçi açısından uygun maliyetlerle temini, ancak doğru devlet politikalarıyla gerçekleşebilir. Bunların yanı sıra tarla verimi, yani birim alandan alınan zirai ürün miktarı, girdi maliyetleri kadar önemlidir ki, çiftçiye danışmanlık vermek suretiyle istenilen seviyelere getirilebilir. Pratikte danışmanlık, sanayi kuruluşu tarafından bir "ziraat ekibi" oluşturularak bizzat yapılmakta, bu ise ilave maliyet getirmektedir. Kanımızca bunun

ağırlıklı olarak devletin mevcut ziraat teşkilatınca firmalarla eşgüdümlü olarak yürütülmesi maliyetlerde tasarrufu ve hizmetin daha iyi yürütülmesini mümkün kılacaktır.
Bu noktada tohum konusunu da irdelemek gerekir. Özellikle tarımsal sanayiye yönelik pek çok zirai üründe yüksek verim nedeniyle kaçınılmaz olarak hibrid tohumlar tercih edilmektedir. Bu tohumların çimlenme özelikleri müdahaleyle yok edildiklerinden ancak bir kez kullanılabilmekte her sene yeniden satın alınmaları gerekmektedir. Oysa bu tohumlar yabancı menşelidir. Tohumculuk uzun vadeli dolayısıyla yüksek sermaye gerektiren riskli bir iştir. Yurtiçinden temini mümkün olmayan hibrid tohumlar için devlet kuruluşlarının ilk aşamada devreye girerek arge çalışmalarına öncülük etmeleri doğru olacaktır.
Bazı hibrid tohumların çimlenme özelliklerini tümüyle yitirmedikleri zaman zaman müşahade edilmektedir. Çalışmalara buradan başlanması düşünülebilir.
2.3.2. Döviz politikası
Gerek tarımsal sanayi gerek diğer sanayi kolları için dış pazarlarda rekabet şansının, ancak gerçekçi bir döviz kuru politikası ile kalıcı olacağı açıktır. Devletin bunu sağlayacak veya doğru tercihlerle telafi edecek tedbirleri hayata geçirmesi arzulanır. Kanımızca tarımsal sanayinin yukarıda açıkladığımız avantajları nedeniyle tercihlerde ön sıralarda tutulması doğru olacaktır.
2.3.3.Tarıma Yönelik Destekler
Destek sözü edildiğinde akla öncelikle hibe olarak verilen maddi destekler anlaşılmaktadır. Oysa kanımızca amaca uygun mevzuat düzenlemeleri maddi desteklerden daha etkilidir. Yukarıda değindiğimiz sözleşmeli tarım, geçici işçiler gibi hususlardaki teşvik edici ve gerçeklerle bağdaşık mevzuat düzenlemeleri etkin destekler olacaktır.
Tarla üretiminin maliyetini düşürmek üzere çiftçilere verilecek destekler planlanırken bunların aynı anda tarımsal sanayii de destekler nitelikte olmasına özen gösterilmelidir. Buna bir örnek bazı ülkelerde uygulandığı şekliyle, ürününü tarımsal sanayi kuruluşlarına döken çiftçilere ek prim verilmesidir. Bu şekilde zirai üretim maliyetleri yüksek bazı tarım ürünlerinin de sınai olarak işlenip uluslararası pazarlarda rekabet edebilir hale getirilebilmesi mümkün olabilmekte, neticede az bir harcamayla ülkeye daha yüksek gelir gelmektedir. Benzer şekilde maliyeti yüksek bazı tarım makinalarının (örneğin pırasa hasat makinası) ziraat teşkilatı marifetiyle ödünç olarak çiftçilerin kullanımına sunulabilir.
Önemli olan tarımsal sanayi sayesinde katma değeri arttırılmış zirai ürünlerin dünya pazarlarında rekabet edebilir durumda olması, yani firmanın kar etmesi, dolayısıyla ülkenin gelir elde edebilmesidir. Bunun sürdürülebilirliği için hammaddeyi üreten çiftçi ailesinin maddi açıdan tatmin olması, yani birer asgari ücret seviyesinin üzerinde gelir elde edebilmelerinin sağlanmasıdır. Öyle ki çiftçi ve sanayi kuruluşu çıkarları farklı taraflar olarak görülmeyip, çıkarları ortak, birbirlerini destekleyen, birlikte var olan ve piyasalarda ancak birlikte rekabet edebilen, bir birim olarak görülmelidirler. Sanayi kuruluşuna olsun çiftçiye olsun, devletin verdiği teşvikler ve yaptığı düzenlemelerin felsefesi buna uygun olmalıdır.

SONUÇ

Sonuç olarak başta belirttiğimiz tezimizi tekrar etmek durumundayız. Tarımın gelişmesi ve tarıma uygun kırsal bölgelerin kalkınması ancak tarımsal sanayinin varlığıyla mümkün olur. Tarımsal sanayinin sağlayacağı kalkınma, sadece ekonomik değil, sosyal ve kültürel alanlarda da olacaktır. Doğru düzenlemeler, doğru teşvikler ile bu çok daha üst seviyelerde gerçekleştirilebilir.
Tarımsal sanayinin kırsal bölgelerde yaygınlaşması ve bunun sonucu nihai sanayi dallarının gelişimi, tarım alanlarının değerini ve bunun farkındalığını arttıracaktır. Çok kez karar vericilerin karşılaştığı; çevrenin korunmasına mı, yoksa bölge için belki katma değer yaratan, fakat çevreye zarar veren sanayiye mi öncelik verilmesi ikilemini ortadan kaldıracaktır.

KAYNAKÇA

1. Yenice Gıda Sanayii A.Ş. Nakit Akışlı Bütçe Tablosu
2. Yenice Gıda Sanayii A.Ş. Mamul Maliyet Tabloları
3. Yenice Gıda Sanayii A.Ş. Müstahsil Taahhüt Mukavelesi
4. Yenice Gıda Sanayii A.Ş. Windsichter hattı yatırım dosyası
5. Yenice Gıda Sanayii A.Ş. Biber sapı ayırma hattı yatırım dosyası
6. Yenice Gıda Sanayii A.Ş. Kurutma fırını ısı geri kazanım projesinin hesaplamaları
7. https://www.doka.org.tr/dosyalar/page_509/attachment/meyve-sebze-konserve-salca-tesisi.pdf
8. https://www.investsanliurfa.com/public/uploads/attachment/08-salca-uretim-tesisi-yatirim-fizibilitesi-1587455242.pdf
9. https://www.ekonomigazetesi.com/ekonomi/1-kisiyi-istihdamin-maliyeti-2-3-milyon-lira-11683/#:~:text=Pandeminin%20etkisinin%20a%C4%9F%C4%B1r%20hissedildi%C4%9Fi%202021,milyon%20360%20bin%20liraya%20y%C3%BCkseldi**.**

STRATEGIC IMPORTANCE OF BLUE-GREEN ALGAE (CYANOBACTERIA) "SPIRULINA" AND GREEN ALGAE (CHLOROPHYTA) "ULVA" AS AQUATIC AGRICULTURE PRODUCTS

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ABSTRACT

Introduction and Purpose: Cultivation of algal biomass is important for its conversion into food, feed ingredients, fuels/chemicals, and algae-derived bioplastics after harvest. In addition, algae offer environmental benefits with high added value, such as their use in carbon capture due to their effect on reducing carbon emissions and in treating wastewater with high nutrient load.

Materials and Methods: Microalgae and macroalgae-based products can play an essential role in the bioeconomy for low-carbon emission industry insight. Integrated Multitrophic Aquaculture (IMTA) is regarded as a viable approach for the sustainable advancement of aquaculture.

Results: *Ulva* spp. (Chlorophyta) is a valuable product for the food, feed and biomaterial industries. Although it reproduces intensively in algal blooms from time to time due to the increasing nutrient load in the seas worldwide, large-scale production with controlled harvesting needs to be developed within the scope of sustainable bioeconomy. In the blue-green algae class (Cyanobacteria), Spirulina is considered a single-cell protein containing high protein concentrations (60-70%), carbohydrates, lipids, and pigments. It is referred to as the "best food of the future" and is characterized as "space food" by NASA due to its nutrient density and extended shelf life.

Discussion and Conclusion:

The blue economy refers to the systematic utilization of marine and ocean resources by integrating short- and long-term economic activity, grounded in the ideals of innovation, social inclusion, and environmental sustainability in maritime contexts. BlueHomeland: It covers all declared or undeclared maritime jurisdictions, internal waters, territorial waters, continental shelf, exclusive economic zones, rivers, and lakes of Turkey. A new agricultural paradigm is proposed for Türkiye regarding the necessity of producing Spirulina, a microalgae, and Ulva, a macroalgae, that can make a sustainable contribution to bioeconomic activities within the scope of the blue economy.

Key Words: Sustainable; microalgae; macroalgae; Spirulina; *Ulva* spp.

INTRODUCTION

Microalgae and macroalgae are agricultural products that serve as raw materials for many aquatic industrial areas (Visuddho et al. 2024). Agricultural specialists should understand the distinctions between various algae species as well as the differences between microalgae and macroalgae. The classification of algae in the kingdom Protista, instead of the kingdom Plants, refers to organisms that lack roots for nutrition absorption and do not possess a vascular system for nutrient transportation to their numerous structures. Thallus is a term used to describe the main body of macroalgae. There is a great diversity in the thallus structure of algae, from unicellular to multicellular. Thallus refers to the primitive plant structure, which is an undifferentiated tissue that performs the work of many organs simultaneously (Pereira 2021).

Algae are photosynthetic organisms that can have different characteristics and grow naturally in inland waters or seawater in the presence of sunlight, and they are prokaryotic or eukaryotic species that can develop on a micro or macro scale. Microalgae can have a prokaryotic or eukaryotic cell structure. The Cyanobacteria class has a prokaryotic cell structure and is known as blue-green algae. Red, golden-brown, and green microalgae can be single-celled organisms with a eukaryotic cell structure and can sometimes live in colonies by combining cells together (da Rosa et al 2023). Algae may sequester CO2 and utilize nitrates, phosphates, and other micronutrients in the water to augment their biomass. Microalgae are called phytoplankton and economical species are grown. Microalgae are a useful source of microbial nutrients in the agricultural industry to improve crop yields and soil health. Microalgae possess the potential to significantly contribute to climate change mitigation via carbon fixation, resulting in substantial oxygen production in the atmosphere. Some members of the class Cyanobacteria participate in the nitrogen cycle by fixing nitrogen in the atmosphere, and when applied to suitable organisms as biofertilizers, they colonize the rhizosphere and promote plant nutrient uptake, making nutrients easily accessible to plant root hairs (Dasgupta et al. 2021).

Macroalgae are also produced through culture and can also be collected from nature. Seaweed farming is becoming widespread worldwide. It uses nitrite/nitrate and phosphate levels as a food source and filters the environment (Khan et al. 2024).

Cultivation of algal biomass is important for its conversion into food, feed ingredients, fuels/chemicals, and algae-derived bioplastics after harvest. In addition, algae offer high value-added environmental benefits, such as their use in carbon capture and treatment of wastewater with high nutrient loads, due to their effects on reducing carbon emissions. Microalgae and macroalgae-based products can play a critical role in the bioeconomy in terms of low-carbon emission industry understanding. Integrated Multitrophic Aquaculture (IMTA) is considered a promising solution for the sustainable development of aquaculture (Ranjan et al. 2023). Of all agricultural crops, algae is the most rapidly growing and may be cultivated on unproductive soils, including urban environments. Within the scope of agricultural support policies implemented in Turkey until the 2000s, supports such as fertilizer, seed, feed, pesticides, irrigation, breeding animals, and artificial insemination were applied in the livestock sector, as well as milk and meat incentive premiums as input support (Dernek, 2006). Although Türkiye became a "self-sufficient" country within the scope of "planned agricultural policy" between 1960 and 1980, it was late in algae cultivation. Algae is the raw material of many industrial areas. The cultivation of seaweed and its collection from nature in harmony with the ecosystem should take its place among sustainable agricultural policies. The blue economy refers to the systematic use of ocean resources through the integration of short- and long-term economic endeavors that emphasize social inclusion, environmental sustainability, and maritime advancements. (Spalding, 2016). Bioeconomy represents a crucial new paradigm for diminishing our reliance on natural resources and addressing the environmental challenges confronting the Earth today. “Blue Bioeconomy” is the management of resources with the goal of preventing resource depletion through a sustainable economic system. Bio-based products encompass bioplastics, biodegradable textiles, and other items associated with eco-design. Similar to biomass, bioenergy, a form of renewable energy, enhances energy supply security, diminishes energy dependency, and generates new prospects for growth and employment.

CONCEPTUAL FRAMEWORK

Turkey possesses an appropriate water resource map for the algae-producing industry. The Blue Homeland represents the expansion of our strategic sovereignty over maritime areas and seabeds located between 26-45° Eastern Longitudes and 36-42° Northern Latitudes. Blue Homeland encompasses all declared or undeclared marine jurisdictional areas of Turkey, including internal waterways, territorial waters, continental shelf, exclusive economic zone, rivers, and lakes (Yaycı 2022).

METHODOLOGY

The blue economy entails the systematic utilization of marine and oceanic resources by integrating short- and long-term economic activity (Choudhary et al. 2021). Within the scope of the blue economy, a new agricultural paradigm is proposed for Türkiye regarding the necessity of producing Spirulina, a microalgae, and Ulva, a macroalgae, that can make a sustainable contribution to bioeconomic activities. The algae production sector is an extremely important and effective agricultural field that concerns the entire country's people in the production of food products as a strategic weapon, the production of biofuel as an energy source, the creation and protection of a healthy environment, and the establishment and maintenance of ecological balance.

CONCLUSION AND DISCUSSION

Microalgae sequester around 50 gigatonnes of CO2 from the atmosphere annually, representing over 50% of global photosynthetic output (Ashour et al 2024). Microalgae can biofix 1.83 kg of CO_2 per kilogram of biomass, and their oil productivity is 10 times higher than conventional biofuel plants (Chisti, 2007). Flue gas containing CO2 generated from businesses such as coal power stations, cement production, steel manufacturing, and oil refineries can be caught and utilized in microalgae cultivation. Algae production can quickly support agriculture in sustainable productivity by reducing the negative impact of greenhouse gases and carbon emissions that affect the climate (Naď et al. 2023).

Microalgae and macroalgae-based products can play an important role in the bioeconomy in terms of low-carbon emission industry understanding. Integrated Multitrophic Aquaculture (IMTA) is considered a promising solution for the sustainable development of aquaculture. A circular bioeconomy is achieved when species that require additional feed, such as fish, are produced integrated with economically important "assimilator" species. Assimilative organisms grow by utilizing organic and inorganic substances, as well as leftovers from other species. The principal producers of assimilator species are algae and plant species that transform inorganic nutrients into organic biomass. Assimilative strains allow producers to improve the environmental performance of their facilities through the ability to naturally recycle nutrients or waste found in and around fish farms. Assimilator species possess commercial worth as marketable commodities and yield economic advantages. Balanced diversity should be a holistic approach to sustainable aquaculture (Fraga-Corral et al. 2022).

Seaweed farming is a young industry. Traditional production is limited to shallow and calm water areas. However, it is also possible to grow, harvest, and seed seaweed directly in deeper and more rugged marine waters, growing, harvesting, and seeding it on a large scale and in an economically viable manner. Sustainable algae farming is an important way to capture and convert CO2 into valuable products (Kim et al. 2019).

Ulva spp. It is a useful product for the food, feed and biomaterial industries. Therefore, successful large-scale production needs to be developed. Some bacteria in the microbiota affecting Ulva in the marine environment affect the development and morphology of Ulva biomass. Ulva biorefinery is the separation of salt, cellulose, ulvan, starch, proteins, lipids, simple monosaccharides and peptides through various process configurations. After removal of salt and ulvan, high protein yield can be obtained from Ulva (Magnusson et al. 2016). Ulva extracts improve plant response to salinity stress (El Boukhari et al. 2021), drought tolerance (Li et al. 2020), growth and antioxidant activity (Osuna-Ruíz et al. 2023). Ulva spp. The use of extracts as a biostimulant source also increases product yield (Hofmann et al 2024). Some biomass produced during green tides, an environmental disaster, can also be converted into products (Shefer et al. 2022).

Plastic packaging is generally produced from petroleum-based sources. Corn, potatoes, vegetable oils, wood, food waste, grain products, etc. Many biomaterials such as are used in the production of bioplastics today. Today, the main types of bioplastics are starch-based, but plastics based on polylactic acid (PLA), poly-3-hydroxybutyrate (PHB), polyamide 11 (PA 11) and organic polyethylene (PE) are also produced. Ulvan substance is an antioxidant molecule and is extracted from Ulva. The addition of ulvan to packaging film increases the antioxidant activity of the film (Gomaa et al. 2022), and such seaweed-based packaging films can extend the shelf life of some packaged products. The sustainable intensification of domestic chicken breeds is significantly hindered by the elevated costs of feed ingredients, thus restricting the expansion of the poultry sector in developing nations. Inexpensive and accessible feed components possessing nutraceutical attributes, such as seaweeds, can be utilized to address this difficulty. Numerous studies on Ulva spp. indicate that it can be used at low inclusion rates (below 10%) without compromising the growth performance of hens. Two hundred seventy-five chickens (202 g live weight; 4 weeks old) were formulated by adding 0 (SW0), 20 (SW20), 25 (SW25), 30 (SW30) and 35 g/kg (SW35) SWM to five isoenergetic and isoproteic compounds. Green seaweed meal had a negative effect on the growth performance, internal organ size, carcass characteristics and meat quality of domestic Boschveld chicken when reared on the diet. It has been determined that it does not create (Nhlane et al 2021).

Ruminant cattle production is vital to meet global protein demand (both meat and milk), but feeding cattle requires intensive feed consumption. Processes such as feed production and transfer occur together with processes that cause environmental degradation. Macroalgae may serve as a feasible alternative feed source owing to their nutritional value; research indicates that including macroalgae in ruminant diets enhances animal performance and lowers methane emissions. (Moorby and Fraser 2021). It is stated that it is possible to use *Ulva lactuca* in ruminant animal nutrition (Tayyab et al. 2016).

Ulva is a feed raw material that increases growth and provides resistance to diseases in fish feed (Güroy et al. 2007; Petit et al. 2024).

Seaweed farming is an ecologically sound way to produce food and other products for the blue bioeconomy. Considering soybean production costs around $162 per acre, production costs for seaweed farms range from $225 to $10,000/dry ton depending on scale (Kite-Powell et al. 2022). There are no known published production costs for growing Ulva. While soybeans contain approximately 36.5% protein, this ratio varies between approximately 4-27% in Ulva.

The use of Ulva (Ulvophyceae, Chlorophyta) in the biofiltration of fish waste in Integrated Multi-Trophic Aquaculture (IMTA) systems is a sustainable practice. The importance of integrating Ulva farm and fish farm is that nitrogen-based nutrient loads such as NO_3^- and NH_4+ and phosphate-based nutrient loads such as PO_4^{3-} increase in the environment as a result of inedible fish meal and decomposition of fish. When the feces and inedible feed dissolve in the water, they are absorbed and removed from the water by Ulva with the advantage of high surface/volume ratio and transformed into products, gaining economic value. Ulva provides an important site for biofilm-forming bacteria (antibiotic tropodithiotic acid) that reduce growth and kill pathogenic microorganisms in fish such as *Vibrio* and *Tenacibaculum* (*Phaeobacter* species). Therefore, the use of Ulva as a substrate for probiotic bacteria (such as Phaeobacter) is a good sustainable microbial control strategy in IMTA-RAS and is compatible with ecological theories supporting the resilience of aquaculture systems. Ulva species, an effective biofiltration agent of fish waste, have been shown to have antagonistic activity against pathogenic Vibrio species and promote reduced mortality in larvae of *Vibrio anguillarum*-infected fish (*Scophthalmus maximus*) colonized with Phaeobacter in Integrated Multi-Trophic Aquaculture Recirculation Systems (IMTA-RAS). (Pintado et al. 2023).

Commercial production of Spirulina is well established worldwide. In fact, spirulina is the most widely grown microalgae in Europe, with around 150 tonnes of dry biomass produced annually in more than 200 sites. Worldwide production was assessed by FAO as 56,208 tons in 2019. The global spirulina market size reached 533 million Euros in 2023. Spirulina is considered a single-cell protein that has attracted the attention of many researchers due to its high protein concentrations (around 60-70%), carbohydrates, lipids, and pigments. Spirulina is very rich in nutrients and is defined as the "best food of the future" because it can offer a long shelf life and is a strategic food source. It has been defined as "Space food" by NASA and European Space Energy. It has extensive applications across various industrial sectors, including pharmaceuticals and food production. It may also serve as feed for poultry, swine, and fish, either directly or in combination with feed components (Altmann and Rosenau, 2022).

Spirulina can be commercialized in several forms, including capsules and powders, as well as in culinary products such as Spirulina noodles, pasta, yogurts, drinks, and cosmetics (Lafarga et al., 2020).

Spirulina (*Arthrospira platensis*) was applied as a foliar spray to lettuce (*Lactuca sativa*) grown in an aquaponic system once a week for five weeks at doses of 4.0, 8.0, and 12.0g spirulina/L. The effect of Spirulina given as a bio stimulant on the leaf length, leaf width, leaf area, dry matter, and antioxidant content of Lactuca sativa in an integrated aquaponic system with tilapia (Oreochromis niloticus) fed with 30% protein feed was determined.

An increase in the number of leaves and leaf length, width, and leaf area was determined in the 8 g Spirulina/L applied group. It has been shown that a linear increase in dry weight was achieved at a dose of 12 g spirulina/L, and spray application had a positive influence on the growth performance and proximate composition of lettuce (Lactuca sativa) cultivated in an aquaponic system (Siringi et al. 2022).

Spirulina comprises elements including iron, magnesium, calcium, and zinc, making it a beneficial source when utilised as a dietary or feed supplement. Spirulina, cultivated globally, serves as a nutritional supplement or full-food component (Güroy 2020). The utilisation of geothermal water in Spirulina culturing can lower its production cost (Güroy et al. 2023). It is highly abundant in proteins and antioxidants. Spirulina is utilized to extract pigments, including phycocyanin, a blue photosynthetic pigment employed in the health, cosmetic, and food sectors (Güroy et al. 2017). It is utilized as a feed supplement in aquaculture and the poultry industry (Güroy et al. 2012; Güroy et al. 2022). Spirulina has numerous vital nutrients, including B vitamins (thiamine, riboflavin, and niacin) and dietary minerals such as iron and manganese.

Novel food is any product that is completely new to European life and was not consumed to any significant extent before 15 May 1997. Regulation (EC) 68/2013 states that algae are registered as accepted feed materials. There are 25 species of algae in France, 3 of which are micro. In addition, Regulation No. 629/2008 (European Commission 07/2008) regarding heavy metals in algae to be sold on the market is taken into account.

REFERENCES

Visuddho, V, Halim, P., Helen, H., Muhar, A.M., Iqhrammullah, M., Mayulu, N., Surya, R., Tjandrawinata, R.R., Ribeiro, R.I.M.A., Tallei, T.E. (2024). Modulation of Apoptotic, Cell Cycle, DNA Repair, and Senescence Pathways by Marine Algae Peptides in Cancer Therapy. Mar. Drugs 2024, 22, 338. https:// doi.org/10.3390/md22080338

Pereira, L. (2021). Macroalgae. Encyclopedia, 1(1), 177-188. https://doi.org/10.3390/encyclopedia1010017

da Rosa, M. D. H., Alves, C. J., dos Santos, F. N., de Souza, A. O., Zavareze, E. d. R., Pinto, E., Noseda, M. D., Ramos, D., & de Pereira, C. M. P. (2023). Macroalgae and Microalgae Biomass as Feedstock for Products Applied to Bioenergy and Food Industry: A Brief Review. Energies, 16(4), 1820. https://doi.org/10.3390/en16041820

Debmalya Dasgupta, Kulbhushan Kumar, Rashi Miglani, Rojita Mishra, Amrita Kumari Panda, Satpal Singh Bisht (2021). Chapter 1- Microbial biofertilizers: Recent trends and future outlook, Editor(s): Recent Advancement in Microbial Biotechnology, , Pages 1-26, ISBN 9780128220986, https://doi.org/10.1016/B978-0-12-822098-6.00001-X.
Khan N, Sudhakar K, Mamat R. (2024) Macroalgae farming for sustainable future: Navigating opportunities and driving innovation. Heliyon. 2024 Mar 20;10 (7): e28208. doi: 10.1016/j.heliyon.2024.e28208. PMID: 38560151; PMCID: PMC10981073.
Devarshi Ranjan, Priyanka Verma, Mayank Bhushan Singh, Shubham Kanaujiya and Anshika Pathak. (2023). Integrated Multi-Trophic Aquaculture System (IMTA) In book: Traditional & Recent Aquaculture Practices (pp.109-125) Publisher: AkiNik Publications
Zeynep DERNEK. (2006). Cumhuriyet'in Kuruluşundan Günümüze Tarımsal Gelişmeler. Süleyman Demirel Üniversitesi Ziraat Fakültesi Dergisi 1(1):1-12, 2006 ISSN 1304-9984 Süleyman Demirel Üniversitesi Ziraat Fakültesi Tarım Ekonomisi Bölümü, Isparta
Spalding, Mark J. (2016) "The New Blue Economy: the Future of Sustainability," Journal of Ocean and Coastal Economics: Vol. 2: Iss. 2, Article 8. DOI: https://doi.org/10.15351/2373-8456.1052
Cihat YAYCI. (2022). MAVİ VATAN "Bir Harita ve Bir Doktrin Kitabı" Türkiye'nin Denizlerdeki Misak-ı Milli'si BLUE HOMELAND A Book of a Map and a Doctrine. ISBN: 978-605-07-0929-2 E-ISBN: 978-605-07-0829-5 DOI: 10.26650/B/SS25.2022.01
Poonam Choudhary, Venkata Subhash G, Monika Khade, Sandip Savant, Amar Musale, Raja Krishna Kumar G, Meenakshi Sundaram Chelliah, Santanu Dasgupta (2021). Empowering blue economy: From underrated ecosystem to sustainable industry, Journal of Environmental Management.Volume291,112697,ISSN0301-4797https://doi.org/10.1016/j.jenvman.2021.112697.
Ashour M, Mansour AT, Alkhamis YA, Elshobary M (2024.) Usage of Chlorella and diverse microalgae for CO2 capture - towards a bioenergy revolution. Front. Bioeng. Biotechnol. 12:1387519. doi: 10.3389/fbioe.2024.1387519
Chisti Y. (2007) Biodiesel from microalgae. Biotechnol Adv. May-Jun;25(3):294-306. doi: 10.1016/j.biotechadv.2007.02.001. Epub 2007 Feb 13. PMID: 17350212.
Martin Naď, Vladimír Brummer, Pavel Lošák, Vítězslav Máša, Kateřina Sukačová, Dominika Tatarová, Marek Pernica, Michaela Procházková (2023). Waste-to-energy plants flue gas CO2 mitigation using a novel tubular photobioreactor while producing Chlorella algae, Journal of Cleaner Production,Volume 385, 135721,ISSN 0959-6526,https://doi.org/10.1016/j.jclepro.2022.13572
M. Fraga-Corral, P. Ronza, P. Garcia-Oliveira, A.G. Pereira, A.P. Losada, M.A. Prieto, M.I. Quiroga, J. Simal-Gandara. (2022). Aquaculture as a circular bio-economy model with Galicia as a study case: How to transform waste into revalorized by-products. Trends in Food Science & Technology. Volume 119, January 2022, Pages 23-35. ISSN 0924-2244, https://doi.org/10.1016/j.tifs.2021.11.026
Jang K. Kim, Michael S. Stekoll, Charles Yarish (2019). Oceanographic Institution Opportunities, challenges and future directions of open-water seaweed aquaculture in the United States. Phycologia 58(5):446-461 DOI:10.1080/00318884.2019.1625611
Marie Magnusson, Christina Carl, Leonardo Mata, Rocky de Nys, Nicholas A. Paul (2016). Seaweed salt from Ulva: A novel first step in a cascading biorefinery model. Algal Research,Volume 16, 2016,Pages 308-316,ISSN 2211-9264, https://doi.org/10.1016/j.algal.2016.03.018.
Laurie C. Hofmann, Sylvia Strauss, Muki Shpigel, Lior Guttman, Dagmar B. Stengel, Céline Rebours, Natasha Gjorgovska, Gamze Turan, Karina Balina, Gabrielle Zammit, Jessica M. M. Adams, Umair Ahsan, Angela G. Bartolo, John J. Bolton, Rosário Domingues, Ömerhan Dürrani, Orhan Tufan Eroldogan, Andreia Freitas, Alexander Golberg, Kira I. Kremer,

Francisca Marques, Massimo Milia, Sophie Steinhagen, Ekin Sucu, Liliana Vargas-Murga, Shiri Zemah-Shamir, Ziv Zemah-Shamir & Antonio J. Meléndez-Martínez (09 Jul 2024): The green seaweed Ulva: tomorrow's "wheat of the sea" in foods, feeds, nutrition, and biomaterials, Critical Reviews in Food Science and Nutrition, DOI: 10.1080/10408398.2024.2370489

Shai Shefer, Mario Lebendiker, Alin Finkelshtein, Daniel A. Chamovitz, Alexander Golberg, Ulvan crude extract's chemical and biophysical profile and its effect as a biostimulant on Arabidopsis thaliana,Algal Research,Volume 62,2022,102609,ISSN 2211-9264,https://doi.org/10.1016/j.algal.2021.102609.

El Boukhari, M. E. M., M. Barakate, N. Choumani, Y. Bouhia, and K. Lyamlouli. 2021. Ulva lactuca extract and fractions as seed priming agents mitigate salinity stress in tomato seedlings. Plants 10 (6):1104. https://pubmed.ncbi.nlm.nih.gov/34070914. doi: 10.3390/plants10061104.

Osuna-Ruíz, I., A. K. D. Ledezma, E. Martínez-Montaño, J. A. Salazar-Leyva, V. A. R. Tirado, and I. B. García. 2023. Enhancement of in-vitro antioxidant properties and growth of amaranth seed sprouts treated with seaweed extracts. Journal of Applied Phycology 35 (1):471–81. doi: 10.1007/s10811-022-02872-2.

Li, F., S. Zuo, Y. Chi, C. Du, Z. Shen, X. Han, X. Wang, and P. Wang. 2020. Alleviation of drought stress in wheat using exogenous Ulva prolifera extract produced by enzymatic hydrolysis. Journal of Renewable Materials 8 (11):1519–29. https://www.techscience.com/jrm/v8n11/40269. doi: 10.32604/jrm.2020.011453

Gomaa, M., Al-Badaani, A.A., Hifney, A.F. *et al.* Utilization of cellulose and ulvan from the green seaweed *Ulva lactuca* in the development of composite edible films with natural antioxidant properties. *J Appl Phycol* **34**, 2615–2626 (2022). https://doi.org/10.1007/s10811-022-02786-z

Nhlane, L. T., Mnisi, C. M., Mlambo, V., & Madibana, M. J. (2020). Nutrient Digestibility, Growth Performance, and Blood Indices of Boschveld Chickens Fed Seaweed-Containing Diets. *Animals*, *10*(8), 1296. https://doi.org/10.3390/ani10081296

Usama Tayyab, Margarita Novoa-Garrido, Michael Y. Roleda, Vibeke Lind, Martin Riis Weisbjerg. (2016). Ruminal and intestinal protein degradability of various seaweed species measured in situ in dairy cows,Animal Feed Science and Technology,Volume 213, Pages 44-54,ISSN 0377-8401,https://doi.org/10.1016/j.anifeedsci.2016.01.003.

J.M. Moorby, M.D. Fraser (2021). Review: New feeds and new feeding systems in intensive and semi-intensive forage-fed ruminant livestock systems,Animal,Volume 15, Supplement 1,2021,100297,ISSN 1751-7311, https://doi.org/10.1016/j.animal.2021.100297.

Kite-Powell, H. L., Ask, E., Augyte, S., Bailey, D., Decker, J., Goudey, C. A., … Yarish, C. (2022). Estimating production cost for large-scale seaweed farms. Applied Phycology, 3(1), 435–445. https://doi.org/10.1080/26388081.2022.2111271

Güroy, Betül Kut; Cirik, Şükran; Güroy, Derya; Sanver, Feyza; and Tekinay, Ahmet Adem (2007) "Effects of *Ulva rigida* and *Cystoseira barbata* Meals as a Feed Additive on Growth Performance, Feed Utilization, and Body Composition of Nile Tilapia, *Oreochromis niloticus*," Turkish Journal of Veterinary & Animal Sciences: Vol. 31: No. 2, Article 2. Available at: https://journals.tubitak.gov.tr/ veterinary/vol31/iss2/2

Pintado, J., Del Olmo, G., Guinebert, T. et al. Manipulating the Ulva holobiont: Co-culturing Ulva ohnoi with Phaeobacter bacteria as a strategy for disease control in fish-macroalgae IMTA-RAS aquaculture. J Appl Phycol 35, 2017–2029 (2023). Https://doi.org/10.1007/s10811-023-02986-1

Altmann, B. A., & Rosenau, S. (2022). Spirulina as Animal Feed: Opportunities and Challenges. *Foods*, *11*(7), 965. https://doi.org/10.3390/foods11070965

Tomas Lafarga, José María Fernández-Sevilla, Cynthia González-López, Francisco Gabriel Acién-Fernández. (2020). Spirulina for the food and functional food industries, Food Research

International,Volume 137,2020,109356,ISSN 0963-9969,https://doi.org/10.1016/j.foodres.2020.109356
J.O. Siringi, Losenge Turoop, Francis Njonge, BIOSTIMULANT EFFECT OF SPIRULINA (ARTHROSPIRA PLATENSIS) ON LETTUCE (LACTUCA SATIVA) CULTIVATED UNDER AQUAPONIC SYSTEM. , *SCIREA Journal of Biology*. Volume 7, Issue 1, February 2022 | PP. 23-40. 10.54647/biology18204
Güroy, B., Karadal, O., Mantoğlu, S. & Cebeci I.O. (2017). Effects of different drying methods on C-phycocyanin content of Spirulina platensis powder. Ege Journal of Fisheries and Aquatic Sciences, 34(2): 129-132. doi:10.12714/egejfas.2017.34.2.02
Güroy. B (2020). Taze Spirulina veya Spirulina Tozu İçeren Muffinlerin Fikosiyanin, Protein İçeriği ve Duyusal Özelliklerinin Belirlenmesi. Gıda ve Yem Bilimi - Teknolojisi Dergisi / Journal of Food and Feed Science - Technology 23: 10-18 (2020/1)
Güroy, B., Güroy, D., Mantoğlu, S., Karadal, O. and Oğuzkan, S.B. 2023. Geothermal water as a nutrient medium source on the biomass productivity and biochemical composition of Spirulina (Arthrospira platensis) under the greenhouse conditions. Int. J. Lim. 2023, 59, 2. https://doi.org/10.1051/limn/2023001
Betül Güroy, İzzet Şahin, Serhan Mantoglu, Selin Kayalı (2012). Spirulina as a natural carotenoid source on growth, pigmentation and reproductive performance of yellow tail cichlid Pseudotropheus acei. Aquacult Int (2012) 20:869–878. DOI: 10.1007/s10499-012-9512-x
Betül Güroy, Derya Güroy, Soner Bilen, Osman Nezih Kenanoğlu, Izzet Şahin, Ertuğrul Terzi, Onur Karadal, Serhan Mantoğlu (2022). Effect of dietary Spirulina (Arthrospira platensis) on the growth performance, immune-related gene expression and resistance to Vibrio anguillarum in European seabass (Dicentrarchus labrax). Aquaculture Research. 2022;53:2263–2274. https://doi.org/10.1111/are.15745

BIOGAS AND BIOMASS: A REVIEW ON RENEWABLE ENERGY SOURCES

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ABSTRACT
This review focuses on the role of biogas and biomass as renewable energy sources, highlighting their potential to address the growing global energy demand and environmental challenges associated with fossil fuel consumption. Biogas, primarily composed of methane, is produced through anaerobic digestion of organic materials, while biomass, derived from plants and animals, is utilized via processes such as combustion, gasification, and pyrolysis. Both energy sources offer significant advantages, including reduced greenhouse gas emissions, energy security, and waste management improvements. The paper explores the technological processes underlying biogas and biomass utilization, emphasizing their versatility in producing electricity, heat, and biofuels. Advanced anaerobic digestion techniques and innovations in biomass conversion technologies, such as enzymatic processes for ethanol production, have increased the feasibility of these renewable energy systems. However, the study also discusses the economic and technical challenges, such as high initial costs, feedstock variability, and the need for effective policy frameworks to encourage adoption and investment. Furthermore, the environmental benefits of biogas and biomass are underscored, including their capacity to enhance rural development, improve air and soil quality, and reduce reliance on fossil fuels. The review also highlights the importance of government policies, subsidies, and international agreements in fostering the growth of these industries. The conclusion emphasizes the need for continued research, technological advancements, and strategic policy support to overcome existing barriers. Collaboration among governments, industries, and academia is crucial for maximizing the potential of biogas and biomass as sustainable energy solutions. By integrating these renewable energy sources into global energy systems, significant progress can be made toward achieving long-term energy sustainability and environmental preservation.

Keywords:
Biogas, Biomass, Renewable Energy, Anaerobic Digestion, Biomass Conversion, Greenhouse Gas Emissions, Sustainable Energy, Energy Security, Waste Management

Introduction

In recent years, the use of fossil fuels has become an enormous problem as conventional energy sources, such as natural gas, coal, and oil, are depleting due to excessive and continuously increasing demand. Renewable energies, which are regarded as environmentally friendly alternatives to fossil fuels, have become more important in terms of sustainable development. (Yi et al., 2023) The high-quality energy demand is currently met through burning fossils such as coal, natural gas, petroleum, and other natural resources; however, this situation implies extra CO_2 in the atmosphere. The high quantity of carbon gas also intensifies the greenhouse gas effects. At this standpoint, both biomass and biogas represent significant solutions for the concentrated energy demand as well as controlling greenhouse emissions. (Kasinath et al.2021)

Based on the fundamental perception of multi-source energy-led distributed energy philosophy, this review study introduces a thorough insight into biogas and biomass in their advanced status as alternative renewable supply sources. The presented review focuses on the recent multidisciplinary research done on crucial indicators related to the operation of biogas and/or biomass energy technologies; otherwise, both biomass and biogas are restricted in terms of economic performance criteria alongside yielding greenhouse commitment perspectives (Kasinath et al.2021). This review encompasses the existing studies under the headings of biogas with specific applications, biomass with certain applications, comparison of the separate applications of biogas or biomass in a specific area, and comparing the greenhouse effects of biomass and biogas. Both the energy use in the world and economies under the light of existing results are overviewed, and the conclusion consists of forward-looking aspects that are balanced and expected to be shared with the reader.

Basics of Biogas and Biomass

Biogas and biomass are important sources of renewable energy. Biogas is the term used to define methane produced by bacteria through anaerobic digestion of organic matter, 60-70% of which is composed of methane along with some traces of hydrogen sulfide, hydrogen, and carbon monoxide, with the remaining 30-40% composed of carbon dioxide. (Kabeyi & Olanrewaju, 2022) On the other hand, biomass is the generic term used for organic materials derived from plants and animals used for energy production. Generally, biomass utilization is based on direct combustion, thermo-chemical technology, and biological technologies. All the biological techniques, including anaerobic and fermentation processes, convert the solid feedstock into gas or liquid fuels, and the produced gases are generally called biogas. (Antar et al.2021)

Biogas can be produced from any organic materials, including agricultural and agro-industrial residues, animal manures, sewage sludge, dedicated energy crops or crop residues, kitchen waste, and the biodegradable portion of municipal solid wastes. Over time, people have relied on fossil fuels for the production of energy, transportation, and industrial processes (Atelge et al.2020). The use of biogas and biomass as sources of sustainable energy production is increasing due to their renewability, versatility, local availability, and multipurpose nature. It is also capable of replacing some fraction of fossil fuel currently being used for the production of heat, steam, electricity, surface vehicle fuels, and related energy products, representing some proportion of the primary energy source, although efforts are still needed to optimize their digestion, compositions, as well as the conversion technology. (Yaqoob et al.2021)

Biogas: Formation and Production

Biogas is formed through the anaerobic digestion of organic matter owing to the interaction between acidogenic and methanogenic microorganisms. Biogas is almost entirely composed of methane and carbon dioxide, but also contains impurities such as water vapor, hydrogen, and hydrogen sulfide. Because of its methane content, biogas is increasingly used for electricity generation and transportation. (Cayetano et al.2022) The use of biogas eliminates both environmental and climate-related problems at their source; biogas reduces greenhouse gas emissions while also producing both an organic fertilizer and high-quality compost. This review provides an overview of the anaerobic digestion process, which serves as a significant unit operation of biogas production. It reports data on the amount of biogas produced per unit substrate as a result of different types of substrates and process parameters. The review also discusses the formation of biogas with regard to different configurations of anaerobic reactors with entirely different mechanisms and substrates. Cost engineering and biogas upgrading have renewed interest in biogas use. (Walling & Vaneeckhaute, 2020)

At ambient pressures, biogas consists of 50–70% methane and 30–40% carbon dioxide with traces of hydrogen, carbon monoxide, and hydrogen sulfide. The biogas produced can be converted to electricity and heat in cogeneration plants, turbo generators, or power stations.

Locomobiles and engines for power generation can be powered by electric power generated by burning biogas in an engine. (Kabeyi & Olanrewaju, 2022)The biogas as a single fuel can also power vehicles as compressed natural gas. Since certain vehicles have been available, 100% CNG vehicles have been on the market. Small-scale biogas power plants and industrial-scale power plants can produce biogas at about 20–40 p/kWh and 3–7 p/kWh, respectively. Biogas is useful in a large number of industrial processes, and the upgrading process will turn biogas into biomethane to meet the natural gas standard. Both biogas and biomethane can be used to replace liquid petroleum gas in the commercial and transportation industry. In fact, the increase in the use of biogas as transport fuel will bring about lower emissions of nitrous oxide, hydrocarbons, and carbon monoxide than gasoline, and has the potential to reduce particulate emissions. The main obstacles to producing biogas are the relatively long response rate complying with either high or low organic loading rates, strain in producing high biogas efficiency under different values of retention times, poor treatment performance at low organic loading rates, need for more process monitoring at constant organic loading rates, and process control. (Dahlgren, 2022)

Biomass: Types and Utilization

Biomass sources include a number of potential energy properties. In terms of their color, they can be categorized as follows: Agricultural residues: energy is primarily captured through photosynthesis. These include both the food chain and the energetic chain, using alternative crops or plant residues. The energetic properties of biomasses are contained in the organic matter, while the inerts have scarce or no energy in them. Forestry products: these are the final byproducts of wood processing and have been used for energy purposes since the invention of the wheel. They are waterlogged and tend to be used near the wood-related industry, or otherwise must be dried to be able to be used in the large co-generation of electricity. Organic waste: in northern countries, where a tradition of recycling is part of the state's efforts, biowaste is increasingly used to create biogas or simply boiler fuel. (Saleem, 2022) Biomass conversion includes the following main technologies, known as "green energies": Direct combustion: the traditional way of transforming biomass energy into participating form is to burn it. Gasification processing: a chemical reaction involves the choice of extracting the potential energy in the forms in which it was formed. This is called gasification. Pyrolysis transforms biomass into bio-oil, water, and a gas mixture by heating in the absence of oxygen. Anaerobic digestion: it is a well-known process in which the sugars ferment rapidly, producing biogas, which is a mixture of methane and CO2, and it also contains a lot of steam. Ethanol produced in this way has been used as a fuel additive. These processes involving enzymes could significantly decrease the temperatures at which ethanol fermentation normally occurs, and therefore decrease energy costs, and these are considered the route to the future. The commercial application of these processes began in the late 70s and early 80s, as have public demonstrations and workshops. (Lewandowski et al., 2020)Wood pelletization: this alternative is also useful to produce a uniform product for burning and giving wood ashes as the main residues. Biomass is used in three different ways: Heating: hot water or saturated steam is produced and distributed through a common exchanger circuit. Food, textiles, ceramics, heating process industries, building, and energy-related applications are using biomass for heating. Electricity generation: pumping water is one of the oldest methods of producing electricity from hydraulic energy. Currently, households are being connected to the grid, especially in poor parts of the world, through small- and medium-sized hydroelectric power stations. Biofuels: presently, the production of methane is more attractive than methanol and ethanol, but it will change. Both methanol and ethanol will re-emerge as potential feedstocks as sahapalans decrease the cost of fixing CO2 in alcohol, overcoming the laws of thermodynamics. (Ramos et al., 2022)

5. Environmental and Economic Benefits

The utilization of biogas and biomass as renewable energy sources is beneficial for the environment and the economy. The use of renewable energy for electricity generation helps to reduce the effects of fossil energy use on global warming and climate change. Farm-based anaerobic digestion (AD) reduces greenhouse gas emissions by 60% relative to maize-based fuel ethanol. Co-digestion of animal waste with either organic waste or an energy crop provides an attractive prospect for improving waste management and successful utilization of otherwise difficult-to-treat waste while increasing the energy yield through the introduction of new chemical elements and/or carbon sources to the system. (Malhotra et al.2022) The use of farm-based feedstock can improve farm operations, enhance the waste management function of a farm unit, and improve air and soil quality in rural communities rather than being offset to urban areas through dilution in waste collection systems and treatment in new urban facilities. (Yadav et al.2023)

The economic benefits of a new biogas and biomass industry include job creation, energy independence, viable rural development, improving local environments, less cash outflows from the local economy, and reduced outlays for waste management. The use of biogas systems is generally cost-effective with low-odorous, low-moisture feedstocks such as chicken and turkey litter, making biogas a very attractive alternative energy source for farms. However, negative biogas system net present values are obtained with high-moisture, high-nitrogen level materials such as swine and dairy manure, particularly when the clientele's internal benefits are not included in the analysis. The use of biomass refineries from feedstocks in closed-loop systems provides economic security. Although feedstocks can vary in price, using a variety of feedstocks enables short-term cash savings. (Rocha-Meneses et al.2023)The long-term effect of energy production costs when using biomass systems varies depending on system price sensitivity to feedstock energy prices, distillers grains and other byproduct prices, and biomass facility capital structure. The ability to vary production between energy and chemicals provides additional economic benefits. In all cases, the environmental effects are seen as very important to the economic prospects. This exchange suggests that any government policy attempting to facilitate and promote the development of these industries must clearly document the environmental advantages. The interrelationships between local economies as a means of ensuring and enhancing overall environmental health and high quality of life are becoming a strong and fruitful area of applications. (Umar et al., 2020)

Challenges in Biogas and Biomass Utilization

The biogas and biomass utilization for renewable energy have some essential challenges that are yet to be addressed for their widespread utilization. The technical challenges include the utilization of efficient processes for effective conversion of energy-storing molecules, lack of annual functional feedstock availability, feedstock handling technology, handling and storage of digestate, a variety of location-specific digester configurations, and bioenergy efficiency in the multi-valorization concept and co-production of biogas with other alternative products. (Kasinath et al.2021)The well-established fossil fuel, location-specific policy regulations, and lack of popular government-imposed energy standards have made it necessary for biotechnologists to develop integration-friendly technologies. The key economic barrier includes the variation in the economic feasibility of successful technologies across locations. (Hina et al.2022)

The high initial investment and low subsequent maintenance and operation costs can appear as a disadvantage when markets are not interested in borrowing or are unable to pay for the new technology investment cost for short-term gains, as the capital investment has been accounted for across 4 to 20 years. Thus, the biomass and biogas solutions must attract a new market that does not compete with the already established traditional market. Regulatory barriers controlling the energy management standards and the incentives play a key role in introducing new technology, and it will be largely beneficial to impose new incentives in the marketplace. (Veleva and Tsvetanova2020) The different interdependent policies regulating the current dependency on feedstock availability, price of products, and choice of carbon credits influence the successful renewable energy strategy or the maturation pathway. Due to cultural constraints, the social acceptance of the energy source, as per the consumption pattern, is very much restricted. Thus, in order to enhance the biomass and biogas solutions effectively, a suitable energy strategy must be strategized to solve the conflicts. (Rocha-Meneses et al.2023)

Future Prospects and Technological Advancements

Based on the recent progress in the field of biogas and biomass-based energy generation, it has been projected that several new technological advancements and better systems will be implemented in the future. Many advanced anaerobic digestion processes are being developed, which will eventually lead to enhancing energy production. In addition, treatments at higher and moderate temperatures are also continuously on pace. (Ampese et al.2022)Nowadays, the complete solid-state digestion processes are attracting biogas energy generators. In addition, gasification is also maturing. Many advanced technologies are being researched to enhance the biomass-to-energy yield. Several technological advancements have been proposed, and in fact, their application is also available in the case of decentralized heat and electricity generation. (Wang et al.2021)

Advanced improved versions of biomass supply chains are again being developed, which are being used to drive sustainable energy resource management. It has been suggested that, in the near future, biogas and biomass will be combined with other renewable energy resources to complement each other and improve energy generation possibilities more economically and effectively in real-time. (Kasinath et al.2021)Now, as the technology matures and more investments are continuously being made in this particular area, one can accept and imagine that biogas and biomass can potentially replace the conventional biofuel energy need, and yes, this is going to happen fairly soon. By the year 2040, significant amounts of heat, electricity, and transport fuel are expected to be produced from biomass, representing about 60% of total renewable energy generation. The rate at which this technology will be optimized depends, to an extent, on incentivization and policy-driven market incentives, although it should not be ignored that these may have to correspond with innovation as identified in the current mainstream energy consumption.

Policy and Regulatory Framework

Creating a supportive policy framework has been identified as an important vehicle for advancing the growth of renewable energy sources and facilitating their sustainability. It is widely recognized that in the absence of specific policy support, a higher investment may be needed to sustain an industry. Both investment and depreciation play a significant role in the growth of renewable energy technologies. (Lu et al.2020)This section discusses the policies, agreements, and regulatory frameworks of different developing countries, which have implemented renewable sources such as biomass and biogas. The essential features that are compared among varying zones of countries are incentives, subsidies, feed-in or preferential tariffs, and regulations that are put in place in favor of both consumers and producers of renewable energy. The international linkages and agreements among different nations and their effect on the biogas and industrial biomass industry have been critically evaluated. (Obaideen et al.2022)

Having a suitable framework for the policies and regulations is just the first step to building the technology industry. The second step is the investment decision. Due to sustainability agreements, donor groups, investor groups, and financing are attracted by these policies, regulations, and implementation frameworks. The thoughts of researchers are not only confined to the plant but also to the development pathway and the framework for development. Whether the policies and agreements that are signed at the national and international levels have synergy in the development pathway is a key question. (Chan2023) All these thoughts and apprehensions have been discussed in this section. The investment climate in biogas and ethanol technologies also includes local-level investment and markets for these technologies resulting from the policy framework. Recognizing these aspects, the climate for investment is linked to the development pathway. The environmental benefits are also calculated to support the choice of different development pathways. In the path-development planning, the choices of different individuals can affect the policies and lead them to different scenarios. The present study takes the scenario or the policy framework in honor of renewable sources of energy. The objectives to be adopted in the scenario are: to include low and high policy support scenarios to guarantee an accelerated diffusion of renewable sources of energy. The objectives to be chosen under the BAU framework assume that the trends in policy and regulatory policies will continue in the future. (Kipkoech et al.2022)

Conclusion

Summary of the Review Article

In this review article, the state of the art, fundamentals, and basic principles of biogas and biomass are discussed in detail. Biogas and biomass are known to be renewable energy sources. Technologies to produce renewable energy from them have recently been developed to increase their commercial use. (Kasinath et al.2021) This study has reviewed the potential application of these technologies as renewable energy sources. In particular, the application of biogas and biomass for sustainable energy development has been discussed in the context of global energy challenges. The role of biogas and biomass in carbon emission reduction, energy security improvement, environmental enhancement, and potential economic growth is discussed. The review also addresses barriers to biogas and biomass technology development and presents solutions for transformation systems to contribute to sustainable development. The necessity of research and technological advancements, as well as supporting policies for biogas and biomass, is highlighted. Public awareness must also be increased. Collaboration with governments, industry, and academic sectors should be promoted. (Kasinath et al.2021)

A Call to Prepare

At present, the world is experiencing an energy crisis, such as rising oil prices and the decreasing availability of oil as the earth's non-renewable resources diminish. As a result, concerted efforts are being made to develop renewable, sustainable energy sources that can be exploited to meet current energy needs without compromising the ability of future generations to meet their own energy needs. These phenomena are leading to more studies on the potential of alternative energy sources. In this regard, the threat of global warming, mainly due to increased carbon dioxide levels in the atmosphere, is compelling countries to seek ways to reduce their greenhouse gas emissions. In addition, reducing greenhouse gas emissions and increasing energy supplies will potentially alleviate poverty through job creation and local economic benefits.

References:

Yi, S., Abbasi, K. R., Hussain, K., Albaker, A., & Alvarado, R. (2023). Environmental concerns in the United States: Can renewable energy, fossil fuel energy, and natural resources depletion help?. Gondwana Research. [HTML]

Kasinath, A., Fudala-Ksiazek, S., Szopinska, M., Bylinski, H., Artichowicz, W., Remiszewska-Skwarek, A., & Luczkiewicz, A. (2021). Biomass in biogas production: Pretreatment and codigestion. Renewable and Sustainable Energy Reviews, 150, 111509. sciencedirect.com

Kabeyi, M. J. B. & Olanrewaju, O. A. (2022). Biogas production and applications in the sustainable energy transition. Journal of Energy. wiley.com

Antar, M., Lyu, D., Nazari, M., Shah, A., Zhou, X., & Smith, D. L. (2021). Biomass for a sustainable bioeconomy: An overview of world biomass production and utilization. Renewable and Sustainable Energy Reviews, 139, 110691. [HTML]

Atelge, M. R., Krisa, D., Kumar, G., Eskicioglu, C., Nguyen, D. D., Chang, S. W., ... & Unalan, S. (2020). Biogas production from organic waste: recent progress and perspectives. Waste and Biomass Valorization, 11, 1019-1040. [HTML]

Yaqoob, H., Teoh, Y. H., Din, Z. U., Sabah, N. U., Jamil, M. A., Mujtaba, M. A., & Abid, A. (2021). The potential of sustainable biogas production from biomass waste for power generation in Pakistan. Journal of cleaner production, 307, 127250. [HTML]

Cayetano, R. D. A., Kim, G. B., Park, J., Yang, Y. H., Jeon, B. H., Jang, M., & Kim, S. H. (2022). Biofilm formation as a method of improved treatment during anaerobic digestion of organic matter for biogas recovery. Bioresource technology, 344, 126309. [HTML]

Walling, E. & Vaneeckhaute, C. (2020). Greenhouse gas emissions from inorganic and organic fertilizer production and use: A review of emission factors and their variability. Journal of Environmental Management. researchgate.net

Dahlgren, S. (2022). Biogas-based fuels as renewable energy in the transport sector: an overview of the potential of using CBG, LBG and other vehicle fuels produced from biogas. Biofuels. tandfonline.com

Saleem, M. (2022). Possibility of utilizing agriculture biomass as a renewable and sustainable future energy source. Heliyon. cell.com

Lewandowski, W. M., Ryms, M., & Kosakowski, W. (2020). Thermal biomass conversion: A review. Processes. mdpi.com

Ramos, A., Monteiro, E., & Rouboa, A. (2022). Biomass pre-treatment techniques for the production of biofuels using thermal conversion methods–a review. Energy Conversion and Management. [HTML]

Malhotra, M., Aboudi, K., Pisharody, L., Singh, A., Banu, J. R., Bhatia, S. K., ... & Tyagi, V. K. (2022). Biorefinery of anaerobic digestate in a circular bioeconomy: Opportunities, challenges and perspectives. Renewable and Sustainable Energy Reviews, 166, 112642. [HTML]

Yadav, S. P. S., Bhandari, S., Bhatta, D., Poudel, A., Bhattarai, S., Yadav, P., ... & Oli, B. (2023). Biochar application: A sustainable approach to improve soil health. Journal of Agriculture and Food Research, 11, 100498. sciencedirect.com

Rocha-Meneses, L., Luna-delRisco, M., González, C. A., Moncada, S. V., Moreno, A., Sierra-Del Rio, J., & Castillo-Meza, L. E. (2023). An overview of the socio-economic, technological, and environmental opportunities and challenges for renewable energy generation from residual biomass: a case study of biogas production in Colombia. Energies, 16(16), 5901. mdpi.com

Umar, M., Ji, X., Kirikkaleli, D., & Xu, Q. (2020). COP21 Roadmap: Do innovation, financial development, and transportation infrastructure matter for environmental sustainability in China?. Journal of environmental management. academia.edu

Hina, M., Chauhan, C., Kaur, P., Kraus, S., & Dhir, A. (2022). Drivers and barriers of circular economy business models: Where we are now, and where we are heading. Journal of Cleaner Production, 333, 130049. sciencedirect.com

Veleva, S. S., & Tsvetanova, A. I. (2020, September). Characteristics of the digital marketing advantages and disadvantages. In IOP Conference Series: Materials Science and Engineering (Vol. 940, No. 1, p. 012065). IOP Publishing. iop.org

Ampese, L. C., Sganzerla, W. G., Ziero, H. D. D., Mudhoo, A., Martins, G., & Forster-Carneiro, T. (2022). Research progress, trends, and updates on anaerobic digestion technology: A bibliometric analysis. Journal of Cleaner Production, 331, 130004. [HTML]

Wang, Y., Zhang, Y., Li, J., Lin, J. G., Zhang, N., & Cao, W. (2021). Biogas energy generated from livestock manure in China: Current situation and future trends. Journal of Environmental Management, 297, 113324. [HTML]

Lu, Y., Khan, Z. A., Alvarez-Alvarado, M. S., Zhang, Y., Huang, Z., & Imran, M. (2020). A critical review of sustainable energy policies for the promotion of renewable energy sources. Sustainability, 12(12), 5078. mdpi.com

Obaideen, K., Abdelkareem, M. A., Wilberforce, T., Elsaid, K., Sayed, E. T., Maghrabie, H. M., & Olabi, A. G. (2022). Biogas role in achievement of the sustainable development goals: Evaluation, Challenges, and Guidelines. Journal of the Taiwan Institute of Chemical Engineers, 131, 104207. segi.edu.my

Chan, C. K. Y. (2023). A comprehensive AI policy education framework for university teaching and learning. International journal of educational technology in higher education, 20(1), 38. springer.com

Kipkoech, R., Takase, M., & Amankwa Afrifa, E. K. (2022). Renewable energies in Ghana in relation to market condition, the environment, and food security. Journal of Renewable Energy, 2022(1), 8243904. wiley.com

BIOHYDROGEN PRODUCTION FROM AGRICULTURAL AND FOOD WASTE

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ABSTRACT
As the global population continues to grow, the demand for energy in developing countries has significantly increased. The current dependence on fossil fuels has proven inadequate, leading to environmental pollution and critical climate changes. Therefore, it is essential to explore green and sustainable alternative energy sources. Hydrogen research has surged due to its renewable, sustainable, and environmentally friendly characteristics. Various methods for hydrogen production are being investigated, including using agricultural and food wastes as raw materials. Utilizing these abundant and renewable resources for hydrogen production offers significant advantages. Furthermore, producing biohydrogen from agricultural and food waste can enhance the economy by increasing the added value of these products. This study aims to evaluate the research conducted on enhancing product value through hydrogen production using agricultural and food waste.
Keywords: Biohydrogen; sustainability; food and agriculture wastes

ÖZET
Küresel nüfus artmaya devam ederken, gelişmekte olan ülkelerdeki enerji talebi de önemli ölçüde artmıştır. Mevcut fosil yakıtlara bağımlılık yetersiz kalmış, çevre kirliliği ve kritik iklim değişikliklerine yol açmıştır. Bu nedenle, yeşil ve sürdürülebilir alternatif enerji kaynaklarının araştırılması zorunludur. Hidrojen üzerine yapılan araştırmalar, yenilenebilir, sürdürülebilir ve çevre dostu özellikleri nedeniyle büyük bir ivme kazanmıştır. Hidrojen üretimi için çeşitli yöntemler araştırılmakta olup, tarım ve gıda atıklarının hammadde olarak kullanılması da bunlar arasındadır. Bu bol ve yenilenebilir kaynakların hidrojen üretimi için kullanılması önemli avantajlar sunmaktadır. Ayrıca, tarım ve gıda atıklarından biyohidrojen üretimi, bu ürünlerin katma değerini artırarak ekonomiyi de canlandırabilir. Bu çalışmanın amacı, tarım ve gıda atıkları kullanılarak hidrojen üretimi yoluyla ürün değerinin artırılmasına yönelik yapılan araştırmaları değerlendirmektir.
Anahtar Kelimeler: Biyohidrojen; sürdürülebilirlik; gıda ve tarım atıkları

GİRİŞ

Ülke ekonomisinin temel taşlarından biri enerjidir. Enerji, bir ülkede yaşayan insanların refah düzeyi ile ilişkilidir. (Dinesh ve diğerleri,2018). Dünya nüfusundaki artış , gelişen ekonomi ve kentleşme gibi faktörlerle enerjiye olan ihtiyaç giderek artmaktadır. Bu artışın, 2010-2040 yılları arasında, enerji ihtiyacının %56 oranında olması beklenmektedir. Dünyada, Sanayi Devriminden bu yana enerji kaynağı olarak fosil yakıtlara büyük bir odaklanma olmuştur. Günümüzde hala, dünyadaki küresel enerjinin %87'lik kısmı fosil yakıtlardan oluşmaktadır. Fosil yakıtlar, önemli bir enerji kaynağı olup toplam tüketiminde ilk sırada yer almaktadır (Sharma ve diğerleri, 2020). Bu tüketimle beraber fosil yakıtların rezervleride tükenmektedir. Fosil yakıtların tüketilen kısmının üretilmesi milyonlarca yıl sürdüğü için yenilenmeyen kaynaklar arasındadır. Fosil yakıtların diğer dezavantajları ise, yakılması halinde CO_2 emisyonu ile çevre, iklim ve insan sağlığı üzerinde ciddi olumsuz etkilere sebep olmasıdır. Fosil yakıtların kullanılmasıyla dünya çapında hava kirliliği kritik seviyeler ulaşmaktadır. Bunun yanı sıra fosil yakıt emisyonundan kaynaklanan sera gazındaki artış, dünya üzerindeki yağış ve sıcaklık düzenine etki ederek iklim değişiklerine yol açmaktadır. Böylece küresel ısınma sorunu da artmaktadır. Fosil yakıtların bu dezavantajlarında dolayı, fosil yakıtlara alternatif olacak yakıtların araştırılması önem kazanmıştır. Sürdürülebilir bir enerji kaynağı üzerine yoğunlaşmak ve keşfetmek, sürekli büyüyen ve gelişen modern toplumlar için çok ciddi bir konudur. Bu nedenle çoğu araştırmacı, sürdürülebilir yeni enerji kaynaklarının keşfedilmesi için çalışmaklarına devam etmektedir. (Marcin Zieliński ve diğerleri, 2017; Kaptan ve Kargı, 2006) Renksiz , kokusuz olan H_2, iki hidrojen atomundan oluşan diatomik bir gazdır. Tıp, gıda teknolojisi, jeoloji, tarım ve enerji gibi birçok bilimsel dallarda hidrojen üzerine araştırmalar yapılmaktadır (Alwazeer ve diğerleri, 2024).

Bu bağlamda hidrojen, yenilenebilir ve çevre dostu kimliği özelliği ile yeşil enerji kaynağı olarak araştırmacıların dikkatlerini üzerine çekmiştir. Hidrojen yandığı zaman, yanma esnasında enerji ve su açığa çıkar. Bu nedenle son zamanlarda araştırmacıların çoğu, hidrojeni çevre kirliliğinden uzak iklim değişikliklerine ve insan sağılığına olumsuz etkide bulunmayan bir enerji taşıyıcısı olarak değerlendirmektedir. Yüksek enerji potansiyeline 122 (kJ/g) sahip hidrojen sıvılaşarak depolanarak, diğer yakıtlardan daha avantajlı olarak öne çıkmaktadır. mona sharma] Hidrojen diğer fosil yakıtlara oranla, yaklaşık 2,75 kat daha fazla enerji açığa çıkarır. Marcin Zieliński ve,Ewa . Bugünlerde hidrojen enerjisi üretimi, depolanması ve taşınmasıyla ilgili teknolojik gelişmeler, bütün düyada hızla ilerlemekte olup, önümüzdeki süreçlerde enerji sistemlerinin temiz ve karbonsuz hale döünüştürlmesine destek olmaktadır [1Xianxian Xu bir,Quan Zhou ve,Dehai Yu b

Hidrojen, enerji kullanımı dışında kimya, gıda, elektronik gibi birçok alanda kullanılmaktadır. Ancak, hidrojenin doğada serbest halde bulunmaması, üretim aşamasında maliyetini yükseltmektedir. (mona sharma) Bu nedenle maliyeti düşük üretim proseslerinin geliştirilmesi önemlidir. fosil yakıt tabanlı bir enerji tabanından, hidrojen tabanlı bir enerjiye geçiş için gerekli depolama, iletme ve dağıtma teknik zorluklarla doludur. Soyut Biyo-hidrojen üretimi: pratik uygulamaya ilişkin beklentiler ve sınırlamalar Yazar bağlantıları üst panelini açar (David ve diğerleri, 2004)

Günümüzde başka bir küresel sorun ise gıda atığının büyümesi ve bunun uygun bir şekilde yönetilememesidir. Gıdaların üretilmesi, toplanması, işlenmesi, paketlenmesi, depolanması, dağılması, pişirilmesi ve servis edilmesi aşamalarının tümünde gıda atığı oluşmaktadır. düşünülmektedir(Pradeshwaran ve diğerleri,2024)

Dünya genelinde bol bulunan gıda atıkları, belediye atıklarının yaklaşık %15- 63 ünü oluşturmakta ve doğru bir şekilde yönetilemediğinde toplama ve taşıma sırasında koku, sızıntı gibi birçok probleme sebep olmaktadır (Kazmi ve diğerleri,2024). Gıdaya olan talep yıllar içerisinde arttıkça, gıda atıklarının oranı da giderek artmıştır. Bu nedenle gıda atığı ve gıda işleme atığı bol miktarda bulunur. Gıda atıkları, yağ, protein ve karbonhidratlar gibi yüksek

oranda organik bileşikler açısından zengindirler. Bu nedenle, yenilenebilir ve sürdürülebilir enerji kaynağı olarak yüksek bir potansiyele sahiptirler. Gıda atıkları, ham biokütleye oranla daha az işlem gerektirdiği için daha hızlı enerji üretimine de olanak sağlar.
Ayrıca, gıda atıklarında biyo-hidrojen üretimi, bu atıkların uygun şekilde işlenerek, bertaraf edilip işlenmesini de sağlar. Bu nedenle, gıda atıklarını enerji üretiminde kullanmak, ucuz ve sürdürülebilir bir enerji kaynağı sağlarken, çevresel sürdürülebilirliği de artırmaktadır (Sridhar ve diğerleri, 2022). Gıda ısrafının önlenmesi, oluşan gıda atıklarının en iyi şekilde yönetilerek çevre kirliliğinin önlenmesi, dönüştürülmüş enerji için tarımsal ve gıda atıklarının eniyi şekilde kullanılması için yöntemler araştırmak önemlidir. (Kibler ve diğerleri, 2018).

Biohidrojen üretimi
Dünya genelinde hidrojen enerjisine olan ihtiyacın artması nedeniyle, düşük maliyetli ve yüksek verimli hidrojen üretimi için teknolojilerin geliştirilmesi üzerine çalışmalar ilgi görmektedir. Geleneksel hidrojen gazı üretim yöntemleri yüksek sıcaklık (>850°C) uygulamaları gerektiren yöntemlerdir. Membran süreçleri, metanın seçici oksidasyonu ve oksidatif dehidrojenasyon gibi yöntemler, kullanılan teknolojileri iyileştirmek için geliştirilmiş yöntemler arasında yer almaktadır. Biyokütlede hidrojen gazı elde etmek, düşük maliyetli ham madde avantajı sağlasa bile, bu işlem için yüksek sıcaklık (T = 1200 °C) gereksinimi nedeniyle önemli bir sınırlama getirmektedir. Suyun hidrolizi hidrojen üretimi için temiz bir teknolojidir. Ancak, bu teknoloji ile H 2 üretimi için kullanılan elektirik maliyeti, işletme maliyetinin %80'ni oluşturmaktadır. Hidrojen gazı üretimi için, biyolojik üretim yöntemi diğer yöntemlere alternatif bir yöntemdir. Biyohidrojen , anaerob ve fotosentetik mikroorganizmalar tarafından karbohidrat açısından zengin ham maddelerin parçalanması ile oluşur. (Kapdan ve Kargı, 2006). Hidrojen üretiminde, biyolojik yöntemler, fizikokimyasal yöntemlere göre kıyasla daha az enerji tüketir ve daha çevrecidir. Gıda atıklarından hidrojen üretimi için doğrudan biyofotoliz, dolaylı biyofotoliz, fotofermantasyon ve karanlık fermantasyon yöntemleri kullanılmaktadır. Bu yöntemler arasında, organik atıkların bozulma performansı ve yüksek hidrojen üretim hızı ile karanlık fermantasyon yöntemi ön sırada yer almaktadır (Kazmi ve diğerleri, 2024 ; Yun ve diğerleri, 2018). Bunun nedeni, karanlık fermantasyon sürecinin çevre koşullarının kontrolü ve glutamat, demir, molibden, vitamin ve vanadyum gibi çeşitli organik atıkları substrat olarak kullanılabilmesidir. Bunun yanı sıra fotofermantasyon ve biyofotoliz gibi tekdüze ışık yoğunluğunu muhafaza ihtiyacı duymamasıdır. Karanlık fermantasyon yöntemi diğer biyohidrojen üretim yöntemlerine göre daha cazibelidir. (Ahmad ve diğerleri, 2024 ; Genç, 2010).

Biyohidrojen Üretimini Etkileyen Faktörler
Biyohidrojeni üretiminde karbonhidrat önemli bir faktördür. Gıda atıkları karbonhidrat, protein, nişhasta, yağ ve selüloz açısından zengindir. Atıklardaki karbonhidratların, fermantasyona uygun hale gelmesi için hidroliz sürecine ihtiyaç vardır. Hidroliz için asit, alkali, enzimatik gibi uygulamalar kullanılabilir. Biyofermantasyonda mikroorganzima önemli bir faktördür. Clostridium ve Enterobacter gibi mikroorganizmalar tercih edilmesiyle birlikte saf kültürler , yüksek saflıkta hidrojen üretimi sağlar. Biyohidrojen üretimini etkileyen diğer parametre ise reaktör tipidir. Kesikli, yarı-kesikli veya sürekli modlarda üretim gerçekleştirilir. Sürekli karıştırmalı tank reaktörleri (CSTR) yaygın olarak kullanılır.(Koshariya ve diğerleri, 2024)

Biyohidrojen üretiminin faydaları ve zorlukları
Gıda atıklarının ham madde olarak hidrojene dönüştürülmesi , çevre kiriliğinin önlenmesi , ucuz ve sürdürülebilir bir kaynak olması ve kobran nötr olması gibi avantajlara sahiptir. Ancak, gıda işleme atıkları çok çeşitli gıdalardan oluştuğu için tür çeşitliliği fazladır. Gıda ayıkları, geniş bir kimyasal komposizyon ve fiziksel özelliğe sahip olduğu için sınıflandırma

yapmak oldukça zordur. Bu durumda gıda atıklarının kullanılarak biyohidrojene dönüştürülme sürecini optimize etmeyi zorlaştırmaktadır. Aynı zamanda bu durum maliyeti artıran ön işlemler gerektirmektedir.(Sridhar ve diğerleri, 2022)

SONUÇ

Fosil yakıtlar karşısında, yenilenebilir, sürdürülebilir ve çevre dostu bir enerji kaynağı olarak tarımsal ve gıda atıklarından biyohidrojen üretimi umut veren bir enerji kaynağı alternatifidir. Gıda atıkları protein, yağ, karbonhidrat açısından zengin kaynaklardır. Biyohidrojenin en umut verici biyokütle kaynaklarını, biyolojik biyofotoliz, fotofermantsyon ve karanlık fermantasyon yöntemleriyle biyohidrojene dönüştürmek mümkündür. Bu yöntemler arasında tarımsal ve gıda atıklarının çok çeşitli olmaları ve substrat karmaşılığı nedeniyle, karanlık fermantasyon yöntemi ön plana çıkmaktadır. Ancak bu yöntemlerde optimizasyon sorunu ortaya çıkmaktadır.Enerji kaynaklarını fosil yakıt bağımlılığından kurtarıp hidrojen tabanına kaydırmak için üretim süreçlerinin optimizasyonuna ihtiyaç vardır. Aynı zamanda üretim maliyetlerinin düşürülmesi için uygun teknolojik alt yapılar üzerine araştırmaların artırılması gerekmektedir. (Xin ve diğerleri, 2010; Kazmi ve diğerleri, 2024; Kumarel ve diğerleri, 2018)

KAYNAKLAR

- Alwazeer, D., Hancock, JT, Russell, G., Stratakos, AC, Li, L. ve Çiğdem, A. (2023). Moleküler hidrojen: Tarımsal ve gıda üretimi zorlukları için sürdürülebilir bir strateji. Gıda Bilimi ve Teknolojisindeki Sınırlar, 4 , 1448-148.
- Digman, B. ve Kim, D.-S. (2008). İnceleme: Gıda işleme atıklarından alternatif enerji. Çevresel İlerleme, 28 (1)https ://doi .veya/10/b.10312
- Kapdan, IK ve Kargi, F. (2006). Atık malzemelerden biyo-hidrojen üretiminin gözden geçirilmesi. Enzim ve Mikrobiyal Teknoloji, 38 ,
- Kamaraj, M., Ramachandran, KK, & Aravind, J. (2020). Atık malzemelerden biyohidrojen üretimi: Faydaları ve zorlukları. Uluslararası Çevre Bilimi ve Teknolojisi Dergisi, 17, 559-5
- Kazmi, B., Sadiq, T., Taqvi, SAA, Nasir, S., Khan, MM ve AlMohamadi, H. (2024). Sürdürülebilir bir geleceğe doğru: Temiz enerji üretimi için gıda atıklarından biyo-hidrojen üretimi. Proses Güvenliği ve Çevre Koruması, 183 ,
- Koshariya, AK, Krishnan, MS, Jaisankar, S., Loganathan, GB, Sathish, T., Ağbulut, Ü., Saravanan, R., Tuan, LT, & Pham, NDK (2024). Atıktan enerjiye: Gıda atığının gazlaştırılmasından hidrojen üretimi üzerine deneysel bir çalışma. Uluslararası Enerji Dergisi, 54 , 1-1
- Kumaravel Dinesh, G., Chauhan, R. ve Chakma, S. (2018). Gıda atıklarından gelişmiş biyohidrojen üretimi için etki ve stratejiler. Yenilenebilir ve Sürdürülebilir Enerji İncelemeleri, 92 , 8
- Park, M.-J., Kim, H.-M., Lee, Y.-H., Jeon, K.-W., & Jeong, D.-W. (2023). Gıda atıklarından yenilenebilir hidrojen üretim sisteminin optimizasyonu: Anaerobik sindirim ve biyogaz reformunun bir kombinasyonu. Atık Yönetimi, 144, 27
- Sharma, M., Kumar, SS, Kumar, V., Parveen, K., Saini, N., Bansal, D. ve Pugazhendhi, A. (2020). Sürdürülebilir biyohidrojen üretimi için yeşil teknoloji (atıktan enerjiye): Bir inceleme. Toplam Çevre Bilimi, 728 , 13848
- Sridhar, A., Ponnuchamy, M., Kumar, PS, Kapoor, A., & Xiao, L. (2024). Gıda atıklarından hidrojen enerjisi üretiminde ilerleme: Bibliyometrik bir analiz. Uluslararası Enerji Dergisi, 54 ,

- Srivastava, N., Srivastava, M., Abd_Allah, EF, Singh, R., Hashem, A. ve Gupta, VK (2021). Mutfak atıklarını potansiyel substrat olarak kullanarak biyohidrojen üretimi: Sürdürülebilir bir yaklaşım. Chemosphere, 271 , 129537.
- Xu, X., Zhou, Q., & Yu, D. (2022). Hidrojen enerjisinin geleceği: Biyo-hidrojen üretim teknolojisi. Uluslararası Hidrojen Enerjisi Dergisi, 47 , 33677-3369
- Yun, Y.-M., Lee, M.-K., Im, S.-W., Marone, A., Trably, E., Shin, S.-R., Kim, M.-G., Cho, S.-K., & Kim, D.-H. (2018). Gıda atıklarından biyohidrojen üretimi: Mevcut durum, sınırlamalar ve gelecek perspektifleri. Biyolojik Kaynak Teknolojisi, 248 , 79-87.
- Zieliński, M., Korzeniewska, E., Filipkowska, Z., Dębowski, M., Harnisz, M., & Kwiatkowski, R. (2017). Biohydrogen production at low load of organic matter by psychrophilic bacteria. Energy.
- Levin, D. B., Pitt, L., & Love, M. (2004). Biohydrogen production: Prospects and limitations to practical application. International Journal of Hydrogen Energy, 29(2), 173-185.
- Pradeshwaran, V., Sundaramoorthy, V., & Saravanakumar, A. (2024). A comprehensive review on biogas production from food waste: Exploring cutting-edge technologies and innovations. Biomass and Bioenergy, 188, 107336.
- Kibler, K. M., Reinhart, D., & Hawkins, C. (2018). Food waste and the food-energy-water nexus: A review of food waste management alternatives. Waste Management, 74, 52-62.
- Genç, N. (2010). Kocaeli Üniversitesi, Mühendislik Fakültesi, Çevre Mühendisliği Bölümü, İzmit-KOCAELİ. Received/Geliş: 03.11.2009 Revised/Düzeltme: 16.06.2010 Accepted/Kabul: 21.06.2010.
- Ahmad, A., Rambabu, K., Hasan, S. W., Show, P. L., & Banat, F. (2024). Biohydrogen production through dark fermentation: Recent trends and advances in transition to a circular bioeconomy. International Journal of Hydrogen Energy, 52(Part A), 335-357.
- Guo, X. M., Trably, E., Latrille, E., Carrère, H., & Steyer, J.-P. (2010). Hydrogen production from agricultural waste by dark fermentation: A review. International Journal of Hydrogen Energy, 35(19), 10660-10673.

A BIBLIOMETRIC ANALYSIS ON HERB-BASED INJECTABLE VACCINES

BİTKİ BAZLI ENJEKTE EDİLEBİLİR AŞILAR ÜZERİNE: BİBLİYOMETRİK BİR ANALİZ

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ÖZET

Bitki bazlı enjekte edilebilir aşılar, aşı üretiminde maliyet, ölçeklenebilirlik ve soğuk zincir lojistiği gibi zorluklara sürdürülebilir çözümler sunmaktadır. Bu aşılar, bitkilerin moleküler mekanizmalarını kullanarak terapötik proteinlerin ekonomik ve çevre dostu bir şekilde üretilmesini sağlar. Geleneksel mikroorganizma ve memeli hücresi tabanlı yöntemlere kıyasla daha düşük maliyetli ve ölçeklenebilir bir alternatif olarak öne çıkan bitki bazlı aşılar, özellikle COVID-19 pandemisiyle birlikte küresel sağlık gündeminde önem kazanmıştır. Bibliyometrik analiz sonuçlarına göre, 1997-2024 yılları arasında bu alanda 305 yayın yapılmış, ABD lider bir iş birliği merkezi olarak öne çıkmıştır. Araştırmalar, "SARS-CoV-2," "rekombinant protein," ve "geçici ekspresyon" gibi anahtar kelimelerle ilişkilendirilmiş, Medicago'nun geliştirdiği SARS-CoV-2 VLP aşısı gibi örnekler, teknolojinin potansiyelini ortaya koymuştur.

Analizlerde 1048 yazar, 159 araştırma makalesi ve 28 kitap bölümü gibi çeşitli yayın türleri tespit edilmiştir. Yıllık %7,18 büyüme oranı ile literatürde artan bir eğilim gözlenmiştir. VOSviewer ve R yazılımları ile yapılan analizler, ülkeler arasındaki iş birliği ağlarını, anahtar kelime ilişkilerini ve yayın performanslarını görselleştirmiştir. Sonuçlar, bitki bazlı aşıların yalnızca maliyet etkin bir çözüm sunmakla kalmayıp aynı zamanda çevresel sürdürülebilirlik ve biyogüvenlik açısından da avantaj sağladığını göstermektedir. Ancak, düzenleyici gereklilikler ve kalite kontrol süreçleri, bu teknolojinin geniş çaplı benimsenmesinde önemli engeller olarak değerlendirilmektedir. Bu bulgular, bitki bazlı aşıların gelecekteki araştırma yatırımları ve geliştirme süreçleri için stratejik içgörüler sağlamaktadır.

Anahtar kelimeler: Bitkisel Tabanlı Aşılar, Bibliometri, Rekombinant Protein

ABSTRACT

Plant-based injectable vaccines offer sustainable solutions to challenges such as cost, scalability, and cold chain logistics in vaccine production. These vaccines use the molecular mechanisms of plants to produce therapeutic proteins in an economical and environmentally friendly way. Plant-based vaccines, which stand out as a lower-cost and scalable alternative to traditional microorganism and mammalian cell-based methods, have gained importance on the global health agenda, especially with the COVID-19 pandemic. According to the bibliometric analysis results, 305 publications were made in this field between 1997 and 2024, and the USA stood out as a leading collaboration center. Studies were associated with keywords such as "SARS-CoV-2," "recombinant protein," and "transient expression," and examples such as the SARS-CoV-2 VLP vaccine developed by Medicago demonstrated the potential of the technology. Various publication types were identified in the analysis, including 1048 authors, 159 research articles, and 28 book chapters. An increasing trend was observed in the literature with an annual growth rate of 7.18%. The analyses performed with VOSviewer and R software visualized the collaboration networks, keyword relationships and publication performances among the countries. The results show that plant-based vaccines not only provide a cost-effective solution but also provide advantages in terms of environmental sustainability and biosafety. However, regulatory requirements and quality control processes are considered as important obstacles to the widespread adoption of this technology. These findings provide strategic insights for future research investments and development processes of plant-based vaccines.

Keywords: Artificial Intelligence, Autonomous Systems, Ethics, Reliability, Openness.

INTRODUCTION

Son yıllarda biyoteknolojideki hızlı ilerlemeler, bitkilerin sağlık alanında yenilikçi çözümler sunma kapasitesini ortaya koymuştur. Bu gelişmeler arasında yer alan bitki bazlı enjekte edilebilir aşılar, sürdürülebilir üretim süreçleri ve düşük maliyet avantajlarıyla geleneksel aşılara kıyasla önemli bir alternatif olarak dikkat çekmektedir (Streatfield & Howard, 2003). Bitkilerin biyoreaktör olarak kullanılması sayesinde, rekombinant proteinler insan ve hayvan hastalıklarına karşı etkili bağışıklık tepkileri oluşturmak için üretilebilmekte ve bu süreçler daha çevre dostu hale gelmektedir (Phan & Conrad, 2016).

Bitkisel kaynaklı aşılar, protein saflaştırma ve hedefe yönelik dağıtım açısından benzersiz avantajlar sunmaktadır (Su et al. 2023). Özellikle, Medicago tarafından geliştirilen SARS-CoV-2 VLP aşısı gibi örnekler, bitkilerde üretilen antijenlerin etkinliğini ve güvenliğini kanıtlayarak bu teknolojinin potansiyelini gözler önüne sermektedir. Geleneksel mikroorganizma ve memeli hücre tabanlı üretim yöntemlerinin yüksek altyapı maliyetleri ve karmaşık süreçlerine karşılık, bitki bazlı terapötik protein üretimi büyük ölçekli üretim ve düşük maliyet açısından önemli avantajlar sağlamaktadır (Venkataraman & 2023; Kumar et al. 2021).

Bu aşılar, hem sistemik hem de mukozal bağışıklık tepkilerini tetikleyebildiği için viral hastalıkların önlenmesinde etkili bir seçenek olarak öne çıkmaktadır (Streatfield, 2006). Bununla birlikte, düzenleyici gereklilikler, kalite kontrol süreçleri ve ürün güvenliği gibi faktörler, bu teknolojinin geniş çaplı kullanımının önündeki temel engelleri oluşturmaktadır (Laere et al. 2016). Ayrıca, düzenleyici onay süreçlerinin yavaş ilerlemesi ve ürünlerin güvenilirliğinin kanıtlanması gerekliliği, bu yenilikçi yaklaşımların yaygınlaşmasını sınırlayan unsurlar arasında yer almaktadır (Jadhav & Khare, 2024). Bununla birlikte, bitki bazlı aşılar, biyoteknolojideki gelişmeler doğrultusunda sağlık sektörüne sunduğu çevre dostu ve ekonomik avantajlarla, küresel sağlık sorunlarının çözümüne yönelik yeşil teknolojilerin artan önemini yansıtmaktadır. Bununla birlikte, bu alanda yapılan araştırmalar ve klinik çalışmalar, bitki bazlı enjekte edilebilir aşıların potansiyelini daha iyi anlamamıza yardımcı olmaktadır. Bitki bazlı aşılarla ilgili literatür kapsamı giderek genişlese de, bu alandaki çalışmaların genel eğilimleri, araştırma boşlukları ve gelecekteki yönelimlerini belirlemek adına kapsamlı bir bibliyometrik analiz gereklidir (Donthu et al. 2021). Bibliyometrik analizler, yayınlar arasındaki ilişki ağlarını, anahtar araştırma alanlarını ve bu alandaki bilimsel ilerlemenin yönünü anlamak için önemli bir araçtır (Donthu et al. 2021).

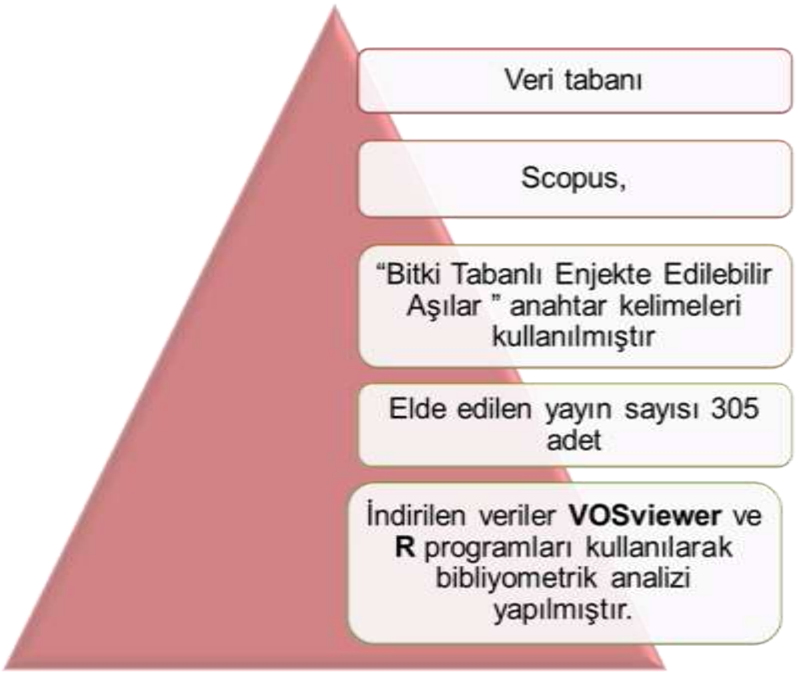
Bu çalışma, bitki bazlı enjekte edilebilir aşılarla ilgili mevcut literatürü bibliyometrik bir yaklaşımla incelemeyi amaçlamaktadır. Bu kapsamda, yayınların yıllara göre dağılımı, etkili araştırma grupları, işbirlikçi ağlar ve en çok alıntı yapılan çalışmalar gibi unsurlar analiz edilmiştir. Elde edilen bulgular, bitki bazlı aşı teknolojisinin bilimsel gelişimine ışık tutarak gelecekteki araştırmalara yön verecek nitelikte olacaktır.

MATERYAL ve YÖNTEM

Araştırmada toprak işlemenin yabancı otlar üzerine etkisi ile ilgili yapılan çalışmaların bibliyometrik analizini yapmak için, "Bitki Tabanlı Enjekte Edilebilir Aşılar" anahtar kelimeleri Scopus veri tabanında arama yapıldığında elde edilen 305 yayın üzerinde VOSviewer ve R programları kullanılarak bibliyometrik analizi yapılmıştır.

Yöntem

Bibliyometrik analiz için Scopus veri tabanında yapılan arama sonucunda elde edilen 305 yayın kullanılarak bibliyometrik analiz yapılmıştır. Bibliyometrik analiz için kullanılan yöntem Şekil 1'de şematize edilmiştir.



Şekil 1. Bibliyometrik analizi için veri indirme şeması

Şekil 2. Çalışmada kullanılan Vosviwer ve R progmında yapılan analizler

Veri Analizi

Ülke sıralaması, dergiler vb. ile ilgili betimsel analiz için Microsoft Excel, atıf ve anahtar kelime analizi ve görselleştirmeleri için VOSviewer ve ülkelerin işbirliği en sık kullanılan terimler, anahtar kelimelerin trend durumları ve anahtar kelimelerin gruplama analizi R programı üzerinden, bibliometrix'in web tabanlı arayüzü olan "biblioshiny" kullanılmıştır.

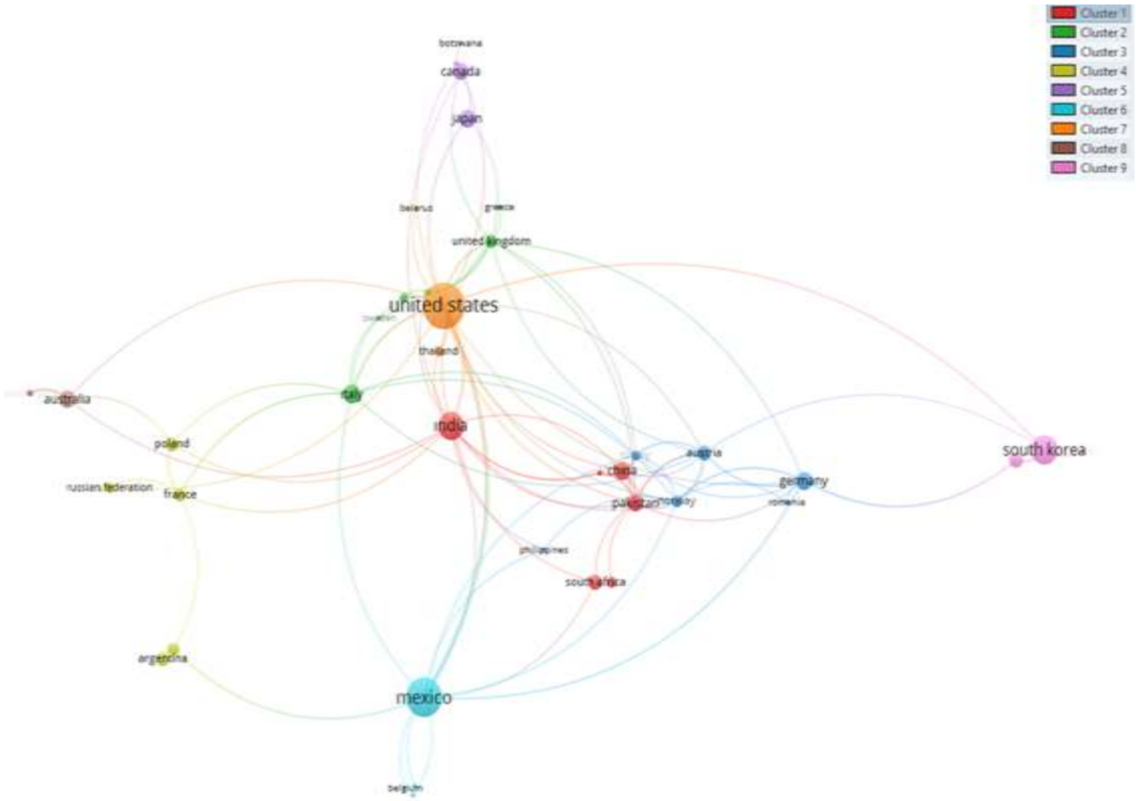
BULGULAR

Bitki bazlı enjekte edilebilir aşılar üzerine yapılan çalışmalar, 1997 yılında başlamış ve zamanla önemli bir gelişim göstermiştir. Yayın sayısında, yıllara bağlı dalgalanmalar yaşanmışmıştır. Bu konu ile ilgili yapılan yayınların ana bilgileri Çizelge 2'de verilmiştir.

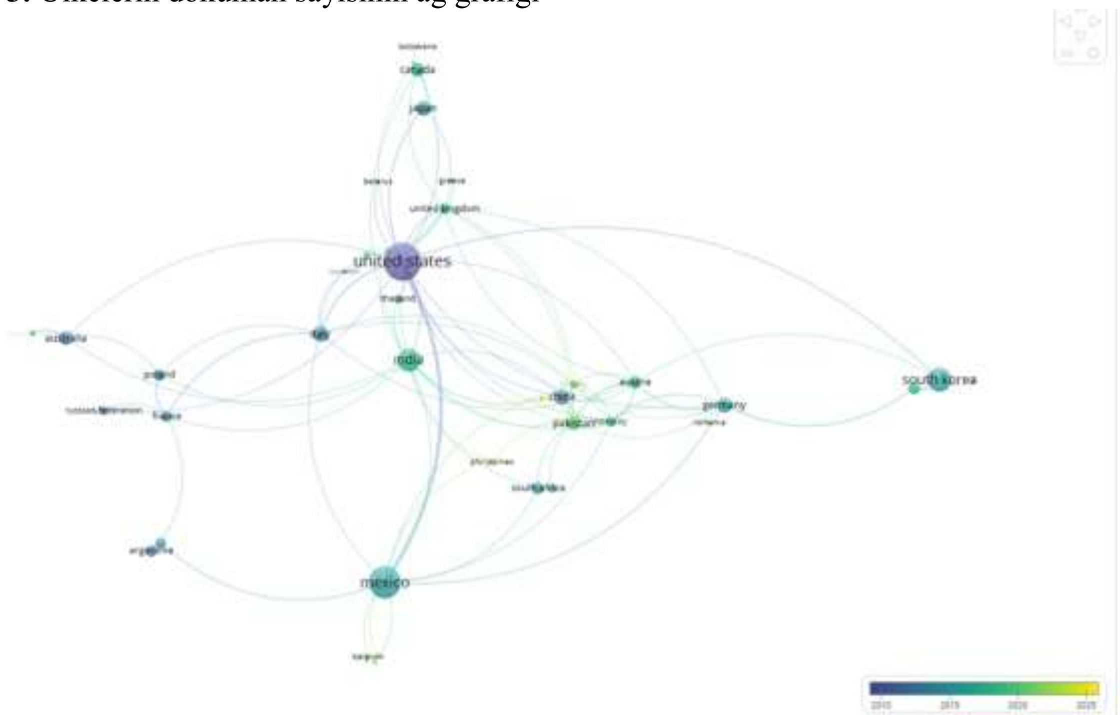
Çizelge 2. Bitki Tabanlı Enjekte Edilebilir Aşılar Üzerine Yapılan Çalışmaların Ana Bilgileri

Veriler Hakkında Ana Bilgiler	Sonuçlar
Zaman aralığı	1997:2024
Kaynaklar (Dergiler, Kitaplar, vb.)	153
Belge	305
Yıllık büyüme oranı %	7,18
Belge ortalama yaşı	10,1
Doküman başına ortalama atıf	24,58
Anahtar Kelimeleri	2705
Yazarlar	1048
Tek yazarlı dokümanlar	45
Doküman başına ortak yazarlar	4,95
Uluslararası ortak yazarlıklar %	23,28
Yayın Türleri	
Makale	159
Kitap	5
Kitap Bölümü	28
Kongre bildirisi	10

1997-2024 yılları arasında bitki tabanlı enjekte edilebilir aşılar konusuna odaklanan bir araştırmada, toplamda 153 farklı kaynaktan 305 doküman incelenmiştir. Bu dokümanların ortalama yaşı 10,1 yıl olarak belirlenmiş, bu da konuya ilişkin literatürün nispeten güncel olduğunu göstermektedir. Araştırma kapsamında toplamda 1048 yazarın katkıda bulunduğu ve bu çalışmaların 2705 farklı anahtar kelime içerdiği belirlenmiştir. Ayrıca uluslararası ortak yazarlık oranı %23,28 olarak hesaplanmış, bu da bitki tabanlı enjekte edilebilir aşılar konusundaki araştırmaların önemli bir kısmının uluslararası iş birliği ile gerçekleştirildiğini göstermektedir. İncelenen dokümanların türlerine bakıldığında, 159'unun araştırma makalesi, 28'inin ise kitap bölümü olduğu tespit edilmiştir (Çizelge 2).



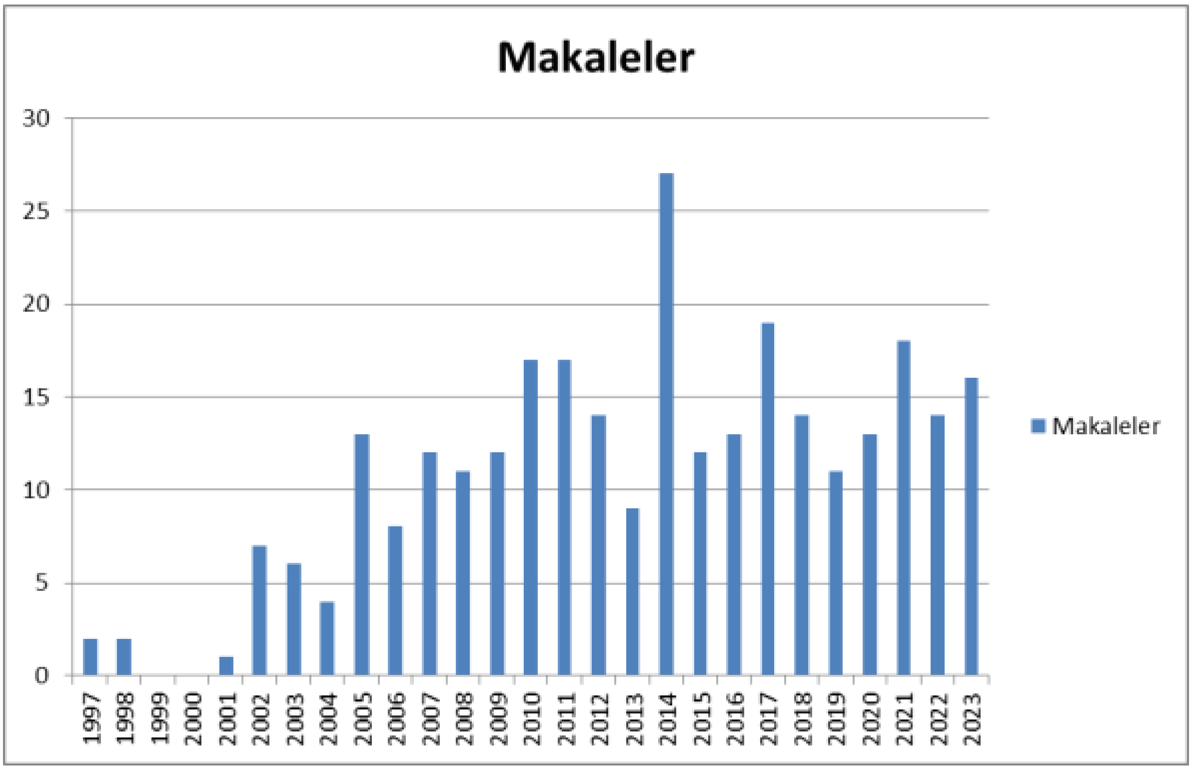
Şekil 3. Ülkelerin doküman sayısının ağ grafiği



Şekil 4. Ülkelerin Zaman Haritası

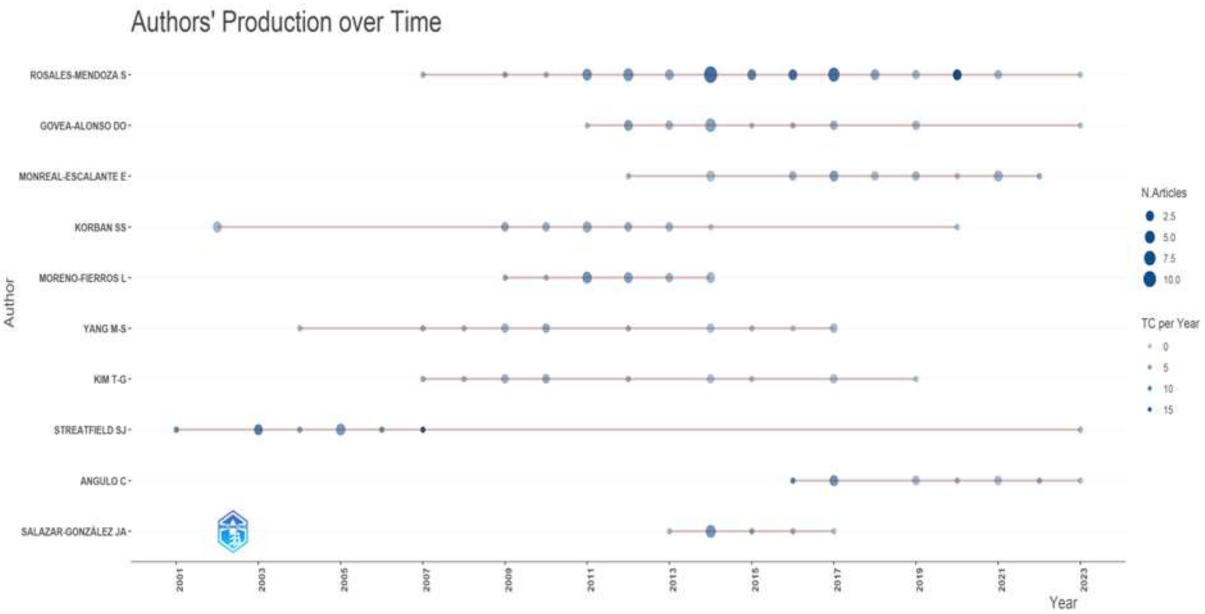
Araştırma kapsamında, ülkelerin bilimsel iş birlikleri ve aldıkları atıflar doğrultusunda 9 ana kümeye ayrıldığı tespit edilmiştir. Bu kümeleme, ülkelerin bitki tabanlı enjekte edilebilir aşılar alanındaki araştırmalarda nasıl bir rol oynadığını ve iş birliği ağlarındaki konumlarını ortaya koymaktadır. İş birliği ağının merkezinde Amerika Birleşik Devletleri'nin (ABD) yer aldığı belirlenmiştir. Bu durum, ABD'nin alandaki bilimsel üretim ve iş birliklerinde lider bir rol oynadığını göstermektedir. Küme analizine göre, Hindistan, Meksika, Almanya, İtalya ve

Güney Kore gibi ülkelerin, kendi kümelerinde yaptıkları iş birlikleri ve aldıkları atıflarla öncü bir konumda olduğu görülmüştür. Türkiye'nin ise Almanya'nın liderlik ettiği kümede yer aldığı belirlenmiştir. Bu durum, Türkiye'nin bilimsel üretim açısından Almanya ve diğer ortaklarıyla yakın bir iş birliği içinde olduğunu göstermektedir (Şekil 3). Ayrıca Türkiye ve Lübnan'ın, bitki tabanlı enjekte edilebilir aşılar alanında güncel çalışmalar yürüttüğü saptanmıştır (Şekil 4).



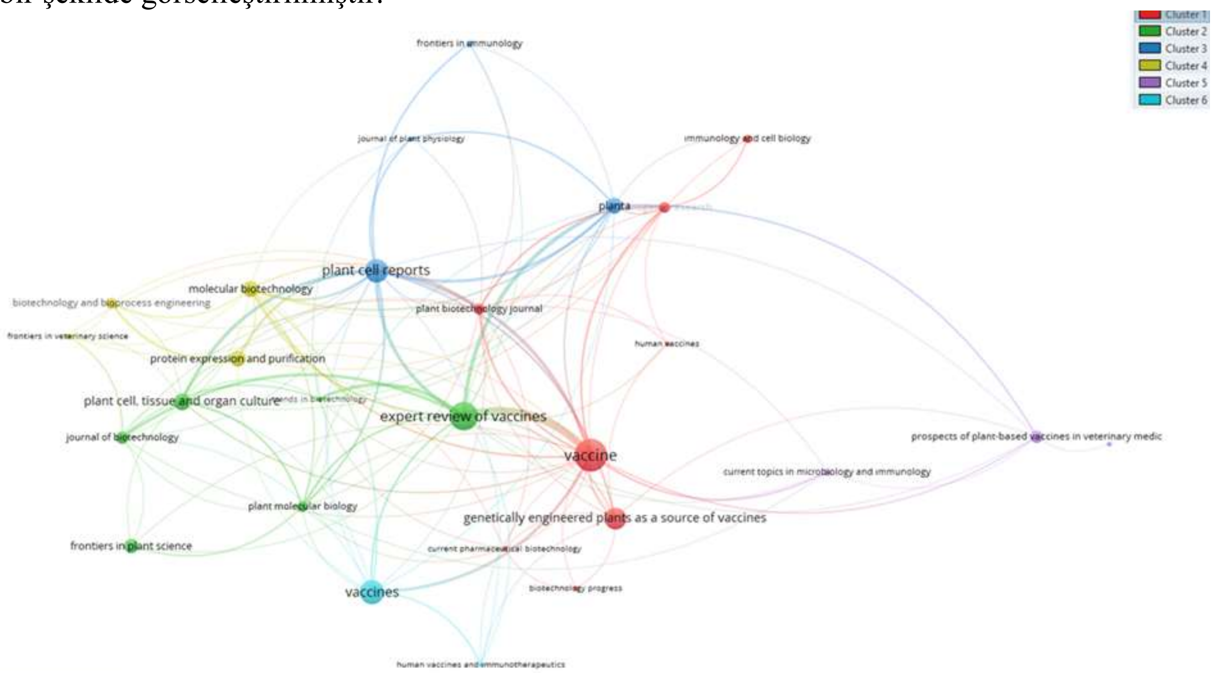
Şekil 5. Bitki Tabanlı Aşılar ile ilgili yapılan yayınların yıllara göre sayısı

Araştırma, 1997-2024 yılları arasında gerçekleştirilen bitki tabanlı enjekte edilebilir aşılar konusundaki çalışmaları kapsamaktadır. Bu süreçte, yıllık yayın sayılarında dikkat çekici dalgalanmalar gözlemlenmiştir. Özellikle 2014 yılı, 27 yayın ile en fazla çalışmanın yapıldığı yıl olarak öne çıkmaktadır. Bu yılı, 2017 yılında gerçekleştirilen 19 yayın takip etmiş, bu da bu dönemde konunun bilimsel alanda yüksek bir ilgi gördüğünü ortaya koymuştur. Çalışmaların yıllara göre dağılımını görsel olarak değerlendirmek amacıyla hazırlanan grafik ise Şekil 5'te sunulmuştur. Bu grafik, yayın sayısındaki artış ve azalışların zaman içindeki seyrini detaylı bir şekilde ortaya koyarak, bu alandaki araştırma eğilimlerini daha net bir şekilde anlamaya olanak sağlamaktadır.



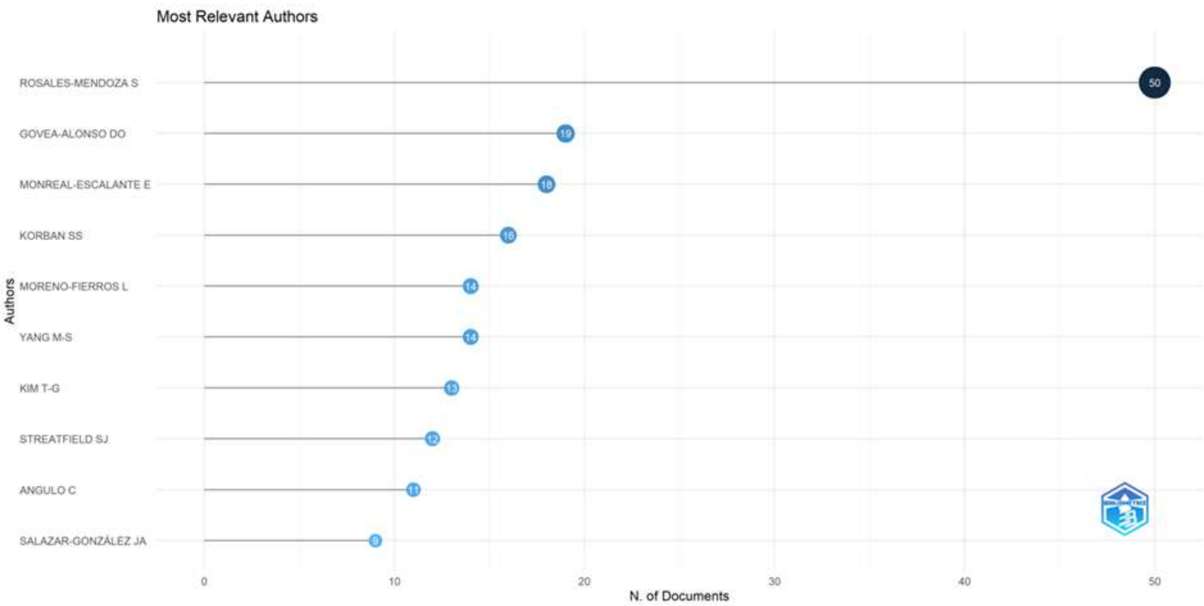
Şekil 6. Yazarların üretkenlik zamanları

Araştırma kapsamında, bitki tabanlı enjekte edilebilir aşılar konusuna uzun yıllar boyunca katkı sağlayan başlıca araştırmacılar tespit edilmiştir. Bu araştırmacılar, alanın gelişimine sürekli ve önemli katkılar sunarak, konuyla ilgili bilgi birikiminin genişlemesine ve derinleşmesine öncülük etmişlerdir. Belirlenen araştırmacılar arasında Streatfield SJ (2001-2023) en uzun süreli katkı sağlayan isimlerden biri olarak dikkat çekmektedir. Onu, Korban SS (2002-2020) ve Rosales-Mendoza S (2007-2023) takip etmektedir. Ayrıca, Yang MS (2004-2017), Govea-Alonso DO (2011-2023), Kim TG (2007-2019) ve Monreal-Escalante E (2012-2022) de bu alanda önemli çalışmalar gerçekleştiren diğer araştırmacılar arasında yer almaktadır. Araştırmacıların çalışmalarının zamansal dağılımı ve sürekliliği Şekil 6'da detaylı bir şekilde görselleştirilmiştir.



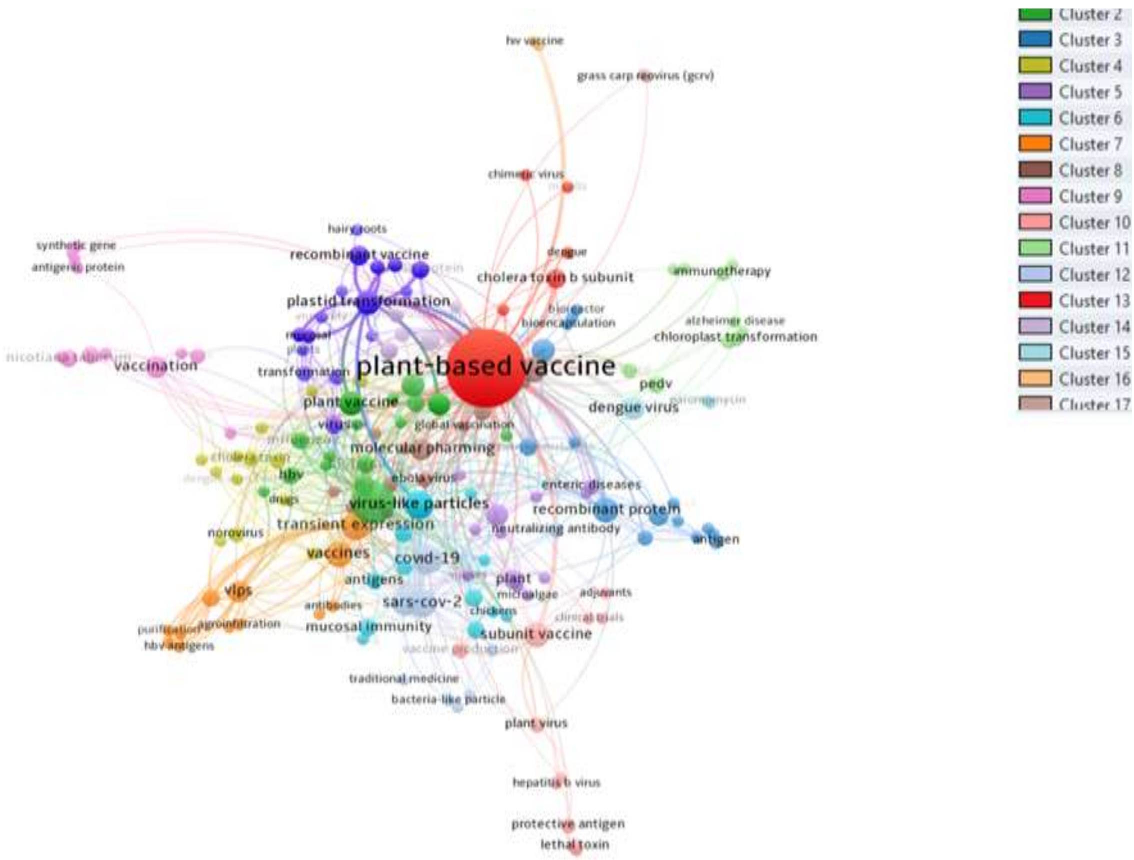
Şekil 7. Dergilerin atıf ağ haritası

Araştırma kapsamında, enjekte edilebilir aşılar ile ilgili toplamda 153 kaynakta yayın yapıldığı tespit edilmiştir. Bu yayınlarda en az iki veya daha fazla kez tekrar edilen anahtar kelimelerden hareketle 32 farklı dergi öne çıkarılmıştır. Bu dergilerin konuya olan katkıları ve bilimsel etkileri dikkate alınarak altı ana kümeye ayrıldığı görülmüştür. En fazla atıf alan dergiler arasında Vaccine, Plant Cell Reports, Expert Review of Vaccines, Molecular Biotechnology, Genetically Engineered as a Source of Vaccine, Plant Biotechnology Journal ve Planta gibi prestijli yayın organları bulunmaktadır. Bu dergiler, alandaki araştırmaların bilimsel yayılımını ve literatüre etkisini artıran temel kaynaklar olarak öne çıkmaktadır. Dergilerin alandaki etkilerinin ve kümeler arasındaki ilişkilerinin görselleştirildiği analiz Şekil 7'de sunulmuştur.



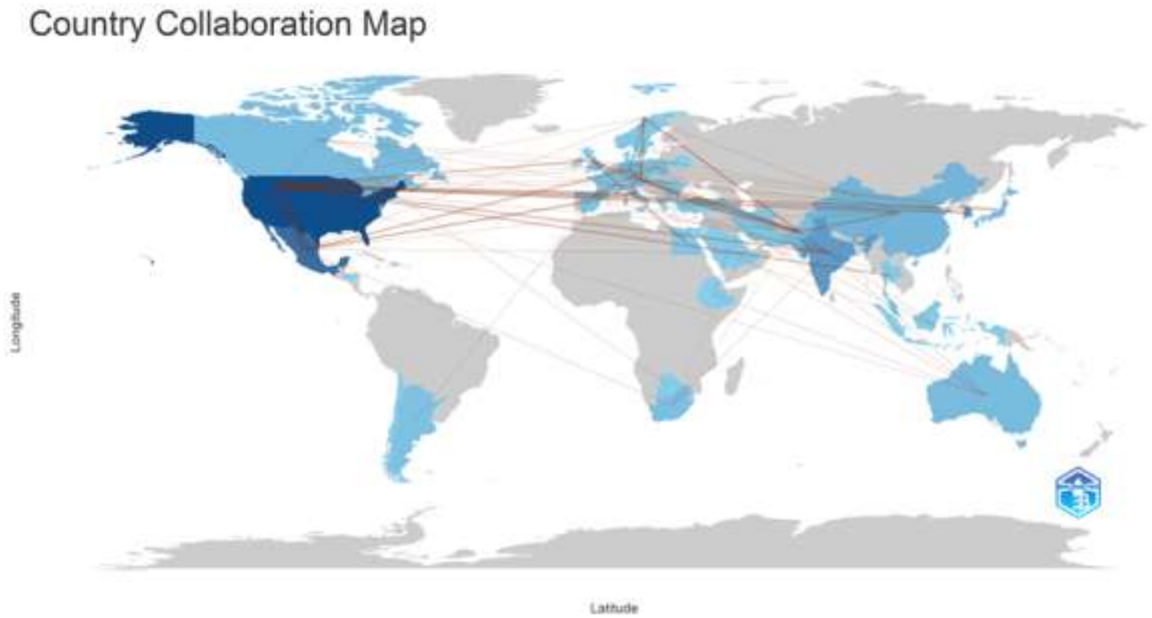
Şekil 8. En fazla yayın yapan yazarlar

Bitki tabanlı enjekte edilebilir aşılar alanında çalışma yapan 1048 yazar arasında, en fazla yayın yapan araştırmacılar tespit edilmiştir. Bu isimler, alanın gelişimine yaptıkları katkılarla dikkat çekmektedir. Rosales-Mendoza S, 50 yayın ile en üretken araştırmacı olarak öne çıkarken, onu sırasıyla Govea-Alonso DO (19 yayın), Monreal-Escalante E (18 yayın), Korban SS (16 yayın), Moreno-Fierros L (14 yayın), Kim TG (13 yayın), Streatfield SJ (12 yayın), Angula C (11 yayın) ve Salazar-Gonzalez JA (9 yayın) takip etmektedir (Şekil 8).



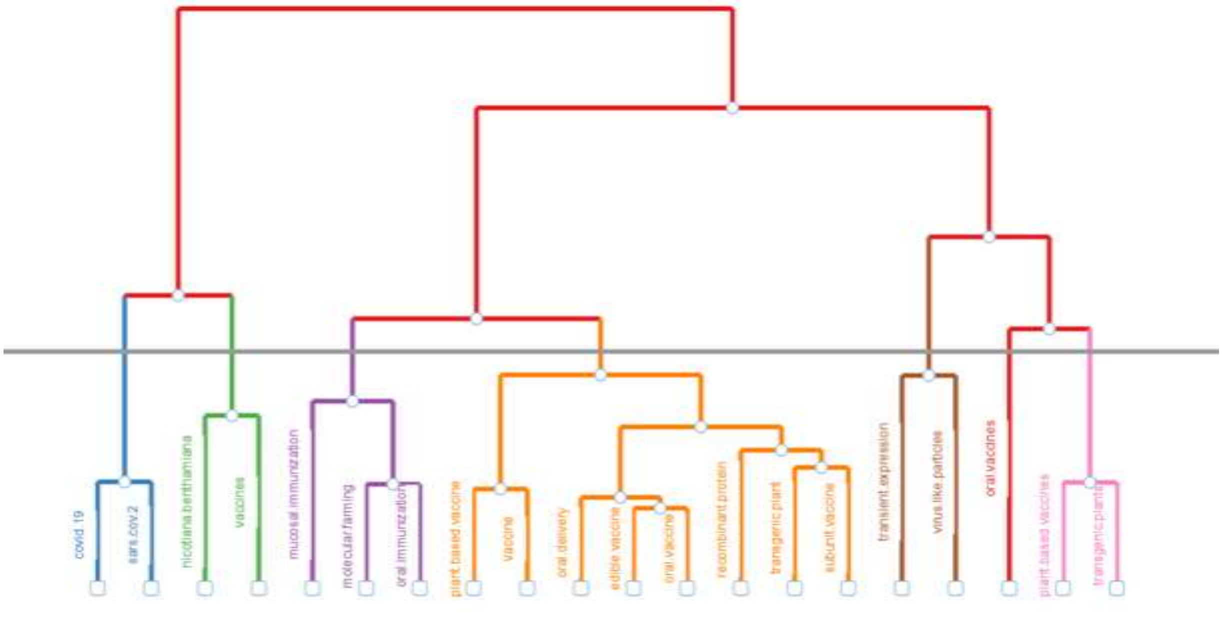
Şekil 9. Anahtar kelime analizi

Bitki tabanlı enjekte edilebilir aşılarla ilgili yapılan çalışmalar, anahtar kelimeler açısından incelendiğinde toplamda 837 farklı anahtar kelimenin kullanıldığı belirlenmiştir. Bu geniş anahtar kelime havuzu, alandaki araştırmaların kapsamını ve çeşitliliğini yansıtmaktadır. Araştırmada, en az iki kez tekrar eden 195 anahtar kelime detaylı bir şekilde değerlendirilmiş ve bu kelimelerin kullanım sıklığına göre 17 ana kümeye ayrıldığı tespit edilmiştir. Analiz sonuçlarına göre, "Bitki bazlı aşılar" anahtar kelimesi ağın merkezinde yer almış ve en sık kullanılan terim olarak dikkat çekmiştir. Bu durum, "Bitki bazlı aşılar" anahtar kelimelerin, bu alandaki çalışmaların temel kavramlarından biri olduğunu göstermektedir. Bunun yanı sıra, "rekombinant protein", "SARS-CoV-2", "aşı", "COVID-19", "plastid dönüşümü" ve "geçici ekspresyon" gibi anahtar kelimeler de sık kullanıldıkları öne çıkmıştır. Anahtar kelimelerin kullanım sıklıkları ve kümeler arasındaki ilişkiler, alandaki eğilimlerin ve araştırma önceliklerinin anlaşılması açısından önemli ipuçları sunmaktadır. Bu kapsamda, anahtar kelimelerin ilişkisel dağılımını ve kümeler arasındaki bağlantıları görselleştiren analiz Şekil 9'da detaylı olarak gösterilmiştir.



Şekil 10. Ülkelerin ortak yayın haritası

Araştırmada, 18 ülkenin iş birliği içinde olduğu tespit edilmiştir. En fazla ortak yayın yapan ülkeler arasında ABD ve Meksika 13 yayınla ilk sırada yer almıştır. Diğer ortaklıklar arasında Pakistan ve Avustralya (4 yayın), Norveç ve Avustralya (3 yayın), Pakistan ve Türkiye (3 yayın), ABD ve İtalya (3 yayın) bulunmaktadır. Ayrıca Türkiye ve Avustralya, Pakistan ve Çin, Fransa ve Polonya, Almanya ve Avustralya, Norveç ve Almanya, Fransa ve İtalya, Meksika ve Almanya, İspanya ve Meksika, Pakistan ve Norveç, Birleşik Krallık ve Mısır ikişer yayın yapmıştır. Ortak yayın ilişkileri Şekil 10'da detaylı olarak gösterilmektedir.



Şekil 11. Topik Dendrogram

Bitki bazlı enjekte edilebilir aşılarla ilgili yapılan çalışmaların anahtar kelimelerinin kümelenme analizi, araştırmaların odaklandığı temaları ve konu başlıklarını açık bir şekilde ortaya koymaktadır. Analiz sonuçlarına göre, bu anahtar kelimeler iki ana küme etrafında toplanmıştır. İlk kümede, özellikle COVID-19 pandemisinin etkisiyle öne çıkan "Covid-19", "SARS-CoV-2", "Nicotiana benthamiana" ve "vaccines" gibi anahtar kelimeler yer almaktadır. Bu küme, bitki bazlı aşıların viral hastalıklarla mücadeledeki rolüne ve özellikle

SARS-CoV-2'ye karşı geliştirilmiş aşılarla ilgili çalışmalara odaklanıldığını göstermektedir. Diğer kümede ise anahtar kelimeler kendi içinde alt gruplar oluşturarak daha çeşitli araştırma alanlarını temsil etmektedir. Bu alt gruplar, bitki bazlı aşıların üretim teknolojileri, immünolojik etkileri ve diğer terapötik uygulamaları gibi konularla ilişkilidir. Bu bulgular, bitki bazlı aşılarla ilgili çalışmaların küresel sağlık ihtiyaçlarına göre şekillendiğini ve literatürün pandemik tehditler, teknolojik yenilikler ve terapötik hedefler gibi çok boyutlu bir yaklaşımla ele alındığını ortaya koymaktadır.

SONUÇ

Bu çalışma, bitki bazlı enjekte edilebilir aşılar konusunda yapılan araştırmaların kapsamını, eğilimlerini ve tematik odaklarını analiz etmiştir. 1997-2024 yılları arasında bitki bazlı enjekte edilebilir aşılarla ilgili 153 kaynaktan 305 dokümanın elde edilmiştir. Özellikle ABD'nin ağın merkezinde yer alması ve Hindistan, Meksika, Almanya gibi ülkelerin öncü rol oynaması, bu teknolojinin uluslararası önemini vurgulamaktadır.

Türkiye'nin, Almanya'nın liderlik ettiği kümelerden birinde yer alması, ülkenin bu alandaki potansiyelini göstermektedir. Ancak, bu sonuç Türkiye'nin araştırma kapasitesinin daha da artırılması gerektiğini de işaret etmektedir.

"Bitki bazlı aşılar", "rekombinant protein" ve "COVID-19" gibi anahtar kelimelerin sık kullanımı, bu alandaki çalışmaların güncel sağlık sorunlarına yönelik olduğunu ve SARS-CoV-2 pandemisinin bitki bazlı aşı araştırmalarına yön verdiğini göstermektedir. Sonuç olarak, bitki bazlı enjekte edilebilir aşılar üzerine yapılan araştırmalar, pandemik tehditlere karşı çözüm geliştirme, üretim süreçlerini optimize etme ve immünolojik etkileri artırma konularında önemli katkılar sağlamıştır.

KAYNAKLAR

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. Journal of business research, 133, 285-296.

Jadhav, R. R., & Khare, D. (2024). Green biotherapeutics: overcoming challenges in plant-based expression platforms. Plant Biotechnology Reports, 1-22.

Kumar, M., Kumari, N., Thakur, N., Bhatia, S. K., Saratale, G. D., Ghodake, G., ... & Chung, S. M. (2021). A comprehensive overview on the production of vaccines in plant-based expression systems and the scope of plant biotechnology to combat against SARS-CoV-2 virus pandemics. Plants, 10(6), 1213.

Laere, E., Ling, A. P. K., Wong, Y. P., Koh, R. Y., Mohd Lila, M. A., & Hussein, S. (2016). Plant-based vaccines: Production and challenges. Journal of Botany, 2016(1), 4928637.

Phan, H. T., & Conrad, U. (2016). Plant-based vaccine antigen production. Vaccine technologies for veterinary viral diseases: methods and protocols, 35-47.

Streatfield, S. J. (2006). Mucosal immunization using recombinant plant-based oral vaccines. Methods, 38(2), 150-157.

Streatfield, S. J., & Howard, J. A. (2003). Plant-based vaccines. International journal for parasitology, 33(5-6), 479-493.

Su, H., Van Eerde, A., Rimstad, E., Bock, R., Branza-Nichita, N., Yakovlev, I. A., & Clarke, J. L. (2023). Plant-made vaccines against viral diseases in humans and farm animals. Frontiers in plant science, 14, 1170815.

Venkataraman, S., Khan, I., Habibi, P., Le, M., Lippert, R., & Hefferon, K. (2023). Recent advances in expression and purification strategies for plant made vaccines. Frontiers in Plant Science, 14, 1273958.

NUTRITIONAL CONTENT AND BIOACTIVE COMPOUNDS OF WALNUT GREEN HUSK AND LEAVES: THEIR APPLICATIONS AND POTENTIAL USE IN ANIMAL NUTRITION

CEVIZ YEŞIL KABUĞUNUN VE YAPRAKLARININ BESIN İÇERIKLERI İLE BIYOAKTIF BILEŞIKLERININ KULLANIM ALANLARI VE HAYVAN BESLEMEDE KULLANILABILIRLIĞI

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Özet
Ceviz, içerdiği zengin besin maddeleriyle önemli bir meyve olarak kabul edilmektedir. Ceviz yeşil kabukları ve yaprakları da atık olarak değerlendirilmekte ve içerdikleri yüksek konsantrasyonlarda fenolik bileşikler, flavonoidler klorojenik asit, kafeik asit, ferulik asit gibi fenolik asitler ile juglon gibi özel bileşikleri ve diğer biyoaktif maddeler içermektedir. Bu bileşiklerin antioksidan, antimikrobiyal ve anti-inflamatuar özellikleri vardır. Bu bileşikler sayesinde endüstride boya üretiminden başlayarak, tıp alanında tedavi edici özelliklerine kadar birçok farklı alanda faydalanılabilmektedir. Ayrıca, bu bileşiklerin hayvan sağlığını destekleyici ve hastalıklara karşı koruyucu etkileri olduğu bilinmektedir. Bu makalede, ceviz yan ürünleri olan yeşil kabukları ve yapraklarının besin içerikleri, biyoaktif bileşenleri ve bu bileşiklerin hayvan besleme alanındaki kullanım potansiyeli ele alınmıştır.
Anahtar kelimeler: Ceviz yeşil kabuğu, ceviz yeşil yaprakları, hayvan besleme, fenolik bileşikler

Abstract
Walnut is considered an important fruit due to its rich nutritional content. The green husks and leaves of the walnut are also evaluated as by-products, containing high concentrations of phenolic compounds, such as flavonoids, chlorogenic acid, caffeic acid, ferulic acid, as well as unique compounds like juglone, and other bioactive substances. These compounds possess antioxidant, antimicrobial, and anti-inflammatory properties. Due to these properties, they can be utilized in a wide range of fields, from industrial dye production to therapeutic applications in medicine. Additionally, these compounds are known to support animal health and provide protective effects against diseases. This article explores the nutritional content and bioactive components of walnut by-products, specifically the green husks and leaves, and discusses their potential applications in the field of animal nutrition.
Key Words: Green walnut shell, green walnut leaves, animal nutrition, phenolic compounds

GİRİŞ

Ceviz yaprağı, iç ve dış kabuğu ve hatta iç zarı bile farklı amaçlarla çok değerli hammadde kaynakları olarak kullanılmaktadır (Karadeniz, 2004, Martinez ve ark. 2010). Dünya genelinde her yıl yaklaşık 1.3 milyon hA' da 2.9 milyon ton ceviz yeşil kabuğu atığının (%64 hesabıyla) (FAO, 2019), ülkemizde ise 125 bin hA' da 144 bin ton ceviz yeşil kabuğu (TÜİK,

2019) ortaya çıktığı tahmin edilebilir. Ceviz yan ürünleri yaprak ve yeşil kabuğu katma değeri yüksek ürünlerin geliştirilmesinde kullanılabilecek kimyasal bileşime ve biyoaktif özelliklere sahiptir. Bu ürünler boya üretiminden tıp alanına kadar endüstri ve sağlık gibi birçok değişik alanda kullanılmaktadır. Biyolojik ve farmakolojik aktiviteleri nedeniyle çeşitli hastalıkların tedavisinde etkili ve olumlu sonuçlar gösterebilmekte, kemoterapötik ajanlar olarak kullanılabilmektedir (Salık ve ark., 2023). Hayvan işletmelerinde yoğun üretimden dolayı oluşabilecek stres kaynakları hayvanların bağışıklık sistemini zayıflatmakta, paraziter hastalıklar da verim ve kaliteyi doğrudan düşürmektedir. Bu nedenle yüksek kapasiteli hayvanlardan maksimum verimin alınabilmesi amacıyla uygun besleme koşullarının yanı sıra özellikle de kanatlı hayvan sektöründe Avrupa Birliğinde, ve Türkiye'de yem katkı maddesi olarak antibiyotik kullanımı yasaklanması sonrası antibiyotik yerine geçebilecek tıbbi ve aromatik özellikli bitkisel yem katkı maddeleri kullanılması önem kazanmıştır. Ceviz yeşil kabuğu ve yaprakları da bu amaçla kullanılabilecek ürün yelpazesi içinde değerlendirilebilir. Bu makalede cevizin önemli yan ürünleri olan ceviz yeşil kabuğu ile ceviz yapraklarının besin içerikleri, biyoaktif bileşenlerinin kullanım alanları ile hayvan beslemedeki kullanılabilirliği irdelenmiştir.

CEVIZ YEŞIL KABUĞU VE YAPRAKLARININ BESIN DEĞERİ, ANTIOKSIDAN AKTIVITE DÜZEYI, FENOLIK BILEŞENLERI VE AROMATIK IÇERIKLERI,

Ceviz hasadında önemli bir yan ürün olarak açığa çıkan ve değerlendirilmeden atılan ceviz yeşil kabuğu (Oliveira ve ark. 2008, Fernandez-Agullo ve ark., 2013) ceviz meyvesinin yaş ağırlığının yaklaşık %64'ünü oluşturmakta (Dehghani ve ark. 2019) Ceviz yeşil kabuğu yüksek konsantrasyonlarda klorojenik asit, kafeik asit, ferulik asit, sinapik asit, gallik asit, ellajik asit, protokateşik asit, siringik asit, vanilik asit, kateşin ve juglon içermektedir. (Dehghani ve ark., 2019, Chatrabnous ve ark., 2018). Juglon, ceviz ağacının karakteristik fenolik bileşiği olup taze ceviz yapraklarında, meyvelerde (özellikle yeşil kabukta), sürgünlerde ve köklerde fazlaca bulunmaktadır (Cosmulescu ve ark. 2014) Ceviz yaprağı aromatik özelliğe sahip bol bulunan ve temini kolay yapraklardandır. Ceviz yaprağı, sekonder metabolitlerden olan fenolik asitler, flavonoidler, organik asitler, tokoferoller, triterpenik asitler, terpenler, terpenoidler, tetralon türevleri, megastigman türevleri ve 5-hidroksi-1,4-naftokinon (juglon) gibi biyoaktif bileşikler ile uçucu aroma bileşikleri (karyofillen oksit, β-karyofillen, germakren, α-pinen ve β-pinen baskın olmak üzere) içermektedir. Bir hektar alandaki ceviz ağacından 375 kg yaprak atığının oluştuğu varsayıldığında, 1.3 milyon hA'da yaklaşık 500 bin ton ceviz yaprağı olduğu tahmin edilmektedir. Ceviz ağacı yaprak döken bir bitki olması nedeniyle de her yıl 500 bin tonun üzerinde bir atık oluşabilmektedir (Salık ve Çakmakçı, 2023). Ceviz yeşil kabuğu, ceviz yeşil yaprağına kıyasla KM oranı, ham lif ve kül bakımından daha zengin olup, ham protein, ham yağ, KH ve tanen bakımından daha fakirdir. Ceviz yaprağı çok sayıda mineral içerir ve Zn, Ca ve Mn bakmından daha zengindir. Ceviz yaprağı ceviz ağacının çeşidi, yetiştiği bölgenin iklimi, rakımı gibi faktörlere göre değişen farklı düzeylerde antioksidan ve uçucu yağlar içeriklerine sahiptir. Doğal bir antioksidan kaynağı olarak kullanılabileceğini göstermiştir (Almeida ve ark., 2008). Fenolik ve Flovonoit bileşikler bakımından yeşil ceviz kabuğunun yeşil ceviz yaprağından daha zengindir. Ceviz ise bir insanın sağlıklı beslenmesi için gerekli olan besinleri bol miktarda bulunduran ve tohumu (iç ceviz) tüketilen sert kabuklu bir meyvedir. Bununla birlikte cevizin yaprağı iç ve dış kabuğu ve hatta iç zarı bile farklı amaçlarla farklı sanayilerde çok değerli hammadde kaynakları olarak kullanılmaktadır (Eratalar ve ark., 2017).

CEVIZIN YEŞIL KABUĞU VE YAPRAKLARININ KULLANIM ALANLARI

Ceviz ise bir insanın sağlıklı beslenmesi için gerekli olan besinleri bol miktarda bulunduran ve tohumu (iç ceviz) tüketilen sert kabuklu bir meyvedir. Bununla birlikte cevizin yaprağı iç ve dış kabuğu ve hatta iç zarı bile farklı amaçlarla farklı sanayilerde çok değerli hammadde kaynakları olarak kullanılmaktadır (Eratalar ve ark., 2017). Cevizin yeşil kabuğu ve yapraklarının bünyesindeki fenolik maddeler ve flavonoidlerin zengin bulunması ile antioksidan antimikrobiyel özelliklerine nedeniyle birçok alanda kullanım alanına sahiptir. Bunlar genel olarak endüstriyel kullanımlar kapsamında tehlikeli maddelerin uzaklaştırılması (boya giderimi, ağır metal giderimi), doğal saç boyası, gıda alanında kullanımları kapsamında doğal antioksidanlar, ceviz kabuğu likörü, tıbbi alanda kullanımı kapsamında trombosit karşıtı madde, sitotoksit aktiviteler olarak kullanılmaktadır.

CEVIZ YEŞIL KABUĞU VE YAPRAKLARININ HAYVAN BESLEME ALANINDA KULLANIMI

Cevizi bir bütün olarak ele aldığımızda özellikle cevizin iç kısmı kanatlı yetiştiriciliği ve özellikle de yem sektörü açısından değerli bir protein ve enerji kaynağıdır. Ancak, Yüksek yağ içeriği sebebiyle yeme homojen olarak karıştırılması kolay olmayan bir yem hammaddesi olduğundan, yem sektöründe yağı alındıktan sonra kullanımına yönelik araştırmalar gerçekleştirilmiştir (Eratalar ve ark., 2017). Yüksek fenolik içeriğe sahip bitkilerin güçlü antioksidan güce sahip olmasından dolayı bitki yapraklarının kanatlı karmalarında katkı maddesi olarak kullanılması ile ilgili çalışmalar yapılmıştır (Popescu ve ark., 2020). Bu yapraklardan birisi de ceviz yaprağı ve yeşil kabuklarıdır. Ceviz yaprağı ve yeşil kabuğunun kanatlı hayvan beslemede kullanımına ilişkin yapılan çalışmalar da antioksidan yem katkı maddesi olabileceği, yumurta sarısı rengini etkilediği, serum antioksidan enzim aktiviteleri üzerinde olumlu etkileri olduğu, yumurta kalitesi üzerinde olumlu etkileri olduğu, gastrointestinal kanalının sağlık durumu üzerinde olumlu etkileri olduğunun tespit edildiği çalışmalar yapılmıştır.

SONUÇ VE ÖNERILER

Ceviz yeşil kabuğu ve yapraklarının hayvan sağlığı, refahı ve ürün kalitesi üzerinde olumlu etkiler yaratabilen orta ila yüksek düzeyde fenolik bileşikler içerirler. Ceviz yan ürünlerin bileşimi, çeşide, iklim ile tarım koşullarına ve işlemeye bağlı olarak bir türden diğerine ve aynı tür içinde önemli ölçüde değişiklik göstermektedir. Bu nedenle ceviz ve ceviz yan ürünlerinin kanatlı hayvan beslemede kullanımına ilişkin daha fazla araştırma yapılması, mevcut bilginin genişletilme kullanımdan önce ceviz ve ceviz yan ürünlerinin besin maddeleri bileşimlerinin etkileyen faktörlerin göz önünde tutulmasında yarar bulunmaktadır.

KAYNAKLAR

Almeida, I.F., Fernandes, E., Lima, J.L.F.C., Costa, P.C., Bahia, M.F. (2008). Walnut (Juglans regia) leaf extracts are strong scavengers of pro-oxidant reactive species. Food Chemistry, 106(1), 1014- 1020.

Chatrabnous, N., Yazdani, N., Tavallali, V., Vahdati, K. (2018). Preserving quality of fresh walnuts using plant extracts. LWT-Food Science and Technology, 91, 1-7.

Cosmulescu, S., Trandafir, I., Nour, V. (2014). Seasonal variation of the main individual phenolics and juglone in walnut (Juglans regia) leaves. Pharmaceutical Biology, 52(5), 575-580.

Dehghani, S., Nouri, M., Baghi, M. (2019). The effect of adding walnut green husk extract on antioxidant and antimicrobial properties of ketchup. Journal of Food and Bioprocess Engineering, 2(2), 93-100.

Fernandez-Agullo, A., Pereira, E., Freire, M.S., Valentão, P., Andrade, P.B., González-Álvarez, J., Pereira, J.A. (2013). Influence of solvent on the antioxidant and antimicrobial properties of walnut (Juglans regia L.) green husk extracts. Industrial Crops and Products, 42, 126-132.
Gıda ve Tarım Örgütü (FAO), (2019). Bitkisel Üretim İstatistikleri. http://www. fao.org/faostat/en/#data/QCL (Erişim Tarihi: 12.10.2021).
Karadeniz, T.,2004.Şifalı Meyveler (Meyvelerde Beslenme ve Tedavi Şekilleri).Burcan Ofset Matbaacılık Sanayi. Ordu. ISBN: 975288867
Martinez, M. L., D. O. Labuckas, A. L. Lamarque and D. M. Maestri, 2010. Walnut (Juglans regia L.): Genetic Resources, Chemistry, By-Products. Journal of The Science of Food and Agriculture 90:1959-1967.7
Oliveira, I., Sousa, A., Ferreira, I.C.F.R., Bento, A., Estevinho, L., Pereira, J.A. (2008). Total phenols, antioxidant potential and antimicrobial activity of walnut (Juglans regia L.) green husks. Food and Chemical Toxicology, 46(7), 2326-2331. [19]
Popescu R.G., Voicu, S.N., Pircalabioru, G.G., Ciceu, A., Gharbia, S., Hermenean, A., Georgescu, E.E., Panaite, T.D., & Dinischiotu, A., (2020). Effects of Dietary Inclusion of Bilberry and Walnut Leaves Powder on the Digestive Performances and Health of Tetra SL Laying Hens. Animals, 10: 823.
S. A. Eratalar, N. Okur, A. Yaman, T. Karadeniz/Bahçe 46 (Özel Sayı 2): 71-76 (2017)
Salık M.A., Çakmakçı S. (2023). Ceviz (Juglans regia L.) Yaprağı ve Yeşil Kabuğu: Fonksiyonel Özellikleri, Sağlığa Yararları ve Gıdalarda Kullanım Potansiyeli. Akademik Gıda 21(1) (2023) 90-100
Türkiye İstatistik Kurumu (TÜİK), (2019). Bitkisel Üretim İstatistikleri, https://data.tuik.gov.tr/Bulten/Index?p=BitkiselUretim-Istatistikleri-2019-30685 (Erişim Tarihi: 12.10.2021).

CLADISTIC ANALYSIS of TURKISH DENİZLİ CUCUMIS MELO ALPHAENDORNAVIRUS (CmEV) ISOLATES FROM MELON (Cucumis melo L.)

KAVUNDAN (CUCUMIS MELO L.) IZOLE EDILEN TÜRK DENIZLI CUCUMIS MELO ALPHAENDORNAVIRUS (CMEV) İZOLATLARININ KLADISTIK ANALIZI

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Özet
Endornaviridae ailesi içindeki virüsler, 9.8 ile 17.6 kb boyutunda yüksek moleküler ağırlıklı dsRNA'lar olarak başlangıçta bakla ve taze fasulyede keşfedilmiş ve daha sonra birçok bitki, fungus ve oomycette rapor edilmiştir. Endornavirüsler, klasik virionlar oluşturmayan kapsidsiz virüslerdir. Bitki endornavirüsleri, tohum, yumurta veya polen yoluyla oldukça bulaşıcıdır. Bazı endornavirüslerin genomları tamamen dizilense de deniz çayırı, arpa ve kavun’dan izole edilenler kısmen dizilenmiştir.
Bu çalışmada Türkiye’nin Denizli bölgesinde kavun (Cucumis melo L.) bitkisinde kabakgil virüslerini anımsatan semptomlar gözlendi. Semptomlu ve semptomsuz 15 bitkinin yapraklarından olası CmEV patojenini belirlemek için genomik RNA izolasyonu yapılmıştır. Etmenin varlığı ve evrimsel ilişkileri RNA-dependent RNA polymerase (RdRp) bölgesine spesifik evrensel primerler, Reverse Transkriptaz Polimeraz Zincir Reaksiyonu (RT-PCR), Dizileme ve Mega 11 yazılımı kullanılarak araştırılmıştır. Yürütülen testler, agaroz jelde 15 örneğin 4’ünde yaklaşık 420 bp boyutunda DNA fragmentleri üretmiştir. Rastgele iki pozitif fragment dizilenmiş ve gen bankasına kaydedilmiştir (PQ507951 ve PQ507952). RdRp kısmi genine bağlı oluşturulan filogenetik dendrogram, Türk-Denizli CmEV izolatlarının Türkiye, Çin, Brezilya, İspanya ve İsrail izolatları ile yakın filogenetik yakınlık gösterdiğini ortaya çıkarmıştır.
Bu, Türkiye’nin Denizli bölgesinde yetiştirilen kavun bitkilerinde CmEV varlığını ve biyolojik ilişki bilgilerini moleküler araçlar kullanarak ortaya çıkaran ilk rapordur.
Anahtar Kelimeler: CmEV, RT-PCR, Moleküler Filogeni, Kavun

Abstract
Viruses in the Endornaviridae family are high molecular weight dsRNAs of 9.8 to 17.6 kb in size, initially discovered in broad beans and faba beans and subsequently reported in many plants, fungi and oomycetes. Endornaviruses are capsidless viruses that do not form classical virions. Plant endornaviruses are highly infectious via seeds, eggs or pollen. While the

genomes of some endornaviruses have been completely sequenced, those isolated from seagrass, barley and melon have been partially sequenced.
In this study, symptoms reminiscent of cucurbit viruses were observed in melon (Cucumis melo L.) plants in Denizli region of Turkey. Genomic RNA was isolated from the leaves of 15 symptomatic and symptomless plants to identify the possible CmEV pathogen. The presence and evolutionary relationships were investigated using universal primers specific for the RNA-dependent RNA polymerase (RdRp) region, Reverse Transcriptase Polymerase Chain Reaction (RT-PCR), Sequencing and Mega 11 software. The tests performed produced DNA fragments of approximately 420 bp in size in 4 out of 15 samples on agarose gel. Two positive fragments were randomly sequenced and deposited in the gene bank (PQ507951 and PQ507952). The phylogenetic dendrogram based on the RdRp partial gene revealed that Turkish-Denizli CmEV isolates showed close phylogenetic affinity with Türkiye, China, Brazil, Spain, and Israel.
This is the first report to reveal the presence of CmEV and biological relationship information using molecular tools in melon plants cultivated in Denizli region of Türkiye.
Keywords: CmEV, RT-PCR, Molecular Phylogeny, Melon

Giriş

Kabakgiller (Cucurbitaceae) ailesi, dünya genelinde hem besin değeri yüksek hem de ticari açıdan büyük önem taşıyan bitki türlerini kapsayan geniş bir familyadır. Bu aile içerisinde yer alan türler, farklı iklim ve toprak koşullarına uyum sağlayarak yaygın bir şekilde yetiştirilmektedir. Familya, 120 civarında cinsi ve 800'den fazla türü içeren geniş bir bitki grubudur. Genellikle otsu olan bu bitkiler, tek yıllık veya çok yıllık olabilir ve ılıman ile tropikal bölgelerde yaygın olarak yetişirler (Welbaum, 2015).

Ekonomik olarak en öne çıkan türler arasında kavun (Cucumis melo L.), hıyar (Cucumis sativus L.), karpuz (Citrullus lanatus Thumb.), kabak (Cucurbita pepo L.) ve balkabağı (Cucurbita spp.) bulunmaktadır. Özellikle bu türler, tarımsal üretimdeki yüksek verim potansiyelleri ve pazar talepleri nedeniyle birçok ülkenin tarım ekonomisine önemli katkılar sağlamaktadır. Ayrıca, taze tüketimden işlenmiş ürünlere kadar geniş bir kullanım yelpazesiyle gıda sanayisinde de vazgeçilmez ürünlerdir. Bu ürünler, ihracat ve ithalat sağlayan önemli gelir kaynakları haline gelmiştir. Kabakgillerin ekim alanlarının artması, bitkisel üretimi etkileyebilen ve tarımsal sürdürülebilirliği tehdit eden çeşitli viral hastalıkların ortaya çıkmasına neden olmuştur (Radouane ve ark., 2021).

Kabakgiller, virüsler dahil birçok zararlı ve patojenin önemli bir konağıdır. Viral olarak 50’den fazla virüsün bu önemli familyayı tehdit ettiği ve ekonomik ve gıda güvenliği açısından tehdit oluşturduğu bilinmektedir (Juárez ve ark., 2019; Karanfil ve Korkmaz, 2020). Uygun çevre koşulları, vektörler ve bitki çeşitliliği, yeni virüs hastalıklarının ortaya çıkması, patojenlerin evrim geçirmesi ve genetik çeşitliliğin artmasına katkıda bulunmuştur. Özelikle vektörler rekombinasyon ve genetik varyasyona yol açarak virüslerin konakçılarına uyum sağlamalarını mümkün kılmıştır (Lecoq and Desbiez, 2012; Navas-Castillo ve ark., 2014; Pozzi ve ark., 2020).

Endornavirüsler, bitkileri, fungusları ve oomiseti enfekte eden çift iplikli RNA (dsRNA) virüsleridir. Bu virüsler yakın zamanda Endornaviridae ailesi olarak sınıflandırılmışlardır (Carstens ve ark., 2009). Bitkileri enfekte eden endornavirüs türleri virion oluşturmaz (kapsidsiz), tüm dokularda bulunur, hücreler arası hareket edemez ve yalnızca dikey olarak (bir bitkiden diğerine tohum veya üreme hücreleri aracılığıyla) çok yüksek bir oranda bulaşıcıdır. Endornavirüslerin genomları tek uzun bir açık okuma çerçevesi (ORF) içerir ve çoğunun artı ipliğin 5’ ucunda bir kesinti (çentik) vardır (Fukuhara ve ark., 2006). Tek ORF tarafından kodlanan varsayılan poliprotein, korunmuş bir RNA bağımlı RNA polimeraz (RdRp) alanı ve diğer üyeler arasında korunmamış alanlar içerir (Roossinck ve ark., 2011).

Dört bitki, dört fungus ve bir oomyseti enfekte eden dokuz bilinen veya potansiyel endornavirüs türü için 11 tam genom dizilimi mevcuttur (Moriyama ve ark., 1995, 1999; Hacker ve ark., 2005; Okada ve ark., 2011; Osaki ve ark., 2006; Park ve ark., 2006; Pfeiffer, 1998; Stielow ve ark., 2011; Tuomivirta ve ark., 2009).
Kabakgillerde virüs hastalıklarının belirtileri oldukça benzer olsa da yaygın semptomları arasında yapraklarda mozaik ve kıvrılma, bodurluk, solgunluk, şekil bozukluğu, renk değişikliği, yapraklarda kabarma ve nekroz yer alır. Bu semptomlar, üretilen kabakgil meyvelerinin estetik değerini ve verimini olumsuz etkiler (Blancard ve ark., 1994). Cucumis melo endornavirus (CmEV), bitki virolojisi alanında, özellikle Cucurbitaceae ailesi içinde büyüleyici bir konudur. Bu virüsün varlığına işaret eden ilk rapor Fukuhara ve ark. (2006) tarafından rapor edilmiştir. Araştırmacılar ilk kez kavun bitkisinde RNA'ya bağımlı RNA polimeraz (RdRp) bölgelerinin kısmi nükleotid dizilerini kullanarak dsRNA analizi sayesinde CmEV genomuna yakın büyüklükte (yaklaşık 14 kbp) fraksiyonlar elde etmişlerdir. Uluslararası Virüs Taksonomisi Komitesi (ICTV) ise yakın zamanda Endornavirüs'ü yeni bir bitki dsRNA virüsü cinsi olarak kabul etmiştir.
CmEV'nin Türkiye'deki varlığı daha önce rapor edilmesine rağmen, bu yeni etmenin Türkiye'deki etmenin yayılımı ve filogenetik ilişkileri ile ilişkili kayıtlar azınlıktadır. Bu amaçla bu araştırma, C. melo bitkilerinden RNA izolasyonu, RT-PCR amplifikasyonu ve yeni nesil sekanslama teknolojilerini kullanarak CmEV'nin varlığını tespit etmeyi hedeflemektedir. Ayrıca elde edilen genomik dizi ve diğer bilinen endornavirüs dizileri karşılaştırılarak, CmEV'nin Türk Denizli CmEV izolatının filogenetik konumu belirlenecektir. Bu çalışmanın sonuçları, kavun yetiştiriciliğinde potansiyel bir öneme sahip olabilecek yeni bir virüsün tanımlanmasına katkıda bulunacak ve endornavirüslerin evrimsel tarihine ışık tutacaktır.

Materyal ve Yöntem

Virüs Şüpheli Bitki Örnekleri

2023 yılında, Türkiye'nin Denizli ilinde virüs benzeri belirtiler gösteren kavun yaprak örnekleri gözlemlendi. Özel bahçeden toplanan 15 örnek soğuk zincirde laboratuvara ulaştırılmış ve analiz edilene kadar -80 ºC'de muhafaza edilmiştir.

RNA Ekstraksiyonu

RNA ekstraksiyonu, Foissac ve ark. (2001)'nın yöntemi temel alınarak silika temelli tekniği ile gerçekleştirilmiştir. Dondurulmuş kabakgil dokuları, ezme tamponunda öğütülmüş ve mikrofüj tüplerine aktarılmıştır. Homojenatlar, sarkozil eklenerek ısıtılmış, ardından soğutulup santrifüj edilmiştir. Elde edilen sıvı faz, etanol, NAI ve silika içeren yeni tüplere alınarak çalkalanmış ve santrifüj edilmiştir. Üst faz uzaklaştırılıp, pelet yıkama tamponu ile temizlenmiş ve RNA içeren pelet, RNA içermeyen su ile çözülmüştür. Son olarak, santrifüj edilen RNA'lar cDNA sentezi ve RT-PCR için -80°C'de saklanmıştır.

Revers Transkripsiyon ve Amplifikasyon

Ekstrakte edilen RNA'lar, cDNA sentezi için şablon olarak kullanılmıştır. cDNA sentezi, RevertAid First Strand cDNA kiti talimatlarına uygun olarak, ters primer ve 2 µl RNA kullanılarak gerçekleştirilmiştir. CmEV tespiti için, referans çalışmalardan alınan ve 413 bp amplikon üreten RdRp'ye özgü primer çiftleri kullanılmıştır. Enfekte kabakgil dokularındaki etmeni tespit etmek amacıyla reverse transcriptase Reverse Transcription Polymerase Chain Reaction (RT-PCR) yöntemi kullanılmıştır. 2 µl cDNA, nükleaz içermeyen su, reaksiyon tamponu, dNTP, MgCl2, primerler ve Taq DNA polimeraz içeren 25 µl'lik bir karışımda PCR deneylerine tabi tutulmuştur. Kullanılan primerler ve sıcaklık döngüleri aşağıda verilmiştir (Tablo 1). Amplifikasyon ürünleri %1'lik Etidyum Bromür katkılı agaroz jelde koşturulmuş ve UV görüntüleme cihazında görüntülenerek fotoğraflanmıştır. Bu çalışmadan elde edilip doğruluğu gen bankasından kontrol edilen bir izolat pozitif kontrol olarak, DNA içermeyen PCR master mix ise negatif kontrol olarak kullanılmıştır.

Tablo 1. Cucumis melo alphaendornavirus enfeksiyonunu tespit etmek için PCR testlerinde kullanılan primerler ve termal döngü programı

	İleri Primer (5′-3′)	Ters Primer (5′-3′)	PCR programı	
CmEV	**GGTGGAATATGGGTTGATG CTAG**	**CGTCGTGATGGACATCAACTCTAC**	**94°C- 4 dak** **94°C- 45 s** **55°C- 30 s** **72°C- 45 s** **10 dak- 72°C.**	**40 döngü**

Dizileme ve Filogenetik Analiz

PCR ile çoğaltılan pozitif viral DNA parçalarından rastgele iki tanesi bir jel ekstraksiyon kiti (Thermo Scientific, USA) kullanılarak jelden saflaştırılmış ve yeni nesil dizileme yöntemiyle (Sentebiolab/Ankara/Türkiye) dizilenmiştir. Viral RdRp gen dizileri gen bankasına kaydedildikten sonra nükleotit benzerliğini belirlemek için bu diziler NCBI'de depolanan diğer CmEV viral nükleotid dizileri ile karşılaştırılmıştır (nükleotid BLAST, BLASTn). Filogenetik ilişkiler, çoklu hizalamalar ve tespit edilen dizilerin nükleotid analizleri, CLC Main Workbench (sürüm 6.7.1), Sequence Demarcation Tool (sürüm 1.2) ve Mega X programı (Kumar ve ark., 2018) kullanılarak gerçekleştirilmiştir. Evrimsel ilişkiler, Neighbor-Joining yöntemi kullanılarak tahmin edilmiş ve güvenilirlik, 1000 bootstrap tekrarı ile hesaplanmıştır. Farklı bir takımdan virüs izolatı (KC900900) daha iyi filogenetik ayrım sağlamak için dış grup olarak atanmıştır.

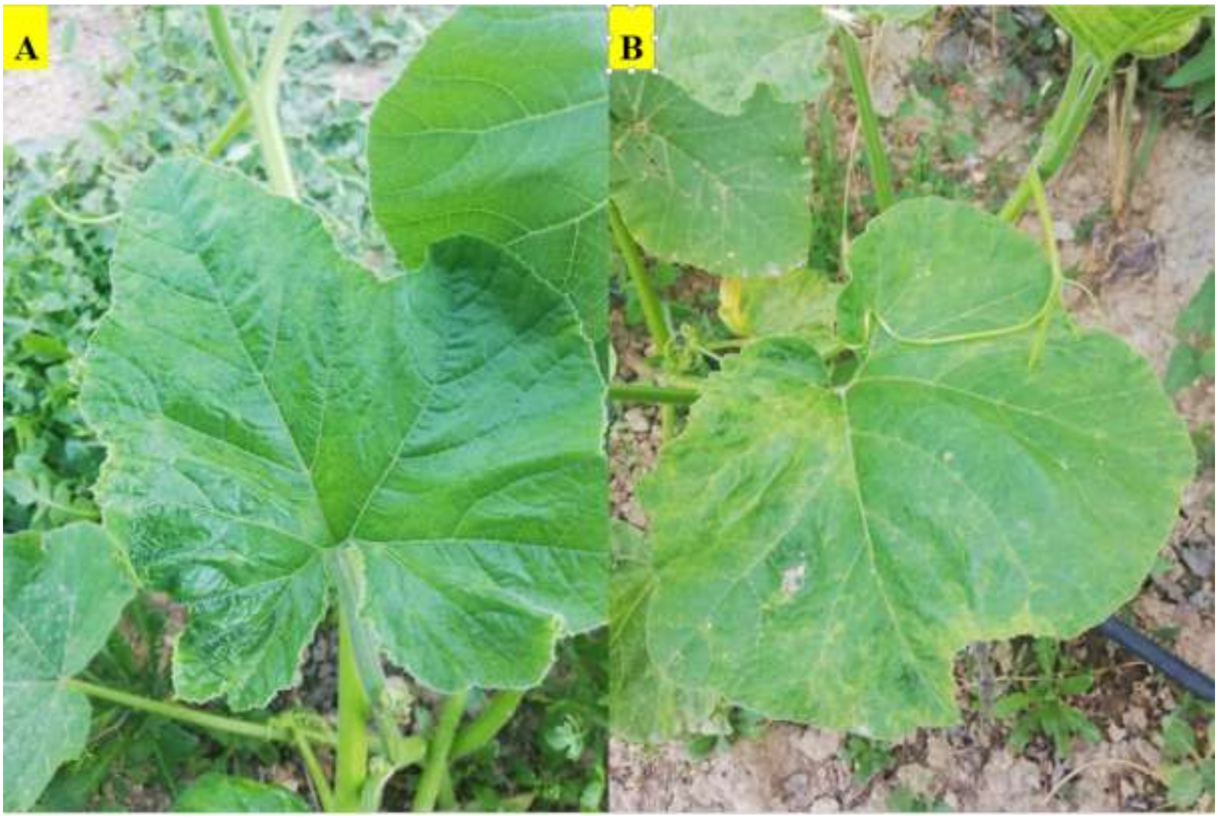
Sonuçlar ve Tartışma

Kabakgiller, dünya genelinde yetiştirilen önemli sebze ürünleri arasında yer almakta ve hem olgun hem de olgunlaşmamış meyve olarak taze ya da pişmiş şekilde tüketilmektedir. 2012 yılında, bu bitkiler ılıman ve tropikal bölgelerde 8,7 milyon hektardan fazla alanda ekilmiş ve 227 milyon tondan fazla ürün elde edilmiştir. Dünya kavun üretiminde Çin 605.000 hektarda 17,5 milyon ton ile öndedir; onu İran (1,5 milyon ton, 82.000 hektar), Türkiye, Mısır ve Hindistan izlemektedir (Robinson ve Decker-Walters, 1997; FAOSTAT, 2014). Virüs enfeksiyonu oranı kesin rakamlarla bilinmemekle birlikte, dünya genelinde yetiştirilen kabakgillerin %1'inin virüsle enfekte olduğu tahmin edilmektedir (Lecoq ve Katis, 2014).
Kabakgiller giderek artan sayıda viral hastalıktan etkilenmektedir; 70'ten fazla virüs türünün doğada kültür kabakgillerini enfekte ettiği tanımlanmıştır. Virüslerin çeşitliliği, konukçularının ekolojik ve genetik çeşitliliği ile ilişkili olabilir (Lecoq, 2003; Lecoq ve Desbiez, 2012). Kabakgillerdeki virüs enfeksiyonları, pazarlanabilir verim üzerinde ciddi olumsuz etkiler yaratmakta ve önemli ekonomik kayıplara yol açmaktadır. Virüs enfeksiyonları, meyve tutumunda düşüklük ve meyve kalitesinde belirgin bir bozulma gibi sorunlar yaratır; bu, genellikle renk değişiklikleri, deformasyonlar, nekrotik semptomlar ve olgunlaşma kusurları gibi çeşitli belirtilerle kendini gösterir (Blancard, Lecoq ve Pitrat, 1994). Bu faktörler, brüt verimde düşüşe neden olur ve ürünlerin pazarlanabilirliğini ciddi ölçüde azaltır. Kabakgil bitkileri çoğunlukla birden fazla virüs tarafından eş zamanlı olarak enfekte edilir, bu da meyvelerde karmaşık semptomlar kombinasyonuna yol açar ve sorunun boyutunu daha da artırır. Ülkeler arasında farklı pazar talepleri ve kalite standartları olduğundan, bu virüslerin küresel ekonomik etkisinin kapsamlı bir değerlendirmesini yapmak zorlaşır. Ancak, şiddetli virüs enfeksiyonlarının, özellikle erken dönemlerde görüldüğünde, neredeyse tam verim kaybına neden olduğu belgelenmiştir. Bu durum, örneğin Hıyar mozaik virüsü (CMV), Kabak sarı mozaik virüsü (ZYMV) ve begomovirüsler gibi virüslerin bulaşmasında sıklıkla gözlemlenmiştir (Lecoq ve Katis, 2014). Bununla birlikte, kabakgil üretiminde göz ardı edilmemesi gereken diğer önemli bir virüs de CmEV'dir. Literatürde bu

virüsle ilgili çalışmalar sınırlı olmasına rağmen, CmEV'nin diğer virüslerle birlikte ürün verim ve kalitesinde kayıplara neden olma potansiyeli önemli bir risk olarak kabul edilmelidir.

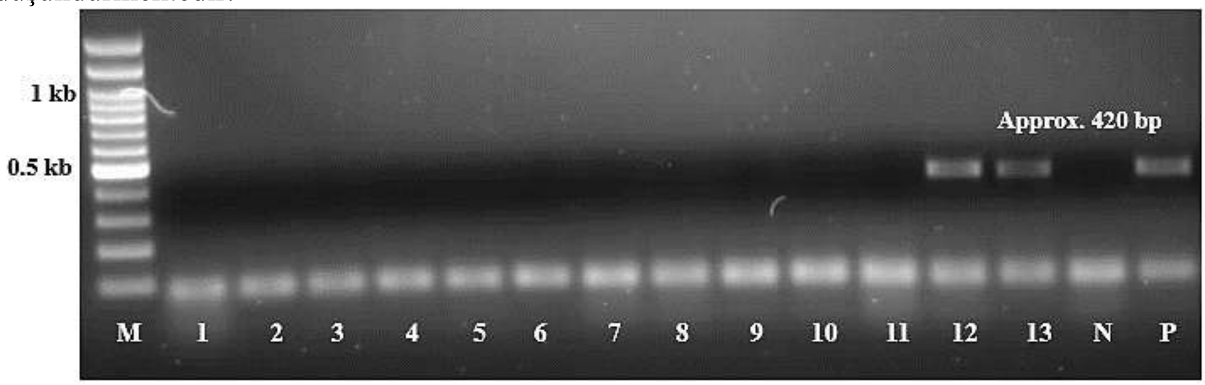
Günümüze kadar farklı konukçularda endornavirüslerin varlığı tespit edilmiş ve genomları tamamen karakterize edilmiştir. Oryza sativa endornavirus (OsEV), Vicia faba endornavirus, Oryza rufipogon endornavirus (OrEV), Phytophthora endornavirus 1 (PEV-1), Helicobasidium mompa endornavirus 1, Gremmeniella abietina tip B RNA virüsü XL (GaBRV-XL), Tuber aestivum endornavirus (TaEV), Bell pepper endornavirus (BPEV), Persea americana endornavirus (PaEV), Phaseolus vulgaris endornavirus 1 ve Phaseolus vulgaris endornavirus 2 (PvEV-1 ve PvEV-2), Grapevine endophyte endornavirus (GeEV), Basella alba endornavirus (BaEV), Lagenaria siceraria endornavirus (LsEV), Yerba mate endornavirus, Rhizoctonia cerealis endornavirus 1 (RcEV1), Rhizoctonia solani endornavirus-RS002 (RsEV), Sclerotinia sclerotiorum endornavirus 1 (SsEV1), Thielaviopsis basicola endornavirus ve Alternaria brassicola endornavirus (Moriyama ve ark., 1995; Pfeiffer, 1998; Moriyama ve ark., 1999; Hacker ve ark., 2005; Osaki ve ark., 2006; Tuomivirta ve ark., 2009; Stielow ve ark., 2011; Okada ve ark., 2011; Sela ve ark., 2012; Villanueva ve ark., 2012; Espach ve ark., 2012; Okada ve ark., 2013; Okada ve ark., 2014; Kwon ve ark., 2014; Debat ve ark., 2014; Li ve ark., 2014; Das ve ark., 2014; Khalifa ve Pearson, 2014; Chen ve Punja, 2014; Shang ve ark., 2015). Ayrıca, deniz çayırı (Zostera marina), arpa (Hordeum vulgare) ve kavundan (Cucumis melo) kısmen karakterize edilmiş birkaç endornavirüs de rapor edilmiştir (Coutts, 2005; Fukuhara ve ark., 2006; Quito-Avila ve ark., 2014).

Endornavirüsler genellikle konakçılarında belirgin semptom göstermeden kalıcı enfeksiyonlar oluştururlar (Roossinck ve ark., 2011; Fukuhara ve Gibbs, 2012; Dolja ve Koonin, 2012). Ancak, Vicia faba endornavirüsü (VfEV; Grill ve Garger, 1981) ve Helicobasidium mompa endornavirüs 1 (HmEV-1; Osaki ve ark., 2006) gibi konakçı özelliklerinde değişikliklere neden olan bazı istisnalar da bulunmaktadır. Çalışmamızda, 8'i virüs simptomlarını hatırlatan (Şekil 1) toplam 15 kavun bitki yaprak örneği CmEV varlığını belirlemek için moleküler olarak testlenmiştir. Bahçe koşullarında kavunda görülen belirtiler yapraklarda deformasyon, mozaik ve sarı yamalı alanların varlığıdır.



Şekil 1. Denizli ilinden bir bahçede 2023 sonbaharında gözlenen yaygın kabakgil virüs simptomlarını barındıran kavun bitkileri A- mozaik desenin genel görünümü, B- Yaprak kenarlarında deformasyon, damar sararması ve sarı yamalı alanlar

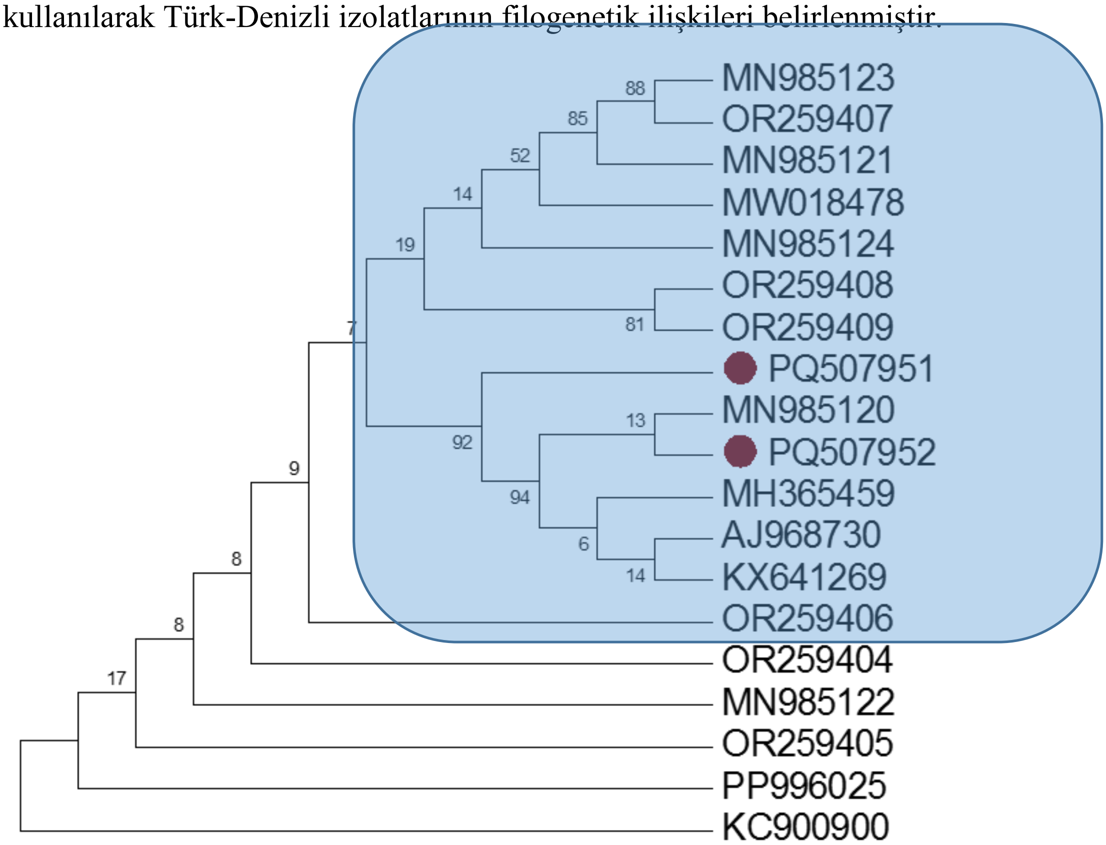
Tüm bitki örnekleri RT-PCR yöntemi ile test edilmiştir. Simptom gösteren 8 kavun yaprağı örneğinden 4'ünde, tür-spesifik primerler kullanılarak yaklaşık 420 bp büyüklüğünde DNA fragmentleri elde edilmiştir; bu da bu örneklerde CmEV enfeksiyonunu doğrulamaktadır (Şekil 2). Ancak, diğer 4 semptomlu örnekte CmEV enfeksiyonuna rastlanmamıştır. Bu durum, benzer belirtilere sahip olan kavun bitkilerinde CmEV enfeksiyonunun tek başına sorumlu olmadığını ve semptomların diğer cucurbit virüslerinden kaynaklanabileceğini düşündürmektedir.



Şekil 2. RdRp'ye özgü primer setleri kullanılarak RT-PCR ile infekteli kavun bitkilerinde CmEV'nin amplifiye edilmiş DNA fragmentlerini gösteren agaroz jel. M: 1 kb DNA markörü 1-11: Sağlıklı kabak bitkileri ya da CmEV negatif örnekler, 12-13: CmEV pozitif örnekler, P: CmEV -pozitif kontrol, N: DNA içermeyen negatif kontrol

CmEV daha önce dünyanın farklı bölgelerinde sınırlı sayıda tanımlanmıştır ve yürütülen çalışmalar ışığında bu virüsün yaygınlığının tespit edilmesi giderek artmaktadır. Her ne kadar etmenin spesifik konukçusu kavun olsa da mevcut literatür taramaları bu etmenin farklı

bölgelerden farklı konaklardali infeksiyonunu raporlamıştır: USA (Georgia)'dan karpuzda (Adeleke ve ark., 2022), Brezilya'dan insan dışkısında (da Costa ve ark., 2019), Ekvator'dan kavunda (Quito-Avila ve ark.,2014), yine USA'da Luffa aegyptiaca, Cucumis melo ve Praecitrullus fistulosus'da (Sabanadzovic ve ark., 2016) ve Çin'de kavundaki (Zeng ve arl., 2020) varlığını doğrulamıştır. Tomašechová ve ark. (2022) tarafından Slovakya'da yürütülen güncel bir çalışmada, CmEV'nin kavun, hıyar, kabak ve patison (Cucurbita pepo var. patisson)'daki varlığı raporlanmıştır. Türkiye'de ise virüs ilk kez Karanfil ve Korkmaz (2020) ile Karanfil ve ark. (2023) tarafından Manisa, İzmir, Çanakkale, Balıkesir ve Bursa illerinde kavun, kabak, karpuz, hıyar ve acur bitkilerinde rapor edilmiştir. Bu nedenle Denizli ilinde kavun bitkilerinde yürütülen bu çalışma CmEV'nin coğrafi dağılımı ve konakçı aralığı hakkında önemli veriler sağlamaktadır.
Denizli ilinde izole edilen iki izolat başarılı şekilde dizilenmiş ve 413 bp büyüklüğünde nükleotit içeren diziler gen bankasına PQ507951 ve PQ507952 erişim numaraları ile kaydedilmiştir. Mevcut erişim numaraları ve dünyanın diğer bölgelerinde belirlenen izolatlar kullanılarak Türk-Denizli izolatlarının filogenetik ilişkileri belirlenmiştir.



Şekil 3. Kısmi RdRp gen bölgesine dayalı olarak Türk Denizli CmEV izolatlarının filogenetik ilişkisi. Filogenetik ağaç, komşu-birleştirme yöntemi kullanılarak ve 1000 bootstrap replikasyonu uygulanarak oluşturulmuştur. Bootstrap eşiği %50 olarak belirlenmiştir. Dış grup olarak Barley yellow dwarf virüsü (BYDV) izolatı kullanılmıştır. Bordo renkle işaretlenenler ise bu çalışmadan elde edilen izolatlardır.

Şekildeki filogenetik ağaca göre, Türk-Denizli izolatları majör bir ana grupta Türkiye, Çin, Brezilya, İspanya ve İsrail izolatları ile kümelenmiştir. Filogenetik ağacın majör ana grubunda diğer Türk izolatları olmasına rağmen, daha spesifik olarak bu çalışmadan elde edilen CmEV izolatları Türkiye'den bir izolat (kavundan), İsrail (kavundan), Brezilya (insan dışkısından) ve İspanya izolatları (kavundan) ile daha yakın filogenetik yakınlık sergilemiştir. Filogenetik ağaca dahil diğer Türk (MN985123, OR259407, MN985121, MN985124, OR259408, OR259409) ve Çin izolatları (MW018478) ile daha az nükleotit konsensüsü sergilemiştir. Bu da, CmEV'nin filogenetik ilişkilerinin doğrudan bitki kaynağı ya da coğrafi orijinine bağlı olmadığını göstermektedir. Bu büyük olasılıkla viral genomdaki genetik yapılarındaki belirgin farklılıkların bir göstergesidir. Bu çeşitlilik muhtemelen belirli çevresel koşulların yanı sıra izolatların kaynağı (örneğin, bitki türü veya örnek alma yeri) ve bu izolatların zaman içindeki evriminden kaynaklanabilir.

Sonuç

Bu çalışma, Türkiye'nin Denizli bölgesinde kavun bitkilerinde CmEV varlığını araştırmaktadır. Endornaviridae ailesine ait virüsler, genellikle kapsidsiz olup, bitkilerde yüksek moleküler ağırlıklı dsRNA'lar olarak bulunur. Araştırma kapsamında, semptomlu ve semptomsuz 15 kavun bitkisinin yapraklarından genomik RNA izolasyonu yapılmış ve CmEV patojeninin varlığı incelenmiştir. RT-PCR ve dizileme yöntemleri kullanılarak elde edilen veriler, Türk-Denizli CmEV izolatlarının Türkiye, Çin, Brezilya, İspanya ve İsrail izolatları ile yakın filogenetik ilişki gösterdiğini ortaya koymuştur. Bu çalışma, kavun bitkilerinde CmEV'nin varlığını ve biyolojik ilişkilerini moleküler araçlarla belirleyen ilk rapor olma özelliğini taşımaktadır.

Referanslar

Adeleke IA, Kavalappara SR, McGregor C, Srinivasan R, Bag S. Persistent, and Asymptomatic Viral Infections and Whitefly-Transmitted Viruses Impacting Cantaloupe and Watermelon in Georgia, USA. Viruses. 2022 Jun 15;14(6):1310. doi: 10.3390/v14061310. PMID: 35746780; PMCID: PMC9227350.

Blancard D., Lecoq H., Pitrat M., 1994. A Colour Atlas of Cucurbit Diseases: Observation, Identification and Control. Manson Publishing Ltd, 299 pp.

Blancard, D., Lecoq, H., & Pitrat, M. (1994). A colour atlas of cucurbit diseases: observation, identification and control (pp. 299-pp).

Carstens EB, Ball LA. 2009. Ratification vote on taxonomic proposals to the International Committee on Taxonomy of Viruses (2008). Arch. Virol. 154:1181–1188

Chen, X., Punja, Z.K., 2014. Characterization of a novel dsRNA endornavirus in theplant pathogenic fungus Thielaviopsis basicola. Mycology 5, 10–15.

Coutts, R.H.A., 2005. First report of an endornavirus in the Cucurbitaceae. VirusGenes 31, 361–362.

da Costa, A. C., Leal, E., Gill, D., Milagres, F. A. D. P., Komninakis, S. V., Brustulin, R., ... & Luchs, A. (2019). Discovery of Cucumis melo endornavirus by deep sequencing of human stool samples in Brazil. Virus Genes, 55, 332-338.

Das, S., Falloon, R.E., Stewart, A., Pitman, R., 2014. Molecular characterization of anendornavirus from Rhizoctonia solani AG-3PT infecting potato. Fungal Biol. 118,924–934.

Debat, H.J., Grabiale, M., Aguilera, P.M., Bubillo, R., Zapata, P.D., Marti, D.A.,Ducasse, D.A., 2014. The complete genome of a putative endornavirusidentified in yerba mate (Ilex paraguariensis St. Hil.). Virus Genes 49, 348–350.

Dolja, V.V., Koonin, E.V., 2012. Capsid-less RNA viruses. In: eLS. John Willey & Sons,Ltd., Chichester, http://dx.doi.org/10.1002/9780470015902.a0023269.

Espach, Y., Maree, H.J., Burger, J.T., 2012. Complete genome of a novel endornavirusassembled from next-generation sequence data. J. Virol. 86, 13142.

FAOSTAT. (2014). Food and Agriculture Organization of the United Nations. Statistical Database. Retrieved from http://www.fao.org/faostat/en/#data/QC

Fukuhara TR, et al. 2006. The wide distribution of endornaviruses, large double-stranded RNA replicons with plasmid-like properties. Arch. Virol. 151:995–1002

Fukuhara, T., Gibbs, M.J., 2012. Family Endornaviridae. In: King, A.M.Q., Adams, M.J.,Carstens, E.B., Lefkowitz, E.J. (Eds.), Virus Taxonomy: Ninth Report of theInternational Committee on Taxonomy of Viruses. Elsevier Academic Press,Tokyo, pp. 519–521.

Grill, L.K., Garger, S.J., 1981. Identification and characterization of double-strandedRNA associated with cytoplasmic male sterility in Vicia faba. Proc. Natl. Acad.Sci. U. S. A. 78, 7043–7046.
Hacker, C.V., Brasier, C.M., Buck, K.W., 2005. A double-stranded RNA from aPhytophthora species is related to the plant endornaviruses and contains aputative UDP glycosyltransferase gene. J. Gen. Virol. 86, 1561–1570.
Juárez M., Rabádan M.P., Martínez L.D., Tayahi M., Grande-Pérez A., Gómez P., 2019. Natural hosts and genetic diversity of the emerging Tomato leaf curl New Delhi virus in Spain. Frontiers in Microbiology 10: 140. DOI: 10.3389/fmicb.2019.00140.
Karanfil, A., & Korkmaz, S. (2020). First Report of Cucumis Melo Endornavirus With a New Host, the Gherkin (Cucumis Anguria Linn.), in Turkey. Trakya University Journal of Natural Sciences, 21(1), 63-67.
Karanfil, A., Zelyüt, F. R., & Korkmaz, S. (2023). Güney Marmara Bölgesi Kabakgil Üretim Alanlarında Cucumis melo endornavirus Enfeksiyonunun Belirlenmesi ve İzolatların Moleküler Karakterizasyonu. Türk Tarım ve Doğa Bilimleri Dergisi, 10(4), 1001-1008.
Khalifa, M.E., Pearson, M.N., 2014. Molecular characterization of an endornavirusinfecting the phytopathogen Sclerotinia sclerotiorum. Virus Res. 189,303–309.
Kumar, S., Stecher, G., Li, M., Knyaz, C. and Tamura, K. (2018). MEGA X: Molecular evolutionary genetics analysis across computing platforms. Molecular Biology and Evolution, 35: 1547–1549.
Kwon, S.-J., Tan, S., Vidalakis, G., 2014. Complete genome sequence and genomeorganization of an endornavirus from bottle gourd (Lagenaria siceraria) inCalifornia U. S. A. Virus Genes 49, 163–168.
Lecoq H., Desbiez C., 2012. Viruses of Cucurbit Crops in the Mediterranean Region. An Ever-Changing Picture. Advances in Virus Research 84: 67–126.
Lecoq, H. (2003). Cucurbits. In Virus and virus-like diseases of major crops in developing countries (pp. 665-688). Dordrecht: Springer Netherlands.
Lecoq, H., & Katis, N. (2014). Control of cucurbit viruses. In Advances in virus research (Vol. 90, pp. 255-296). Academic Press.
Li, W., Zhang, T., Sun, H., Deng, Y., Zhang, A., Chen, H., Wang, K., 2014. Completegenome sequence of a novel endornavirus in the wheat sharp eyespotpathogen Rhizoctonia cerealis. Arch. Virol. 159, 1213–1216.
Moriyama H, Horiuchi H, Nitta T, Fukuhara T. 1999. Unusual inheritance of evolutionarily-related double-stranded RNAs in interspecific hybrid between rice plants Oryza sativa and Oryza rufipogon. Plant Mol. Biol. 39:1127–1136
Moriyama H, Nitta T, Fukuhara T. 1995. Double-stranded RNA in rice: a novel RNA replicon in plants. Mol. Gen. Genet. 248:364–369
Moriyama, H., Horiuchi, H., Koga, R., Fukuhara, T., 1999. Molecular characterizationof two endogenous double stranded RNAs in rice and their inheritance byinterspecific hybrids. Journal of Biological Chemistry, 274(11), 6882-6888.
Navas-Castillo J., López-Moya J.J., Aranda M.A., 2014. Whitefly-transmitted RNA viruses that affect intensive vegetable production. Annals of Applied Biology 165: 155–171. DOI: 10.1111/aab.12147.
Okada, R., Kiyota, E., Moriyama, H., Fukuhara, T., Valverde, R.A., 2014. A newendornavirus species infecting Malabar spinach (Basella alba L.). Arch. Virol.159, 807–809.
Okada, R., Kiyota, E., Sabanadzovic, S., Moriyama, H., Fukuhara, T., Saha, P.,Roossinck, M.J., Severin, A., Valverde, R.A., 2011. Bell pepper endornavirus:molecular and biological properties and occurrence in the genus Capsicum. J.Gen. Virol. 92, 2664–2673.

Okada, R., Young, C.K., Valverde, R.A., Sabanadzovic, S., Aoki, N., Hotate, S., Kiyota,E., Moriyama, H., Fukuhara, T., 2013. Molecular characterization of twoevolutionarily distinct endornaviruses co-infecting common bean (Phaseolusvulgaris). J. Gen. Virol. 94, 220–229.

Osaki H, Nakamura H, Sasaki A, Matsumoto N, Yoshida K. 2006. An endornavirus from a hypovirulent strain of the violet root rot fungus, Helicobasidium mompa. Virus Res. 118:143–149

Park Y, Chen X, Punja ZK. 2006. Diversity, complexity and transmission of double-stranded RNA elements in Chalara elegans (synanam. Thielaviopsis basicola). Mycol. Res. 110:697–704

Pfeiffer P. 1998. Nucleotide sequence, genetic organization and expression strategy of the double-stranded RNA associated with the '447′ cytoplasmic male sterility trait in Vicia faba. J. Gen. Virol. 79:2349–2358

Pozzi E.A., Bruno C., Luciani C.E., Celli M.G., Conci V.C., Perotto M.C., 2020. Relative incidence of cucurbit viruses and relationship with bio-meteorological variables. Australasian Plant Pathology 49: 167–174. DOI: 10.1007/s13313-020-00687-8.

Quito-Avila, D.F., Peralta, E.L., Martin, R.R., Ibarra, M.A., Alvarez, R.A., Mendoza, A., Insuasti, M. & Ochoa, J. 2014. Detection and occurrence of melon yellow spot virus in Ecuador: an emerging threat to cucurbit production in the region. European Journal of Plant Pathology, 140(2): 193-197.

Radouane, N., Ezrari, S., Belabess, Z., Tahiri, A., Tahzima, R., Massart, S., ... & Lahlali, R. (2021). Viruses of cucurbit crops: Current status in the Mediterranean Region. Phytopathologia Mediterranea, 60(3).

Robinson, R. W., & Decker-Walters, D. S. (1997). Cucurbits. CAB International.

Roossinck MJ, Sabanadzovic S, Okada R, Valverde RA. 2011. The remarkable evolutionary history of endornaviruses. J. Gen. Virol. 92:2674–2678

Sabanadzovic, S., Wintermantel, W.M., Valverde, R.A., McCreight, J.D. & Aboughanem-Sabanadzovic, N. 2016. Cucumis melo endornavirus: genome organization, host range and co-divergence with the host. Virus Research, 214: 49-58.

Sela, N., Luria, N., Dombrovsky, A., 2012. Genome assembly of Bell pepperendornavirus from small RNA. J. Virol. 86, 7721.

Shang, H.-H., Zhong, J., Zhang, R.-J., Chen, C.-Y., Gao, B.-D., Zhu, H.-J., 2015. Genomesequence of a novel endornavirus from the phytopathogenic fungus Alternariabrassicicola. Arch. Virol. 160, 1827–1830.

Stielow B, Klenk HP, Menzel W. 2011. Complete genome sequence of the first endornavirus from the ascocarp of the ectomycorrhizal fungus Tuber aestivum Vittad. Arch. Virol. 156:343–345

Tomašechová, J., Olmos, A., Ruiz-García, A. B., Canales, C., Mrkvová, M., & Glasa, M. (2022). First report of Cucumis melo endornavirus infecting Cucurbitaceae plants in Slovakia. Journal of Plant Pathology, 104(3), 1179-1180.

Tuomivirta TT, Kaitera J, Hantula J. 2009. A novel putative virus of Gremmeniella abietina type B (Ascomycota: Helotiaceae) has a composite genome with endornavirus affinities. J. Gen. Virol. 90:2299–2305

Villanueva, F., Sabanadzovic, S., Valverde, R.A., Navas-Castillo, J., 2012. Completegenome sequence of a double-stranded RNA virus from avocado. J. Virol. 86,1282–1283.

Welbaum G.E., 2015. Vegetable Production and Practices. CAB International Publisher, 189-204.

Zeng, R., Xu, L., Gao, S., Song, Z., Gao, P., & Dai, F. (2020). First report of Cucumis melo endornavirus on Cucumis melo in China. Journal of Plant Pathology, 102, 1355-1355.

TUZ TEMELLİ STRATEJİK GIDA VE TARIM ÜRÜNLERİ

SALT-BASED STRATEGIC FOOD AND AGRICULTURAL PRODUCTS

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ÖZET
Çankırı ili dünyadaki tuz madeni zenginliği bakımından, Polonya-Krakow'dan sonra ikinci sıradadır. Çankırı ilinin mevcut tuz yatakları, içermiş olduğu sodyum klorürün yanı sıra içerisindeki muhtemel eser toprak elementlerinin varlığıyla hem bir ham madde hem de stratejik alanlarda kullanılan endüstriyel ürünlere dönüştürülme potansiyeliyle "tuz temelli stratejik ürünler" ön plana çıkmaktadır. Gıda ve tarım alanında söz konusu potansiyelin kullanımı aynı zamanda bölgesel kalkınma anlamında da büyük bir öneme sahiptir. İhtisaslaşma programına dahil olan Çankırı Karatekin Üniversitesi İhtisaslaşma projesi kapsamında "Sektörel Tuz ve Tuz Temelli Stratejik Ürünler" alanında 6 odak noktasında (Sağlık, Analiz, İnovatif Ürünler Programı, Tuz Temelli Stratejik Ürünler Programı, Tuz Ekosistemi Programı, Sanat, Tasarım, Medya ve Farkındalık Programı) çalışmalarını yürütmektedir. Tuz Temelli Stratejik Ürünler Programı bünyesinde gerçekleştirilecek olan projeler ile Çankırı ilinin en önemli yeraltı zenginliklerinden ve gelir kaynaklarından olan tuzun stratejik ürünlere dönüştürülmesiyle bölgenin ve ülkenin katma değer potansiyelinin artırılması hedeflenmektedir. Bu çerçevede gıda sektörüne yönelik Çankırı Kaya tuzu Katkılı Alternatif Ürünlerin geliştirilmesine ilişkin çalışmalar başlatılmıştır. Tuz Ekosistemi Programında yer alan projeler ile Çankırı iklimine uygun, tuzlu koşullara adapte olan tıbbi ve aromatik bitkilerin belirlenerek, bu bitkilerden sabit, uçucu yağlar ve ekstraktlar elde edilerek etki değeri yüksek gıda, kozmetik, sağlık ve temizlik ürünlerine dönüştürülmesine yönelik ilk adımların atılmasına imkan sağlanacaktır.
Anahtar Kelimeler: Çankırı, Kayatuzu, Tuz Temelli Stratejik Ürünler, Gıda, Tıbbi ve Aromatik Bitkiler

ABSTRACT
Çankırı province is second only to Poland-Krakow in terms of salt mineral wealth in the world. The existing salt beds of Çankırı province, with the sodium chloride they contain as well as the possible trace soil elements, stand out as "salt-based strategic products" with the potential to be transformed into both a raw material and industrial products used in strategic areas. Utilizing this potential in the fields of food and agriculture holds significant importance for regional development. Within the scope of the specialization project, Çankırı Karatekin University, which is included in the specialization program, carries out its studies in 6 focal points (Health, Analysis, Innovative Products Program, Salt-Based Strategic Products Program, Salt Ecosystem Program, Art, Design, Media, and Awareness Program) in the field of "Sectoral Salt and Salt-Based Strategic Products." With the projects to be carried out within the scope of the Salt-Based Strategic Products Program, it is aimed to transform salt,

one of the most important underground resources and income sources of Çankırı province, into strategic-based products and increase the added value potential of the region and the country. In this context, studies have been initiated regarding the development of alternative products containing Çankırı rock salt for the food sector. Through the Salt Ecosystem Program's projects, the first steps will be taken to find medicinal and aromatic plants that grow well in the Ankara climate and are used to living in salty conditions. These plants will then be turned into high-impact food, cosmetics, health, and cleaning products by extracting fixed and essential oils from these plants.
Key Words: Çankırı, Rock Salt, Salt Based Strategic Products, Food, Medicinal and Aromatic Plants

GİRİŞ

Çankırı ili dünyadaki tuz madeni zenginliği bakımından, Polonya-Krakow'dan sonra ikinci sıradadır. DPT Sekizinci Beş Yıllık Kalkınma Planında sadece Üniversitemizin kurulu bulunduğu Çankırı'nın, Merkezde 327.230.545 ton ve yakın bölgesi olan Balıbağı'nda 808.000.000 ton görünür olmak üzere toplam 1.135.230.545 ton tuz rezervine sahip olduğu rapor edilmiştir.

Çankırı ilinin ağırlıklı sofra tuzu ve kaya tuzu ve süs eşyası üretimi ile yetindiği ve ekonomik açıdan potansiyeline göre yeterli bir katma değer sağlayamadığı görülmektedir. Oysa mevcut tuz yatakları; içermiş olduğu sodyum klorürün yanı sıra içerisindeki muhtemel eser toprak elementlerinin varlığıyla da gerek bir hammadde ve gerekse de stratejik alanlarda kullanılan endüstriyel ürünlere dönüştürülme potansiyeliyle "tuz temelli stratejik ürünler" yaratılması potansiyeline sahiptir.

Tuz, gelişen bir il olan Çankırı'nın tanınma ve kalkınmasında bir katalizör olarak değerlendirilmektedir. Yalnızca gıda ve kimya değil, sağlık (tamamlayıcı tıp), sanat, endüstri ve turizm gibi yönleriyle etkin olarak değerlendirilmesi gereken çok önemli bir kaynaktır.

Ülkemizdeki kaya tuzu ve kaya tuzu temelli ürünlerin üretilmesi konusunda son dönemde çok ciddi yatırımlar yapılmaktadır. Sanayi ve Teknoloji Bakanlığı yatırım teşvik belgeli yatırımları incelendiğinde kapasite olarak sadece Çankırı'da çıkartılan kaya tuzunun yaklaşık 4 katı kadar yatırım ülkemizin muhtelif illerinde devam etmektedir. Tüm bu yatırımların katma değerli ürünlere dönüşmesi için sektörün bilimsel ve teknolojik olarak gelişimi, alternatif üretilebilecek sanayi ürünlerinin ortaya konulabilmesi ve kaya tuzu içinde bulunan nadir toprak elementlerinin kazanımı konularında araştırmalar yapılarak sektörün gelişimi ve büyümesi açısından üniversitemizin katkı sağlaması amaçlanmaktadır.

İhtisaslaşma programına dahil olan Çankırı Karatekin Üniversitesi İhtisaslaşma projesi kapsamında "Sektörel Tuz ve Tuz Temelli Stratejik Ürünler" alanında 6 odak noktasında (Sağlık, Analiz, İnovatif Ürünler Programı, Tuz Temelli Stratejik Ürünler Programı, Tuz Ekosistemi Programı, Sanat, Tasarım, Medya ve Farkındalık Programı) çalışmalarını yürütmektedir. Tuz Temelli Stratejik Ürünler Programı bünyesinde gerçekleştirilecek olan projeler ile Çankırı ilinin en önemli yeraltı zenginliklerinden ve gelir kaynaklarından olan tuzun stratejik ürünlere dönüştürülmesiyle bölgenin ve ülkenin katma değer potansiyelinin artırılması hedeflenmektedir.

GIDA ve SEKTÖREL TUZ

Tuz, lezzet artırıcı özelliği nedeniyle tat kelimesi ile yaygın olarak kullanılmaktadır. Yemek yapılırken tuz ilavesinde bulunmak yiyeceklerin daha fazla sıvı kaybetmesine ve aromalarının geride kalmasını sağlayarak lezzeti ve kokuyu artırmaktadır. Bu nedenle tuz yiyeceklerde lezzeti artıran bir katkı maddesi olarak kullanılmaktadır. Türkiye'de geleneksel süt ürünlerinin üretiminde, salça yapımında, turşu ve sirke kurulumunda kaya tuzu içeriğindeki enzim yapısının fermente ürünlere katmış olduğu değer sayesinde tercih edilmektedir. Kaya tuzu yapısı gereğince daha fazla nem tutabilmektedir. Bu durumda yemek yapımında yiyeceklerin aroma ve kokusunu daha fazla salmasına ve lezzetin daha fazla artmasına fayda sağlamaktadır (Dermirkol ve ark., 2018). Edwards (2008) farklı kılavuz ve girişimler çerçevesinde temel tuzdan tuz ikamelerine ve bitkisel baharatlara kadar birçok ürünün bu amaçla kullanıldığını ifade etmektedir.

KATMA DEĞERİ YÜKSEK TARIMSAL ÜRÜNLER ve SEKTÖREL TUZ

Tıbbi ve aromatik bitkiler etken maddeleri ve kullanım alanları bakımından çok geniş bir alanı kapsamakta, familyalarına, içerdikleri etken maddelerine, tüketim ve kullanımlarına, kullanılan organlarına ve farmakolojik etkilerine göre farklılıklar oluşturmaktadır

Çankırı ili toplam 754.200 ha olup bu alanların yaklaşık 1/3'ü (240.570 ha) tarım alanı özelliğinde ve çoğunlukla engebeli arazilerdir (Anonim, 2023). Çankırı'nın coğrafi konum itibariyle geçit bölgesinde yer alması, ayrıca merkez ve ilçelerinin birbirinden oldukça farklı ekolojik ve topoğrafik yapıya sahip olması gibi özellikleri çok çeşitli tarımsal ürünlerin yetiştirilmesine imkan tanımaktadır.

Bölgenin uzun yıllar (1991-2020) yıllık toplam yağış ortalamasının 427.9 mm olması (MGM 2024) ve elverişli tarım alanları içinde sulanabilir arazinin toplam tarım alanı içindeki oranının %12.9 (30.990 ha) gibi düşük bir seviyeye sahip olması, üreticilerin çoğunlukla kuru tarım koşullarında yetiştiricilik yapmasına neden olmaktadır.

Bölgede ağırlıklı olarak buğday ve arpa gibi tahıllar (140.000 ha) yetiştirilmekte olup tahılların toplam alan içindeki payı %58.5'dir. Bunu, 53 bin ha ve %22'lik oran ile nadas alanları takip etmektedir. Tahıllardan sonra en fazla ekimi yapılan bitki türleri 12.800 ha ekim alanı ve %5.3 ile yem bitkileri, 6.280 ha ekim alanı ve %2.6 ile baklagillerdir. Tarıma elverişli olup da kullanılmayan alan ise 20.000 ha olup, bu da toplam alan içinde %8.3'lü bir paya sahiptir (Anonim, 2023). Nadas alanları ile tarıma elverişli olup da ekilmeyen alanlar dikkate alındığı zaman, her yıl toplam 73.000 ha tarım arazisinin değerlendirilmediği, bunun da toplam tarım alanı içindeki payının %30 civarında olduğu görülmektedir. Özetle, özellikle iklim koşullarına bağlı olarak tarım alanlarının yaklaşık 1/3'ü atıl durumda kalmaktadır. Diğer yandan, Çankırı buğday verim ortalaması 240 kg/da olup, birim alan verimi Türkiye ortalamasının (280 kg/da) altındadır. Bu durum da üreticilerin tahıllardan yeterli düzeyde gelir elde etmesinin önündeki en büyük engellerden birisi olarak karşımıza çıkmaktadır. TÜİK verilerine göre Çankırı'da tıbbi ve aromatik bitkiler yetiştiriciliği istatistiksel olarak kayıtlarda yer almayacak düzeydedir. Sadece 2022 yılında 1 ton kimyon, 16 ton da çörek otu elde edilmiştir (TÜİK 2024).

Bölgenin tarımsal yapısı ve ekolojik koşulları dikkate alındığında, projeye dâhil edilen bitkilerin çok yıllık türler olması ve kuru tarım koşullarında yetiştirilmeye uygun, ayrıca bölge üreticisine alternatif olarak sunulabilecek ürünler olduğu görülmektedir. Tarım alanlarının her yıl yaklaşık 1/3'ünün ekilmediği, tahıl ekilen yaklaşık %60'lık alanın da düşük verimlilik nedeniyle yeterince gelir getirmediği, özellikle tuzlu koşullara adapte olan ürünlerin yetiştirilmediği ve buna bağlı olarak ürün yelpazesinin sınırlı olduğu dikkate alındığında üreticilerin alternatif ürünlere yönelmesi kuvvetle muhtemeldir.

Tıbbi ve aromatik bitkilerin yetiştiriciliğinde en önemli unsur kaliteli ve verimli ürün elde etmektir. Uygun ekolojik koşullar, çeşitler ve yetiştirme teknikleri ile verimli ve kaliteli ürün elde etmek mümkündür. Sekonder metabolitler içinde yer alan uçucu yağlar, oldukça kompleks yapıdaki uçucu bileşenlerin bir araya gelmeleriyle oluşurlar. Tuzluluğun sadece uçucu yağ miktarını değil aynı zamanda uçucu yağ bileşenlerinin kompozisyonlarını da değiştirdiği tespit edilmiştir. Nane yağının kalitesini belirleyen ve en önemli bileşenleri olan mentol ve menton miktarlarının en yüksek değerlere 100 mM konsantrasyonunda NaCl uygulanan bitkilerinden elde edildiği belirtilmiş (Baydar ve Çaban, 2017), reyhan bitkisinde en yüksek uçucu yağ oranı tuz stresi koşullarında tespit edildiği tuz stresinin bitkilerdeki uçucu yağ gibi ikincil metabolitlerin üretimini arttırırken, birincil metabolitlerinin azalmasına neden olabileceği vurgulanmıştır (Kaya ve İnan, 2017)

İhtisaslaşma programı çerçevesinde kekik, lavanta, tıbbi adaçayı, altınotu, civanperçemi, melisa, ekinezya, rumi papatyası olmak üzere farklı tür ve bu türlere ait çeşitler adaptasyon çalışmalarında yer alacak, bitkilerin farklı dönemlerde hasat edilmesi ile etki değeri yüksek kozmetik, sağlık ve temizlik vb. ürünlere dönüştürülebilecek en etkin uçucu yağ dönemi belirlenecek, aynı zamanda bu alanda bulunacak bal arılarından elde edilecek ballarda verim ve kalite özellikleri tespit edilmektedir. Elde edilecek ham maddeler ilaç, gıda, tarım, kozmetik ve tekstil boyası gibi çok sayıda ve farklı sanayi alanlarda değerlendirilmektedir. Aynı zamanda ilgili alanda üretilecek balın da verim ve kalite bakımından yüksek etkiye sahip ürün olacağı düşünülmektedir.

SONUÇ

Bölge üniversiteleri içerisinde ilk kez Üniversitemiz tarafından konu edilen ihtisaslaşma konusu ile temel amacımız Çankırı Karatekin Üniversitesi'nin "Sektörel Tuz ve Tuz Temelli Stratejik Ürünler" konusunda uzmanlaşması ve bu bağlamda bölgenin gelişmesine katkı sağlamasıdır. Bu doğrultuda ihtisaslaşmanın önemli bir programını oluşturan gıda ve tuza adapte olan tıbbi ve aromatik bitkilerin katma değeri yüksek ürünlerine dönüştürülmesi ile hem bölge hem de ülke ekonomisi açısından önemli katkılar sunacaktır.

KAYNAKLAR

Anonim (2023). Çankırı Tarım ve Orman İl Müdürlüğü, Çalışma Raporu-2023.

Baydar, N.G. & Çoban, Ö. (2017). Tuz Stresinin Nane (Mentha piperita L.)'de Büyüme ile Uçucu Yağ Miktarı ve Bileşenleri Üzerine Etkileri. Turkish Journal of Agriculture-Food Science and Technology, 5(7), 757-762.

Demirkol, Ş., Çifçi, H. & Çifçi, A. G. İ. (2018). Kaya Tuzunun Gastronomi ve İnanç Açısından Önemi: Hacıbektaş Kaya Tuzu. 1. Uluslararası Turizmde Yeni Jenerasyonlar ve Yeni Trendler Konferansı (1-3 Kasım 2018) Bildiriler Kitabı, 298-309.

Edwards, A. (2008). Salt, salt substitutes, and seasoning alternatives. Journal of Renal Nutrition, 18(6), e23-e25.

Erbaş, M. (2006). Yeni bir gıda grubu olarak fonksiyonel gıdalar. Türkiye, 9, 24-26.

Kaya, A. & İnan, M. (2017). Tuz (NaCl) stresine maruz kalan reyhan (Ocimum basilicum L.) bitkisinde bazı morfolojik, fizyolojik ve biyokimyasal parametreler üzerine salisilik asidin etkileri. Harran Tarım ve Gıda Bilimleri Dergisi, 21(3), 332-342.

Kayabaşı, A. & Bağış, N. G. (2021). Gastronomide yükselen eğilim: Umami trendi. Gastronomide Alternatif Yaklaşımlar.

Şimşek, A. G. N., Taştan, H., & Dönmez, B. (2017). Fonksiyonel Gıdaların Yararlı Bulunması ve Kullanım Sıklığı İlişkisi, 1. Uluslararası Turizmin Geleceği Kongresi: İnovasyon, Girişimcilik ve Sürdürebilirlik Kongresi (Futourism 2017), 28-30.

TÜİK (2024). https://data.tuik.gov.tr/Kategori/GetKategori?p=tarim-111

DETERMINATION OF THE GENETIC DIVERSITY OF AVENA FATUA (L), A PROBLEM IN WHEAT GROWING AREAS

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ABSTRACT
The primary objective of this study was to investigate the genetic diversity of Avena fatua L. populations resistant to ALS inhibitors and evaluate how this diversity influences the development of herbicide resistance. ALS inhibitors are widely used in weed management; however, the repeated application of herbicides with similar modes of action has led to the emergence of herbicide-resistant weed populations, posing a significant challenge in agricultural practices. This study was conducted using A. fatua seeds collected from wheat-growing regions in four provinces (Samsun, Amasya, Çorum, and Sinop) of the Black Sea region in Turkey. Genetic variation among the populations was assessed using the Simple Sequence Repeat (SSR) marker technique. A total of 15 different primers were utilized to screen for both resistant and susceptible A. fatua populations. The analysis revealed 63 alleles across 15 loci in the 24 populations studied, with no evidence of low polymorphism. The overall genetic diversity of the populations was found to be 74%, with significant genetic differences between the resistant and susceptible populations. These findings highlight the importance of considering both the genetic diversity and resistance status of A. fatua in the development of integrated weed management strategies. The results provide valuable insights that could guide the management of herbicide resistance and contribute to the design of future, more effective weed control approaches.
Keywords: SSR, Avena fatua, Genetic Diversity, Wheat

INTRODUCTION
Agriculture, which began with crop production, has shaped the history of humanity, and as societies developed and changed, each formed its own policies to sustain agricultural activities. Wheat is one of the most important cultivated crops for living beings, both in terms of its historical significance and its production across the world (Atar, 2017). Wheat possesses a wide adaptability and has varieties that can thrive in different climatic and soil conditions. This has allowed wheat to spread across a wide geographical area globally. Wheat accounts for 20% of the calories consumed worldwide and plays a crucial role as the staple food for more than 35% of the global population (Kurt & Yağdı, 2021).
According to 2024 data from the United States Department of Agriculture (USDA), global wheat production reached 788.95 million metric tons. Turkey ranks 10th worldwide in wheat production, with a total of 21 million metric tons.
One of the primary factors limiting wheat production is plant protection issues, including diseases, pests, and weeds (Sırrı, 2019). Weeds, in particular, pose significant challenges to

wheat yield. In areas where wheat is cultivated, weed infestation exceeds the economic damage threshold, adversely affecting both yield and quality. Due to competition with weeds, global grain losses range from 20% to 40% (Güncan, 2010).

Among the weeds causing problems in wheat fields, Avena species stand out, both globally and in Turkey. Avena fatua can be distinguished from wheat during the spike stage by its spike structure and the highly hairy seeds compared to cultivated oats. In the early stages, A. fatua can be differentiated from wheat by the absence of auricles, which are present in wheat. A. fatua generally heads at the same time as wheat but matures more quickly, dropping most of its seeds into the field during the wheat harvest. The remaining seeds mix with wheat grains during harvest, reducing the market value of the product (Anon., 2017).

Chemical control remains the most effective method to prevent yield losses caused by weeds in agricultural lands. Like many weed species, A. fatua is a significant problem in agricultural fields, leading to substantial yield losses. Continuous and indiscriminate use of herbicides increases the risk of resistance development. Herbicide resistance occurs primarily due to the prolonged use of herbicides with the same active ingredient or the application of high doses (Demirkan, 2008).

Excessive use of herbicides results in various negative outcomes, significantly impacting both agriculture and the environment. It not only depletes Turkey's flora and fauna but also leaves residues in the soil and contributes to herbicide resistance in weeds (Mengüç, 2018).

Wheat is one of the leading crops where herbicides are widely used, and as a result, resistance has increased in weed species (Türkseven, 2015). In wheat cultivation, herbicides with ALS (acetolactate synthase) and ACCase (acetyl-CoA carboxylase) inhibition mechanisms are commonly used for weed control (Torun, 2020).

ALS inhibitor herbicides are preferred due to their low cost, broad-spectrum control, low dosage effects, and low mammalian toxicity (Wilhelm et al., 1998). However, continuous and uncontrolled herbicide use can lead to the development of herbicide resistance in weeds. When exposed to herbicides, weeds rapidly undergo a metabolic adaptation process, breaking down herbicides and leading to resistance problems (Ghanizadeh & Harrington, 2017). The first case of herbicide resistance in Turkey was observed in A. sterilis in wheat fields (Uludağ et al., 2001). These resistant populations have continued to spread over time, giving rise to new biotypes with varying levels of resistance.

Research on the growth and development of resistant and susceptible weed species has yielded varying results. The differences between populations are due to different gene variants and the varying frequencies of these variants within populations. Genetic diversity is defined as the genetic differences occurring within a species. One of the most important factors enabling a species to adapt to different environmental conditions is its genetic diversity. High genetic diversity within a species enhances its ability to adapt to changing environmental conditions. This increased genetic diversity significantly influences the development of herbicide resistance and enhances the adaptability of resistant populations (Yamaguchi et al., 1996; Yabuno, 2001; Michishita & Yamaguchi, 2003). Advances in modern molecular techniques have provided new perspectives in weed science by allowing researchers to study genetic variation in weed populations (Ye et al., 2004; Boylu & Kaya Altop, 2021).

MATERIALS AND METHODS

Materials

Avena fatua (L.)

Avena fatua is a monocot plant belonging to the Poaceae family. A. fatua is one of the most problematic weeds in temperate agricultural regions worldwide. It is a seed-propagating plant, with a single plant producing up to 1,000 seeds. The seeds are oval-shaped, with a length of 7 mm, a width of 2.5 mm, and a thickness of 2 mm, featuring pointed ends. The seed coat has a distinct line, and the base is hairy. The seeds do not fall in spikes but are dispersed individually. The optimum germination temperature ranges from 15 to 20°C. While it adversely affects cultivated crops, its invasive nature also poses a threat to local biodiversity. The plant can grow to a height of 100-130 cm, featuring a straight and robust stem. The upper and lower surfaces of the leaves are hairless, with hairy edges that shed as the plant ages. The regions where the leaves attach to the stem are hairless and tightly encircle the stem. Newly formed leaves are curled to the left, and the ligule can reach a length of 6 mm; it is membranous with finely serrated edges and lacks auricles.

Materials used in molecular studies

In the molecular study, DNA was extracted from the green tissues of the plants using the DNeasy Plant Mini DNA Kit (Qiagen, Netherlands) according to the kit protocol. For SSR analysis, fifteen different primers were used for each sample collected from populations identified as resistant to ALS-inhibiting herbicides, and the primers were synthesized by Oligomer Biotechnology (Ankara).

Methods

Sampling of populations

The Avena fatua populations identified as resistant to ALS inhibitors were obtained from the seed bank of the herbarium laboratory in the provinces of Samsun, Amasya, Çorum, and Sinop. The SSR method was employed to determine the genetic diversity of Avena fatua populations.

DNA extraction was performed according to the DNeasy Plant Mini DNA Kit protocol. Leaf discs weighing 100 mg were taken from fresh leaf samples and placed in Eppendorf tubes, which were then frozen in liquid nitrogen and crushed using a homogenizer. After adding 400 µl of AP1 buffer and 4 µl of RNase, the mixture was vortexed for 30 seconds and then incubated in a water bath at 65°C for 10 minutes. Following this, 130 µl of AP2 buffer was added, and the mixture was incubated on ice for 5 minutes. The resulting supernatant was transferred to new Eppendorf tubes after centrifugation at 14,000 rpm for 2 minutes. AP3/E buffer was added, and half of the mixture was transferred to white tubes and centrifuged at 8,000 rpm for 1 minute. After discarding the pellet, 500 µl of AW buffer was added, followed by a second centrifugation at 8,000 rpm for 1 minute.

During the drying step, 500 µl of AW buffer was added, and the mixture was centrifuged at 14,000 rpm for 2 minutes. Then, 100 µl of AE buffer was added to the column, and the column was incubated at room temperature for 5 minutes before centrifugation at 8,000 rpm for 1 minute. The obtained DNA samples were stored at -28°C. The concentration of DNA samples to be used in SSR-PCR reactions is critical for the success of the reactions. The samples were analyzed using a 3% agarose gel run with 1X TBE buffer and visualized with a gel imaging system (Vilber Lourmat).

Preparation of agarose gel

The analysis of PCR products was performed using a 3% agarose gel. The gel was prepared by dissolving 8 g of Serva Agarose (Germany) and 4 g of Nusseive GTG Agarose (Combrex, USA) in 1X TBE buffer using a microwave. The mixture was cooled to 50 ºC, and Ethidium Bromide (0.5 µl/ml) was added. A total of 20 µl of the DNA sample was mixed with 3 µl of loading buffer and loaded into the gel wells, with a 100 bp DNA marker added to the first well. The electrophoresis was run at 110 V for 2.5 hours, and the DNA bands were visualized and documented using a Vilber Lourmat gel imaging system.

Evaluation of bands

The results of the SSR analysis are based on the presence (1) or absence (0) of bands observed in the gel after electrophoresis. In this study, optimal PCR conditions were established through repeated amplifications, and conditions that provided a stable band profile for each primer were selected. To obtain the phenogram, both monomorphic (bands present in all varieties) and polymorphic (bands present in some varieties but absent in others) bands in the gels were identified.

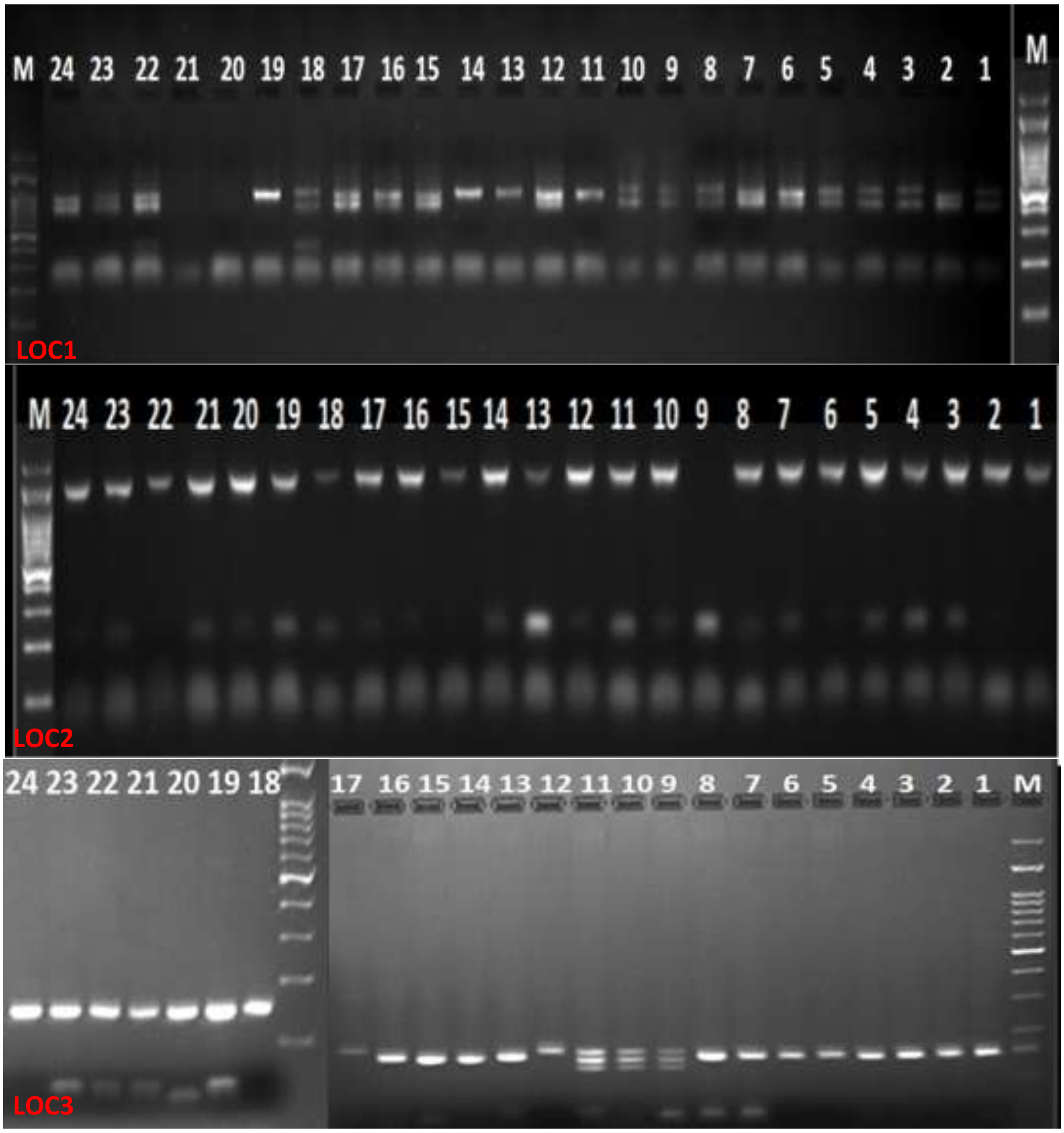
Statistical analyses

For molecular studies, the band images obtained from the gel were first evaluated based on marker sizes. The SPSS 21.0 (for Windows) software was utilized for this analysis. The sizes of polymorphic bands were entered into the computer as present (1) or absent (0), thereby creating band matrices for use in subsequent analyses. In the final stage, dendrograms for the species were drawn using the SAHN (sequential, agglomerative, hierarchical, and nested clustering) subprogram and the UPGMA (based on Jaccard's coefficient) algorithm based on the similarity matrices.

RESULT

Molecular findings of Avena fatua

In this study, 24 genotypes of Avena fatua collected from wheat-cultivated fields in 4 provinces were screened with 15 different SSR primers. The gel images obtained after the SSR-PCR analysis and subjected to 3% agarose gel electrophoresis are presented below.



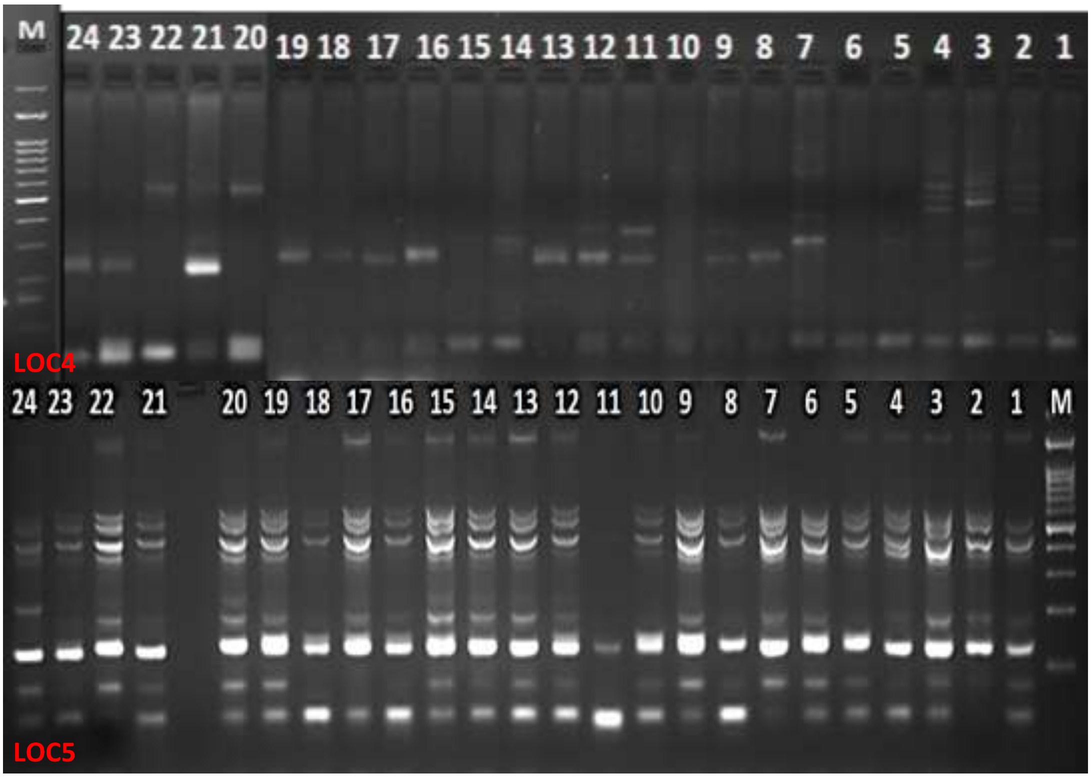


Figure 1. Band images of some primers (LOC1-LOC5) in the gel after electrophoresis.

Phylogenetic tree of A. fatua genotypes

The data on the presence (1) or absence (0) of band indices obtained with polymorphic primers indicate that all the analyzed genotypes are divided into two main clusters according to the dendrogram information generated by the statistical SPSS 21 software (Figure 2). Based on these genotypes, the phylogenetic tree is also divided into two main groups. The first main group is further divided into two subgroups (1.1 and 1.2). The second main group (2) represents the sensitive populations, including the samples ÇOR7 (Çorum) and ÇOR24 (Çorum).

The phylogenetic tree generated from the UPGMA analysis revealed that some samples collected from Amasya province exhibited the highest genetic similarity of 88% among themselves. The lowest genetic similarity (0.25%) was observed between the populations from Çorum (ÇOR7) and Sinop (SİN4).

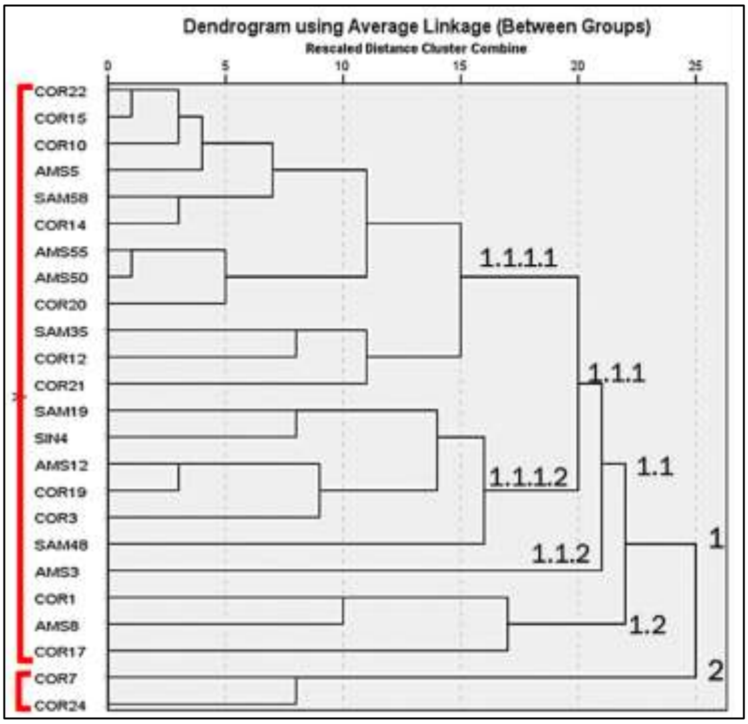


Figure 2. Phylogenetic tree A. fatua genotypes

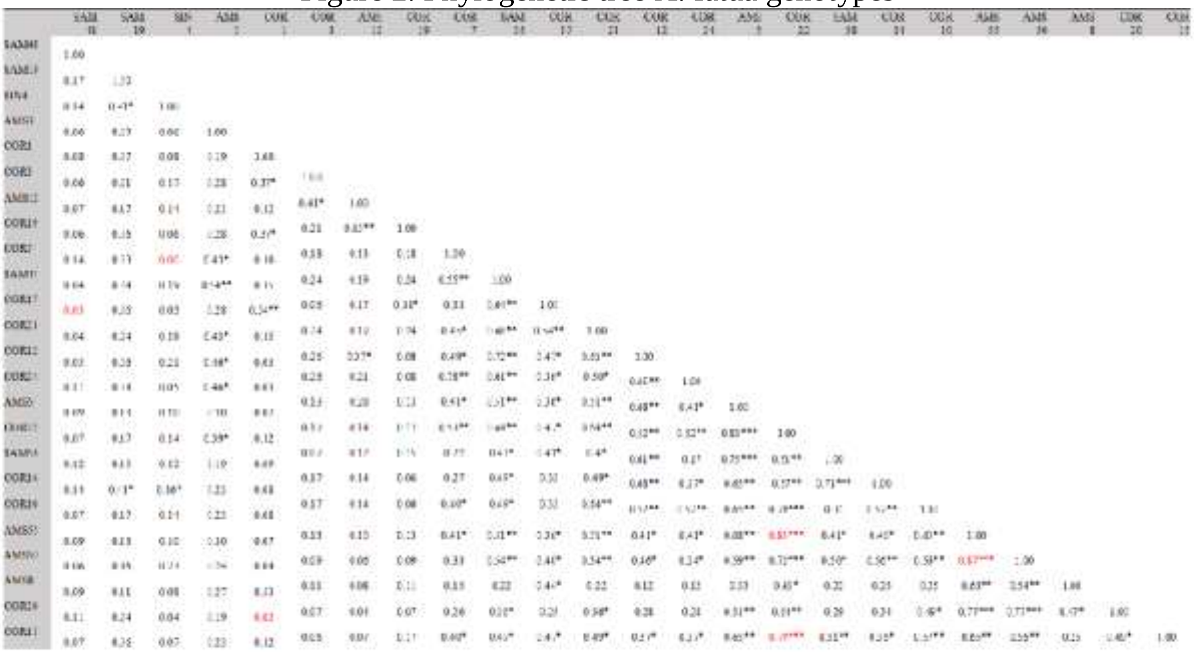


Figure 3. Similarity matrix of A. fatua genotypes

Principal component analysis

According to the results of the SSR-PCR analysis, six principal component axes explaining approximately 74.43% of the variations in molecular data among A. fatua populations and their associated factor groups are presented in Table 1. The findings indicate that the total diversity was determined to be approximately 37.30%, 47.29%, 55.97%, 63.32%, 69.31%, and 74.43%, respectively. It was observed that the genotypes had significant effects on the variations: the COR22 genotype contributed 37% variation, the COR19 genotype contributed 47% variation, the SAM19 genotype contributed 55% variation, the AMS8 genotype contributed 63% variation, the SAM48 genotype contributed 69% diversity, and the AMS12 genotype contributed 74% diversity. The highest principal component value was found in the COR22 population.

Table 1. Factor groups corresponding to populations created according to SSR-PCR band results

PCR Axes						
	1	**2**	**3**	**4**	**5**	**6**
Eigenvalues	8.954	2.396	2.084	1.765	1.436	1.230
Variation	37.309	9.984	8.682	7.352	5.983	5.127
Cumulative Variation	37.309	47.293	55.976	63.328	69.311	74.438
Factor Loadings						
POPULATION	**(PC1)**	**(PC2)**	**(PC3)**	**(PC4)**	**(PC5)**	**(PC6)**
SAM48	-0.024	-0.139	0.363	0.206	0.422	0.330
SAM19	0.285	-0.169	0.538	0.461	-0.201	0.109
SIN4	0.203	-0.123	0.557	0.370	-0.121	0.106
AMS3	0.506	0.387	0.112	-0.127	-0.064	0.251
COR1	0.188	0.611	-0.381	0.388	0.145	0.286
COR3	0.256	0.492	0.284	0.189	-0.431	-0.005
AMS12	0.271	0.576	0.305	0.171	-0.109	-0.580
COR19	0.238	0.689	-0.133	0.168	0.149	-0.401
COR7	0.602	0.222	-0.007	-0.487	-0.191	0.174
SAM35	0.792	0.188	0.157	-0.151	0.101	0.233
COR17	0.611	0.353	-0.201	0.113	0.395	0.258
COR21	0.766	0.105	0.129	-0.080	0.068	0.122
COR12	0.763	0.095	0.399	-0.205	0.167	-0.031
COR24	0.647	0.203	0.150	-0.506	-0.242	0.193
AMS5	0.825	-0.151	-0.038	-0.049	0.141	-0.340
COR22	0.905	-0.138	-0.172	-0.049	-0.078	-0.076
SAM58	0.635	-0.181	0.076	0.086	0.579	-0.235
COR14	0.702	-0.280	0.388	0.115	0.188	-0.065
COR10	0.750	-0.243	0.024	-0.173	-0.200	-0.071
AMS55	0.817	-0.231	-0.319	0.141	-0.229	-0.055
AMS50	0.797	-0.312	-0.091	0.319	-0.131	0.040
AMS8	0.479	0.069	-0.443	0.529	-0.131	0.222
COR20	0.641	-0.305	-0.302	0.209	-0.320	-0.090
COR15	0.702	-0.180	-0.393	-0.190	0.195	-0.073

CONCLUSIONS

SSR markers were utilized to determine the genetic differences among Avena fatua populations, revealing that these populations exhibit genetic diversity. The overall genetic diversity was calculated to be 74%, and a significant genetic difference was observed between resistant and sensitive populations.

The genetic similarity among A. fatua genotypes varied between 1% (0.01) and 100% (1.00), with the lowest similarity found between the ÇOR7 population from Çorum and the SİN4 population from Sinop (0.25%). In contrast, the highest similarity (88%) was detected among some samples collected from Amasya. Molecular studies have indicated a high level of diversity in A. fatua genotypes and confirmed the absence of geographical isolation. Despite a high rate of self-fertilization, it is believed that some degree of cross-fertilization may also occur. Furthermore, the likelihood of genetic transfer between resistant and sensitive populations is high due to the influence of weed species that have developed herbicide resistance. It is suggested that the observed resistance may be attributed to these species.

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REFERENCES

Anonim. (2017). Buğday Entegre Mücadele Teknik Talimatı. Tarımsal Araştırmalar ve Politikalar Genel Müdürlüğü Gıda ve Kontrol Genel Müdürlüğü. Çankaya/ANKARA www.tarim.gov.tr

Atar, B. (2017). Gıdamız buğdayın, geçmişten geleceğe yolculuğu. Yalvaç Akademi Dergisi, 2(1), 1-12.

Boylu, D.,ve Altop, E. K. (2021). Buğday Alanlarında Sorun Olan Alopecurus myosuroides Huds.'un Morfolojik ve Genetik Çeşitliliğinin Belirlenmesi. Turkish Journal of Weed Science. 24 (2). 108-127.

Demirkan, H. (2009). Herbisitlere dayanıklılık konusunda dünyada yapılmış bildirimlerin değerlendirilmesi. Ege Üniversitesi Ziraat Fakültesi Dergisi, 46(1). 71-78.

Ghanizadeh, H., and Harrington, K. C. (2017). Non-target site mechanisms of resistance to herbicides. Critical Reviews in Plant Sciences. 36 (1). 24-34.

Güncan, A. (2010). Yabancı Ot Mücadelesi, Selçuk Üniversitesi Ziraat Fakültesi, Genişletilmiş ve ilave 2. Baskı. Konya. (s. 278).

Kurt, P., ve Yağdı, K. (2021). Bazı ekmeklik buğday genotiplerinde SSR (Mikrosatalit) markörü kullanılarak kahverengi pas dayanıklılık geni Lr10'un belirlenmesi. Kahramanmaraş sütçü imam üniversitesi tarım ve doğa dergisi. 24(4). 850-858.

Mengüç, Ç. (2018). Herbisit Toksisitesi ve Yabancı Otlara Karşı Alternatif Mücadele Stratejileri. Turkish Journal of Weed Science. 21 (1). 61-73.

Sırrı, M. (2019). Buğday ekim alanlarında sorun oluşturan yabancı ot türleri: Siirt ili örneği. Türkiye Tarımsal Araştırmalar Dergisi. 6(2). 142-152.

Torun, H. (2020). Buğday Alanlarında Sorun Olan Kısır Yabani Yulaf (Avena sterilis L.) Popülasyonlarının Bitki Boyu ve Yaş Ağırlıklarına Bazı ALS ve ACCase Inhibitörü Herbisitlerin Etkileri. Kahramanmaraş Sütçü İmam Üniversitesi Tarım ve Doğa Dergisi. 23 (2). 358-366.

Türkseven, S. ve Nemli, Y. (2015). Türkiye'de Avena fatua L.'nin Herbisitlere Dayanıklılığı ile İlgili İlk Kayıt. Turkish Journal of Weed Science. 18 (2). 1-11

Uludağ, A., Nemli, Y., ve Rubin, B. (2001). Yabani yulafta (Avena sterilis L.) cladinofop'a dayanıklılık üzerine çalışmalar. Türkiye II. Herboloji Kongresi Bildiri Özetleri, Ankara Üniversitesi Ziraat Fakültesi Bitki Koruma Bölümü.

Wilhelm, N., and Hollaway, K. (1998). Persistence of sulfonylurea herbicides on alkaline soils. In 9th Australian Agronomy Conference. Wagga Wagga.

Yamaguchi, H., Utano, A. Y. A., Yasuda, K., Yano, A., and Soejima, A. (2005). A molecular phylogeny of wild and cultivated Echinochloa in East Asia inferred from non-coding region sequences of trnT-L-F. Weed Biology and Management. 5 (4). 210-218.

EFFECTS OF DIGITAL AGRICULTURE TECHNOLOGIES ON YIELD AND QUALITY IN FIELD CROPS

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ABSTRACT
Digital agriculture technologies offer a comprehensive solution for improving the yield and quality of field crops by utilizing tools such as sensors, satellite imaging, data analytics, and artificial intelligence. These technologies enable precise determination of plants' fundamental needs, such as water, nutrients, and light. For instance, precision agriculture technologies allow real-time monitoring of soil and plant conditions, ensuring the accurate provision of necessary nutrients and water. Additionally, data collection and analysis facilitate the early detection of adverse conditions such as pests or disease symptoms. This capability is critical for maintaining plant health and maximizing yield. Digital agriculture technologies also contribute to sustainable production goals while reducing costs. From a sustainability perspective, these technologies minimize environmental impact by enabling reduced water and fertilizer usage. With all these features, digital agriculture technologies are pivotal in modern farming, not only for increasing yield and quality but also for fostering environmental responsibility. The purpose of this review is to examine the impacts of digital agriculture technologies on field crops and highlight the importance of these innovations in agricultural practices.
Keywords, Analytics, Quality, Sensors, Yield

INTRODUCTION
Today, challenges in agricultural productivity, resource management, and sustainability have made the integration of digital technologies a necessity in the agriculture sector. Digital agriculture technologies enable the precise, efficient, and informed management of agricultural activities. These technologies offer advantages such as increased productivity, cost reduction, and minimized environmental impact, thereby enhancing the competitiveness of farmers and agricultural enterprises. A wide range of technologies, including agricultural machinery, wireless sensors, unmanned aerial vehicles, and big data analytics, is shaping the future of agriculture. Through digitalization, processes such as yield prediction, plant health analysis, and disease and stress detection are conducted more quickly and accurately, optimizing production quality and resource use (Akyol, 2023; Avşar, 2024; Gürlek, 2024). The purpose of this review is to examine how digital agriculture technologies are transforming agricultural activities and to emphasize their beneficial impacts on field crop production. It also highlights the critical importance of digitalization in addressing economic and environmental sustainability in the agriculture sector.

DIGITAL AGRICULTURE TECHNOLOGIES
Kahraman (2017) emphasizes that digital technologies enable farmers to manage agricultural areas more efficiently and facilitate crop monitoring, contributing to a more sustainable agricultural structure. Ersöz and Özmen (2020) highlight that the successful implementation of digital transformation processes requires the adaptation of both employees and managers, which is crucial for maximizing the advantages of digitalization. Similarly, Sağlam (2021)

notes that tailoring digitalization processes to specific business needs plays a decisive role in transformation success and underscores the importance of effectively utilizing technological tools to enhance competitive advantage.

Digital agriculture technologies are crucial for enhancing efficiency and sustainability in agricultural activities. CEMA (2017) reports that integrating precision agriculture technologies with GPS improves the monitoring and management of agricultural areas, offering farmers better control and optimization opportunities. Similarly, Ercan et al. (2019) state that equipping agricultural machinery with sensors facilitates inter-machine communication, enabling integrated management of production processes. These technological advancements not only enhance efficiency but also provide significant convenience to farmers.

McCouch (2018) identifies digital agriculture as an approach that enables more effective management of current agri-food systems and the establishment of sustainable systems, offering advantages such as time savings, cost reduction, production increases, and environmental protection. Özdoğan et al. (2017) highlight that fundamental elements of digital agriculture—such as SMS, smartphone applications, the Internet of Things (IoT), robotics, UAVs, cloud computing, and big data analytics—integrated into agricultural processes result in more efficient production. Digitalization contributes not only to accelerating processes but also to enabling businesses to utilize resources more efficiently. Yücel and Adiloğlu (2019) report that digitalization saves time for businesses and enhances operational efficiency, while Sağlam (2021) emphasizes that customizing digital transformation processes to business needs determines transformation success.

Technologies such as drones play a critical role in monitoring pests, detecting weeds, and accelerating pesticide applications, reducing costs and environmental impacts. Kern (2015) notes that drone use in China has halved pesticide usage and reduced water consumption by 90%. FAO (2022) defines the concept of e-agriculture as an area that leverages information and communication technologies to promote rural development and agricultural production. The establishment of national e-agriculture strategies is seen as the first step in the digital transformation process.

CONTRIBUTIONS OF DIGITAL TECHNOLOGY TO FIELD CROP PRODUCTION

The effects of digital agriculture technologies on yield and quality in field crops are realized through the precise, efficient, and informed management of agricultural processes. For example, wireless sensor networks (WSNs) and remote sensing (RS) enable precise detection of soil moisture, temperature, and nutrient deficiencies. This data allows for irrigation and fertilization to be tailored to the specific needs of plants, preventing yield loss.

Among the digital technologies used in agriculture, the Internet of Things (IoT), wireless sensor networks, remote sensing, unmanned aerial vehicles (UAVs), big data analytics, machine learning, deep learning, and artificial intelligence (AI) are particularly prominent. These technologies play a vital role in ensuring the long-term sustainability of agriculture and industry. Specifically, they offer solutions in areas such as yield prediction, plant health, disease detection, water stress, and nitrogen stress, enabling agricultural activities to be managed more consciously and effectively. By providing precise data for agricultural processes, these technologies facilitate plant management. For instance, they are effectively utilized for tasks such as yield prediction, weed and disease detection, analysis, and classification of product quality characteristics. Furthermore, they contribute to improved production quality through the identification and classification of plant species (Çakmakçı & Çakmakçı, 2023).

Historically, mechanization was a key factor in productivity increases. Willet (1978) noted that modern machinery accelerated production and increased agricultural productivity.

Demirci and Özçelik (1987) and Işık (1988) emphasized that tractors were the most important tools in agricultural mechanization and highlighted the need to consider farm size and soil structure when selecting tractors. Sabancı et al. (1986) evaluated the level of mechanization based on tractor power and used this metric to analyze the impact of mechanization on productivity.

In recent times, Kern (2015) noted that robotic technologies have been used for weed control and precision agricultural operations, highlighting the improved accuracy provided by autonomous robots such as "Lettuce Bot" and "Vitirover." Sümer et al. (2008) stated that renewing agricultural machinery is a critical investment for businesses, with economically stable enterprises preferring new machinery.

Digital transformation plays a significant role in increasing productivity and quality in agricultural production. Mert (2020) stated that digital transformation improves customer satisfaction and productivity while simplifying business processes. Nalbantoğlu (2021) emphasized that investments in digital transformation projects reduce operational costs and enhance process efficiency.

Digital agricultural solutions are transforming agricultural activities from both economic and environmental sustainability perspectives. These technologies stand out as effective tools for enhancing productivity and optimizing agricultural production. Anonymous (2016) noted that digital agriculture offers an approach combining digital innovations and system analytics to manage agri-food systems more effectively. This approach provides significant benefits, such as environmental protection and increased production. Anonymous (2022) highlighted the future importance of the sector, projecting a 10.5% growth rate in the digital agriculture sector from 2022 to 2027, with an estimated market value of $29.8 billion by 2027.

CONCLUSION

Digital agriculture technologies are emerging as powerful tools for increasing agricultural productivity and supporting environmental sustainability. Through precision agriculture applications and technologies such as sensors and remote sensing, farmers can utilize resources more efficiently while achieving significant improvements in yield and quality. Moreover, innovative applications like UAVs and autonomous robots accelerate agricultural processes and reduce costs. Digital transformation not only optimizes production processes but also serves as a critical step in preparing the agriculture sector for the future. Adopting these technologies is inevitable to meet the growing global food demand and minimize environmental issues. The potential of digital agriculture presents itself as a force shaping the future of farming, driving both economic growth and environmental conservation. In this context, the widespread adoption of digital agriculture technologies will become the cornerstone of sustainable farming practices.

REFERENCES

Akyol, I. (2023). Tarımda Dijital Dönüşüme Yönelik Uygulamalar ve Politikaların Türkiye İçin Değerlendirilmesi (Yüksek Lisans Tezi). Ankara Üniversitesi, Fen Bilimleri Enstitüsü, Ankara.

Anonymous. 2016. Precision-agriculture and the future of farming in Europe, 40, Brussels.

Anonymous. 2022. Web Sitesi: https://www.marketsandmarkets.com/Market-Reports/ digital-agriculture-market-235909745.html?gclid=CjwKCAjwx Oym BhAFE iwAnodBLLfLKC1vhwha286gt2MfPnZU-5dNDvtTmCkCaL6BFJ-Ll6OIMwj ORoC 5REQA vD BwE Erişim Tarihi: 17.03.2022

Avşar, G. (2024). Türkiye'de Tarımda Dijital Dönüşüm Kapsamında Uygun Bir Tarım Makinaları ve Teknolojileri Sanayi Kümelenme Modeli Geliştirilmesi (Doktora Tezi). Ankara

Üniversitesi, Fen Bilimleri Enstitüsü, Tarım Makinaları ve Teknolojileri Mühendisliği Anabilim Dalı, Ankara.
CEMA (2017). Digital Farming: What does it Really Mean. 2020 tarihinde http://cemaagri.org/sites/default/files/CEMA_Digital%20Farming%20-%20Agriculture%204.0_%2013%2002%202017.pdf. Erişim Tarihi: 17.04.2022
Çakmakçı, M.F. & Çakmakçı, R. (2023). Uzaktan Algılama, Yapay Zeka ve Geleceğin Akıllı Tarım Teknolojisi Trendleri. Avrupa Bilim ve Teknoloji Dergisi, (52), 234-246.
Demirci, R., ve Özçelik, A., 1987. Orta Anadolu Tarım İşletmelerinde Müşterek Makina Kullanma Şekillerinin Ekonomik Açıdan Araştırılması ve Uygun Modelin Tespiti. Doğa TÜBİTAK Tarım ve Ormancılık Dergisi, Cilt 11, Sayı 2, Ankara.
Ercan, ġ., Öztep, R., Güler, D., Saner, G. (2019). Tarım 4.0 ve Türkiye‟de Uygulanabilirliğinin Değerlendirilmesi, Tarım Ekonomisi Dergisi, 25(2).
Ersöz, B., & Özmen, M. (2020). Dijitalleşme ve Bilişim Teknolojilerinin Çalışanlar Üzerindeki Etkileri. AJIT-e: Academic Journal of Information Technology,11 (42).
Gürlek, E. (2024). Tarım Makinalarına İlişkin Satın Alma, Kiralama ve Ortak Makine Kullanım Kararında Faktörlerin Belirlenmesi (Doktora Tezi). Çukurova Üniversitesi, Fen Bilimleri Enstitüsü, Tarım Makinaları ve Teknolojileri Mühendisliği Anabilim Dalı, Adana.
Işık A., 1988. Sulu Tarımda Mekanizasyon Araçlarının Optimum Makine Ve Güç Seçimine Yönelik İşletme Değerleri Ve Uygun Seçim Modellerinin Oluşturulması Üzerinde Bir Araştırma, D. Tezi, Ç.Ü. Fbe, Yk:108, Adana. Pp: 180.
Kahraman, H., (2017). Dijital Tarım‟la Birlikte Gelen Akıllı Tarım. http://www.endustri40.com/endustri-4-0la-birlikte-gelen-akillitarim/ (ErişimTarihi: 15.03.2022).
Kern, M. 2015. Digital agriculture. ISPSW Strategy Series: Focus on Defense and International Security, 331(8).
Mccouch, S. 2018. Transforming Agriculture: How Will We Sustainably Feed 10B People?. Brief Overview of Digital Agriculture (DA) Workshop. Cornell Initiative for Digital Agriculture (CIDA).
Mert, G. (2020). Kurumların Stratejik Yönetim Süreçlerinde Dijitalleşmenin Rolü. Journal of Social, Humanities and Administrative Sciences, 6 (22).
Nalbantoğlu, B. C. (2021). Covid 19 Sürecinin Dijital DönüŞüme Etkileri. Balkan ve Yakın Doğu Sosyal Bilimler Dergisi, 7 (4), 13-18.
Özdoğan. B., A. Gacar ve H. Aktas. 2017. Digital agriculture practices in the context of agriculture 4.0. Journal of Economics, Finance and Accounting (JEFA), V.4, Iss.2, p.184-191
Sabancı, A., Özgüven, F., 1986. Tarım Makinaları İşletme ve Bakım Tekniği. Çukurova Üniversitesi Ziraat Fakültesi Yayınları, No:117, Adana.
Sağlam, M. (2021). İşletmelerde Geleceğin Vizyonu Olarak Dijital Dönüşümün Gerçekleştirilmesi ve Dijital Dönüşüm Ölçeğinin Türkçe Uyarlaması. İstanbul Ticaret Üniversitesi Sosyal Bilimler Dergisi, 20 (40), 395-420.
Sümer, S. K., ,Say, S. M., Özpınar, S., 2008. Çanakkale İlinde Kullanılmış Traktör Fiyatlarının Değerlendirilmesi. Tekirdağ Ziraat Fakültesi Dergisi, 5(3).
Willet G. S., 1978. Fınancıng Farm Machınery: Own, Lease Or Rent?. The Washington State. University Cooperative Extension Service, Washington, E.M. 4359.
Yücel, G., & Adiloğlu, B. (2019). Dijitalleşme- Yapay Zeka ve Muhasebe Beklentiler. Muhasebe ve Finans Tarihi Araştırmaları Dergisi, (17), 47-60.

BIOPESTICIDAL EFFICACY OF HELIOTROPIUM INDICUM LEAF EXTRACTS IN POSTHARVEST PEST CONTROL OF STORED GRAINS

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Abstract

The hexane, ethyl acetate, and methanol leaf extracts of Heliotropium indicum were screened for their biopesticidal activity against the weevils of rice, sorghum and maize grains. Each extract demonstrated promising efficacy in causing mortality at various concentrations (2.5 g/kg, 5.0 g/kg, 10 g/kg, and 20 g/kg) 24-96 h postexposure. Among the extracts, the methanol extract emerged as the most effective, exhibiting the highest mortality rate of 96.67% at a concentration of 20 g/kg, 96 h after exposure, comparable to the standard insecticide (cypermethrin). In contrast, the negative control, consisting of untreated grains, showed 1.67% mortality rate for Sitophilus zeamais 72 h post-exposure, which could be attributed to natural death or mechanical injury. .Additionally, the methanol, and ethyl acetate, extracts demonstrated high mortality rates for Sitophilus zeamais. This level of effectiveness is similar to that of cypermethrin, indicating that Heliotropium indicum could be a valuable biopesticide for the postharvest management of stored grains. This study suggests the potential for these plant extracts to serve as natural alternatives to synthetic insecticides, offering a sustainable solution for pest control in stored grain protection. The novelty of this research lies in its comprehensive approach to utilizing multiple solvent extracts from a single plant species, highlighting the untapped potential of Heliotropium indicum in the development of eco-friendly biopesticides. This could pave the way for further investigations into other medicinal plants with similar properties, ultimately contributing to safer and more sustainable agricultural practices.

Introduction

Grain weevils, particularly the species Sitophilus oryzae, Sitophilus granarius and Sitophilus zeamais, represent major pests affecting stored grains like rice, sorghum, and maize. These pests inflict severe damage, resulting in significant weight losses that can reach up to 80%, contamination with mycotoxins, and a reduction in the commercial value of the grains. Historically, various methods have been employed by humans to combat these pests, ranging from mechanical practices and the use of organic and inorganic materials to more spiritual approaches such as prayers, rituals, and casting of spells (Okwute,2012). In the past half-century, chemical insecticides have dominated pest control strategies. However, due to a growing awareness of the risks associated with synthetic insecticides, there is a noticeable shift towards biopesticides. These plant-derived alternatives are considered safer for the environment, because they are biodegradable, and leave no harmful residues in the soil, food, or feed (Dhawan, and Peshin, 2009). Some commonly used fumigants in storage facilities, such as phosphine have raised concerns due to issues like pest resistance, toxic waste, and health hazards (Nayak, and Collins, 2008; Benhalima et al., 2004). .Therefore, the need for safer, environmentally friendly, and cost-effective alternatives is increasingly evident (Attia et al., 2020; Gerson et al., 2003). Plant-derived compounds offer a promising solution as they break down quickly in the environment and are generally less toxic to mammals. Moreover, they tend to be more selective towards non-target organisms. Despite the identification of over 2,000 plant species with insecticidal properties, their application remains limited due to challenges such as over-harvesting and negative impacts on biodiversity (Garud et al., 2015). .One plant of interest is Heliotropium indicum L., a common weed known for its medicinal properties. This plant is widely utilized in traditional medicine for treating a range of ailments, including wound healing, bone fractures, eye infections, menstrual disorders, and anti-inflammatory and anti-cancer activities (Sarkar et al., 2021). Despite its extensive medicinal applications, H.indicum has not been explored for managing insect pests in stored grains. Plant extracts are known to have various adverse effects on insects, such as inducing toxicity, causing mortality, and reducing fertility. This study therefore aimed at investigating the biopesticidal properties of Heliotropium indicum leaf extracts for controlling stored grain weevils. This marks the first investigation into the use of H.indicum for such a purpose. By evaluating the efficacy of H.indicum as a botanical insecticide, this research seeks to contribute to the development of sustainable and eco-friendly pest control methods for stored grains. The results could pave the way for new, environmentally safe alternatives to traditional chemical insecticides, thereby addressing the need for solutions that are both effective and non-harmful to the ecosystem.

Aim of the Study

This study aimed to investigate the biopesticidal properties of Heliotropium indicum Leaf Extracts for Controlling rice, sorghum and maize weevils.

Objectives of the Study

The objectives of this study were to:

i. extract the bioactive constituents from the leaf extract of H.indicum
ii. test the insecticidal activity of four extracts on weevils of rice, sorghum and maize at various concentrations and exposure time
iii. determine the percentage viability, adult emergence and weight loss postexposure
iv. determine the percentage grain damage, and weight loss

Significance of the Study

This study aims to enhance grain storage and manage infestations of insects in stored grains. Furthermore, it seeks to improve food safety technology and reduce post-harvest losses of grains. By enabling the sale of higher-quality grain products locally, this research will also increase the market value of stored grains and contribute to the country's Gross Domestic Product (GDP).

Materials and methods

Collection of Plant Sample and preparation of extracts

Fresh leaves of Heliotropium indicum L.,were collected from botanical garden opposite the Benue State University Second Gate in Makurdi, Benue State and the plant was authenticated at the herbarium section of the Forestry Research Institute of Nigeria (FRIN), Ibadan, by Mr. Egunjobi A.J. and Mr. Adeyemo A. A, and a specimen copy with herbarium number FHN/113768 was deposited. The leaves were washed with tap water to remove any foreign materials. After draining them on the shelves and air-dried for 14 days in a well-ventilated, shaded area, they were pounded with mortar and pestle to coarse powder and was stored in an airtight polythene bag before successive solvent extraction. A powdered sample (420 g) was allowed to make contact with 1.2 L of hexane in a stopper glass container for 72 h, with occasional shaking, following the method of Ncube et al.(2008). The extract was decanted, filtered with Whatman No.4 filter paper, and concentrated to dryness as crude hexane extract. This process was successively repeated for ethyl acetate, methanol and distilled water to get their respective crude extracts in accordance to the description of Goselle et al. (2017).

Insecticidal activity of crude extracts

Parameters

The parameters to consider for the efficacy of the extracts on the studied insects are: mortality, adult emergence, germinability, and weight loss.

Test Insects

The following test insects were used for this research work:

Rice weevil	Sitophilus oryzae
Sorghum weevil	Sitophilus granarius
Maize weevil	Sitophilus zeamais

While Sitophilus zeamais (the maize weevil) and Sitophilus oryzae (the rice weevil) have wings and can fly, Sitophilus granarius (the sorghum weevil) does not. S. oryzae primarily infects rice, whereas S. zeamais primarily infests maize. Furthermore, S.zeamais tends to do better in warmer climates than S.granarius.

Insect mortality determination

After insect culturing, about twenty grams0 (0.20 kg) of clean uninfected rice, sorghum, and maize grains were weighed into a l L kilner jar. Then, extract solutions of 2.5 g/kg, 5 g/kg, 10 g/kg, and 20 g/kg of hexane, ethyl acetate and methanolic leaf extracts were measured with the aid of a micropipette and mixed with each substrate in the kilner jars. They were thoroughly mixed together by gently shaking the jars and were left open for 40 min to allow the solvents to evaporate. Thereafter, twenty unsexed insects of less than 4 days-old adult S.oryzae, S.granarius, and S.zeamais were introduced to each of the kilner jars and covered with muslin cloths. Each treatment was replicated three (3) times. The control experiment had only 0.02 kg each of untreated rice, sorghum, and maize grains with twenty unsexed adult insects without the plant extracts. Insect mortality was assessed every day for 4 days (24 -96 h). Dead weevils were those that did not respond to sharp pin probe. At the end of 96 h exposure to treatment, data on percentage adult mortality were corrected in the negative control using Abbot (1925) formula.

$$\% \text{ Insect Mortality} = \frac{number\ of\ dead\ weevils}{total\ number\ of\ weevil\ used\ for\ infestation} \times 100 \qquad (1)$$

Using Abbot Formula for correcting the control,

$$\% \text{ Corrected Mortality} = \frac{T-C}{100-C} \times 100 \qquad (2)$$

Where : T= Treated mortality in %,C = Control mortality in %

In order to assess the viability of seeds, a germination test was conducted using twenty (20) seeds were randomly selected from each jar. Then, the seeds were placed on moist filter paper in plastic petri dishes kept in an incubator at 25°C and the number of germinated seeds were counted and recorded and percentage seed viability was calculated.

$$\% \text{ viability} = \frac{number\ of\ germinated\ seed}{total\ number\ of\ seed\ sown} \times 100 \qquad (3)$$

The experimental set up was kept inside the insect rearing cage for further 40 days to allow the new adults emerge. Hand lens was used to view the number of eggs laid and percentage adult emergence was calculated as below.

$$\% \text{ Adult emergence} = \frac{number\ of\ adult\ insect\ emmergence}{total\ number\ of\ egg\ laid} \times 100 \qquad (4)$$

The grains were later sieved to remove the dust produced from adult feeding and re-weighed by using a Mettler Weighing balance and the percentage loss in weight determined.

$$\% \text{ Weight loss} = \frac{Change\ in\ weight}{Initial\ weight} \times 100 \qquad (5)$$

Results and Discussion

Insecticidal activity of Heliotropium indicum extracts

Tables 1-3 show the effects of H,indicum leaf extracts on mortality of Sitophilus species

It can be observed from Tables 1 that the hexane leaf extract exerted potency on Sitophilus oryzae at concentrations of 2.5 g/kg to 20 g/kg from 24-96 h postexposure. The highest mortality of 36.67% was observed for Sitophilus oryzae treated with Hexane extract at concentration of 20 g/kg 96 h postexposure, while the lowest mortality exerted on Sitophilus oryzae was 1.67%. However, the standard chemical insecticide (cypermethrin at 0.5 ml) was observed to have caused mortality of up to 100% on S. oryzae at 96 h post exposure while the negative control caused 1.67 % mortality 72 h postexposure. On the other hand, ethyl acetate extract caused the greatest and lowest mortality of 50% and 3.3% on rice weevil. However, similar trend was observed on the potency of methanolic extracts on the insect pests of these stored grains. As can be observed from the Tables 2, the lowest and highest mortality of 63.3% and 5% was observed for rice weevils.

Table 1: **Effects of leaf extract of H.indicum L on mortality of Sitophilu soryzae**

Extract	**Substrate**	**Conc. (g/kg)**	**Mortality (Mean±SE)**			
			24 h	48 h	72 h	96 h
Hexane	Rice	2.5	0.00±0.00	5.00±0.00	10.00±0.00	15.00±0.00
		5.0	0.00±0.00	5.00±0.00	10.00±0.00	20.00±0.00
		10.0	0.00±0.00	1.67±1.67	5.00±2.89	23.33±6.01
		20.0	1.67±1.67	5.00±0.00	16.67±1.67	36.67±1.67
EA		2.5	0.00±0.00	0.00±0.00	3.33±1.67	10.00±2.89
		5.0	0.00±0.00	0.00±0.00	6.67±1.67	15.00±2.89
		10.0	0.00±0.00	3.33±1.67	10.00±2.89	20.00±2.89
		20.0	6.67±1.67	15.00±2.89	31.67±4.41	50.67±6.67
MeOH		2.5	0.00±0.00	5.00±0.00	10.00±0.00	18.33±1.67
		5.0	6.67±1.67	11.67±1.67	21.67±1.67	38.33±3.33
		10.0	8.33±1.67	13.33±1.67	28.33±1.67	46.67±1.67
		20.0	10.0±0.00	20.00±0.00	33.33±1.67	63.33±1.67
Control		0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
Cypermet		0.5 ml	68.0±4.41	76.67±6.67	96.67±3.33	100.0±0.0

The values are expressed as the mean ± SE at the (P≤0.05) level of significance

Where: EA= Ethyl acetate , MeOH= Methanol, Cypermet= Cypermethrin

Table 2 shows the effects of leaf extract of H.indicum L on mortality of Sitophilus granarius(sorghum weevils). As can be observed in Table 3, the hexane extract caused the least mortality of 1.67% on Sitophilus granarius and the highest mortality of 30% 96 h postexposure to 20 g/kg of the hexane extract, while ethyl acetate extract caused the highest mortality of 43.3% for S,granarius when treated in 20 g/kg of the extract 96 h post exposure and the lowest mortality of 1.67% 72 h postexposure to 2,5 g/kg of ethyl acetate extract. Additionally, the methanolic extract at the concentration of 20 g/kg caused highest mortality of 90% for S.granarius, and lowest mortality of 3.33% at 2.5 g/kg 24 h postexposure to treatment.

Table 2: Effects of leaf extract of H.indicum L on mortality of Sitophilus granarius

Extract	**Substrate**	**Conc. (g/kg)**	**Mortality (Mean±SE)**			
			24 h	48 h	72 h	96 h
Hexane	Sorghum	2.5	0.00±0.00	0.00±0.00	0.00±0.00	1.67±1.67
		5.0	0.00±0.00	0.00±0.00	2.00±2.00	10.00±2.89
		10.0	0.00±0.00	0.00±0.00	3.33±1.67	13.33±1.67
		20.0	0.00±0.00	1.67±1.67	11.7±1.67	30.00±2.89
EA		2.5	0.00±0.00	0.00±0.00	1.67±1.67	8.33±3.33
		5.0	0.00±0.00	3.33±1.67	8.33±4.41	15.00±5.77
		10.0	1.67±1.67	5.00±2.89	11.67±4.41	23.33±3.33
		20.0	5.00±0.00	10.00±0.00	20.00±2.89	43.33±4.41
MeOH		2.5	3.33±3.33	10.00±2.89	18.33±4.41	35.00±2.89
		5.0	6.67±3.33	13.33±4.41	23.33±3.33	40.00±2.89
		10.0	6.67±1.67	23.33±4.41	35.00±8.67	60.00±8.66
		20.0	13.33±1.67	31.67±1.67	53.33±3.33	90.00±2.89
Control		0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
Cypermet		0.5 ml	68.00±4.41	76.67±6.67	96.67±3.33	100.0±0.0

The values are expressed as the mean ± SE at the (P≤0.05) level of significance
Where: EA= Ethyl acetate, MeOH= Methanol, Cypermet= Cypermethrin

Table 3 shows the effects of leaf extracts of H.indicum on the mortality of S.zeamais. As can be observed from Table 3, the hexane extract caused the lowest mortality of 1.67% for S.zeamais 24 h postexposure to 10 g/kg hexane extract, while the greatest mortality of 71.67% was observed 96 h postexposure with increasing extract concentration to 20 g/kg. Similarly, Ethyl acetate extract caused the lowest mortality of 3.33% for the maize weevils 24 h postexposure to 10 g/kg extract and the highest mortality of 90% was also observed 96 h post exposure with increasing concentration to 20 g/.kg. Methanol extract showed the most effectiveness with the lowest mortality of 5% 48 h postexposure to 5 g/kg of the extract, while with increasing time and concentration, the highest mortality of 96.67% was observed. This was similar to the insecticidal activity of the standard insecticide which recorded 100% mortality 96 h postexposure at 0.5 ml

Table 3: Effects of leaf extract of H.indicum L on mortality of Sitophilus zeamais

Extract	**Substrate**	**Conc. (g/kg)**	**Mortality (Mean±SE)**			
			24 h	48 h	72 h	96 h
Hexane	Maize	2.5	0.00±0.00	8.33±1.67	18.33±1.67	41.67±8.82
		5.0	0.00±0.00	10.00±2.89	25.00±2.89	550.0±2.89
		10.0	1.67±1.67	13.33±1.67	30.00±2.89	60.00±2.89
		20.0	8.33±1.67	20.00±2.89	36.67±1.67	71.67±3.33
EA		2.5	0.00±0.00	5.00±0.00	10.0±0.00	16.7±1.67
		5.0	0.00±0.00	5.00±0.00	13.33±1.67	23.33±4.41
		10.0	3.33±1.67	13.33±3.33	21.67±4.41	36.67±7.26
		20.0	13.33±1.67	35.00±2.89	58.33±3.33	90.00±2.89
MeOH		2.5	0.00±0.00	0.00±0.00	15.00±0.00	55.00±11.54
		5.0	0.00±0.00	5.00±0.00	21.67±1.67	76.67±4.41
		10.0	3.33±1.67	13.33±1.67	36.67±3.33	91.67±6.01
		20.0	11.67±1.67	26.67±4.41	50.00±5.00	96.67±1.67
Control		0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
Cypermet		0.5 ml	68.00±4.41	76.67±6.67	96.67±3.33	100.0±0.0

The values are expressed as the mean ± SE at the (P≤0.05) level of significance

Where
EA= Ethyl acetate , MeOH= Methanol, Cypermet= Cypermethrin

Percentage seed viability

Table 4 shows the percentage seed viability after exposure to treatments. It can be observed from Table 4 that all the treated seeds investigated showed percentage germinability of up to 80%. For instance, paddy rice treated with hexane extract showed 81.67% germinability, while sorghum and maize given the same treatment showed germinability of 85 %, and 86.67%, respectively. The negative control (untreated grains) showed 85% germinability level while all seeds treated in cypermethrin showed 75% germinability. In the same vein, rice grains treated with ethyl acetate extracts of H.indicum showed 85% germinability level. Sorghum, and maize, showed 88.33%, and 83.33% germinability levels, respectively. The same trend was observed in methanol extracts. Rice treated with methanol leaf extract of H.indicum showed 88.33% germinability level. The same was observed in sorghum and maize with percentage germinability of 85%, and 83.33%, while the negative and positive controls showed percentage germinability of 85%, and 75%, respectively.

Table 4: Percentage Seed viability post-exposure to H.indicum extracts

Substrate	N	% Seed Viability (mean ± SE)		
		HE	EE	ME
Rice(Paddy)	20	81.67±1.67	85.00±0.00	88.33±3.33
Sorghum	20	85.00±0.00	88.33±1.67	85.00±2.89
Maize	20	86.67±1.67	83.33±1.67	83.33± 1.67
Cypermethrin	20	75.00±0.00	75.00±0.00	75.00±0.00
Control	20	85.00± 0.00	85.00±0.00	85.00± 0.00

The values are expressed as the mean ± SE at the (P≤0.05) level of significance
Where HE= Hexane Extract, EE= Ethyl acetate Extract, ME= Methanolic Extract, N=Number of seeds sown

Adult Emergence

Table 5 shows the percentage of adult emergence postexposure to the extracts of H.indicum L. Adult emergence of rice weevil was least among the seeds treated with extracts of H.indicum, while the control significantly had the highest adult emergence of 35%. The highest adult emergence of 2% was observed in S.granarius, and S.zeamais exposed to methanol leaf extracts of H.indicum at 2.5 g/kg. There was no adult emergence observed in the treatments with positive control (cypermethrin). Insecticidal property of any plant extracts would depend on the active constituents of the plant material

Table 5: Effect of H.indicum leaf extracts on adult emergence of stored grain insects

Substrate	Conc. (g/kg)	% adult emergence (mean ± SE)				
		HE	EE	ME	Cypermet.	Control
Rice	2.5	0.67+0.33	0.33+0.33	1.00+0.00	0.00	35.00+2.89
	5.0	0.67+0.33	1.33+0.33	1.00+0.00	0.00	35.00+2.89
	10.0	0.00+0.00	1.00+0.00	1.00+0.00	0.00	35.00+2.89
	20.0	0.00+0.00	1.00+0.00	1.00+0.00	0.00	35.00+2.89
Sorghum	2.5	1.67+0.33	0.33+0.33	2.00+0.00	0.00	35.00+2.89
	5.0	0.33+0.33	0.67+0.33	1.67+0.33	0.00	35.00+2.89
	10.0	0.00+0.00	0.00+0.00	1.67+0.33	0.00	35.00+2.89
	20.0	0.00+0.00	0.00+0.33	0.00+0.00	0.00	35.00+2.89
Maize	2.5	1.33+0.33	0.33+0.33	2.00+0.00	0.00	35.00+2.89
	5.0	1.00+0.00	0.67+0.33	1.67+0.33	0.00	35.00+2.89
	10.0	0.00+0.00	0.00+0.00	1.67+0.33	0.00	35.00+2.89
	20.0	0.00+0.00	1.00+0.00	0.00+0.00	0.00	35.00+2.89

The values are expressed as the mean ± SE at the (P≤0.05) level of significance
Where HE= Hexane Extract, EE=Ethyl acetate Extract, ME=Methanol Extract, Cypermet= Cypermethrin

Seed Weight Loss

Table 6 shows the seed weight loss postexposure to H. indicum Leaf extracts .It can be observed that the percentage weight loss in rice grains treated with hexane leaf extract was 0.63 %, while that of sorghum, and maize were 1.56%, and 1%. The weight loss in rice grains treated with ethyl acetate leaf extract was 1.25%, while that of sorghum, and maize were 3.31%, and 6.50%. Similarly, the percentage weight loss in rice grain treated with methanol leaf extract of H.indicum was 1%, whereas, sorghum, and maize grains exposed to methanol leaf extracts of H.indicum had percentage weight losses of 2%, and 1.75%. Meanwhile, the control (untreated grains) also recorded a weight loss of 31.5%, but the percentage weight loss in grains treated with Cypermethrin was 0.25 %.

Table 6: Percentage seed weight loss post-exposure to H.indicum leaf extracts

Substrate	% Seed Weight Loss (mean+SE)				
	HE	EE	ME	Cypermethrin.	Control
Rice	0.63+0.23	1.25+0.63	1.00+0.00	0.25+0.25	31.50+0.64
Sorghum	1.96+0.25	3.31+0.23	2.00+0.41	0.25+0.25	31.50+0.64
Maize	1.00+0.00	6.50+0.95	1.75+0.25	0.25+0.25	31.50+0.64

The values are expressed as the mean+SE at the (P≤0.05) level of significance

Where: HE=Hexane Extract,EE=Ethyl acetate Extract, ME=Methanol Extract, AE=Aqueous Extract, Cyperm.= Cypermethrin 2.5 E.C (Positive control), Control= Untreated Grains (negative control).

Discussion

The insecticidal potential of plants is attributed to the presence of phytochemicals present in them. They are responsible for the significant insect mortality. Phytochemicals from plants, such as alkaloids, terpenoids, and phenolics, act as natural insecticides by disrupting the physiological functions of insect pests in stored grains (Isman 2006). These compounds can interfere with the nervous system, inhibit enzyme activities, or damage the gut lining of insects, ultimately causing death. For instance, neem extracts containing azadirachtin which reduces feeding and reproductive abilities in insect pests, leading to mortality (Isman, 2006). Similarly, essential oils like those from Ocimum basilicum have been shown to exhibit fumigant toxicity, killing insect pests like Sitophilus zeamais. The phytochemicals present in the extracts are known to be important sources of toxicants against major insect pests.. This is in agreement with Hassanali et al. (1990) who reported that the active constituent eugenol, extracted from Ocimum suave is an effective repellent against S.zeamais. The active constituent in these plant material appears to be responsible for their insecticidal properties against the stored grain weevils, just as the presence of active constituents in Nicotiana tabacum (nicotine) is attributed to contact, stomach and respiratory poisoning properties (Isman, 2006), especially in Zonocerous variaegatus

The H.indicum L extracts showed a definite level of toxicity against Sitophilus species. Tables 1-3 showed that the hexane leaf extract exerted potency on Sitophilus oryzae at concentrations of 2.5 g/kg to 20 g/kg from 24-96 h.

The results in Tables 1-3 showed the lowest and highest percentage mortality of grain weevils treated in various leaf extracts of H.indicum. Cypermethrin has been very effective in controlling adult **S. zeamais** which agrees with the findings of Asawalam et al. (2006) who reported 100% mortality to Sitophilus zeamais when treated with cypermethrin-stored maize. This study revealed the active potentials of this plant product as plant-derived insecticides against stored grain weevils, and provides a scientific rationale for the use of this botanical as alternative to synthetic insecticides in postharvest protection of stored grains. The treatment with methanolic leaf extract of H.indicum had the highest percentage mortality as well as reduced number of adult emergence and the least percentage weight loss. This was supported by the report of Adedire and Lajide, (1999) on Piper guineense belonging to the family piperacea and stated that the plant possesses some forms of insecticidal properties against the eggs of stored cowpea grains, (bruchid) which are capable of suppressing various developmental instars of Callosobruchus maculatus. This study also agrees with the report of Okwute (2006) who investigated three Sri Lankan plants' extracts: Plearostylia opposita (Wall); Alston (Celastraceae), Aegle marmelos Correa (Rutaceae), and Excoecaria agallocha (Euphorbiaceae), and found out that the plants were insecticidal, and for the first time three compounds were found to possess the daphnane orthoester skeleton which may be the constituent of ethyl acetate extract of E.agallocha and have been found to be insecticidal.

As can be observed from Table 4, grains treated with cypermethrin showed reduced seed viability due to chemical residues that disrupt germination processes. In contrast, the plant extracts are less toxic to seeds thereby preserving their biological functions and leading to higher seed viability while still effectively controlling pests (Kedia et al., 2015). This shows that all the seeds were viable after treatments with various leaf extracts of H.indicm because they showed germination rate above 75% in wet planting condition. This agrees with the report of Okwute (2012) who reported that cowpea seeds exposed to crude Dalbergia saxatalis showed viability with a germination rate of over 70% after five days of exposure to planting (wet) conditions. There was no statistical difference observed between all the treatments and controls at ($P \leq 0.05$) significance level. The result so far indicated that all the seeds were viable after exposure to leaf extracts of H.indicum.

The result of adult insect emergence post exposure to plant extracts is shown in Table 5. The plant extracts significantly reduce adult insect emergence at ($P \leq 0.05$) significance level postexposure by disrupting critical developmental stages (Isman, 2000). Compounds like essential oils, alkaloids, and terpenoids interfere with larval development, pupation, or eclosion. For instance, Azadirachta indica (neem) extract disrupts molting and metamorphosis by inhibiting ecdysteroid activity, reducing adult emergence rates (Tripathi et al., 2002). Similarly, essential oils from Mentha species have fumigant and contact toxicity that can damage the insect nervous system, leading to high mortality before reaching adulthood (Isman, 2000). These bioactive compounds offer eco-friendly alternatives to synthetic insecticides, minimizing insect populations in stored grains. The various plant extracts used in the study significantly suppressed the emergence of the weevils of stored grains when compared with the control.

Seed weight loss after treatment with H.indicum leaf extracts was lower compared to cypermethrin. Plant extracts, such as neem or essential oils from basil and mint, provide effective pest control with minimal impact on seed integrity (Koul et al., 2008). They inhibit feeding and reproduction in insect pests, reducing damage to stored grains. Conversely, standard insecticides may leave harmful residues that impair seed quality, affecting germination and nutrient retention, indirectly causing greater weight loss (Ogendo et al., 2008). Additionally, insect resistance to chemical insecticides can lead to suboptimal control, exacerbating seed damage.

The noticeable increase in percentage weight loss in the control may be due to feeding effect of the weevils on the substrates due to the weevils' population as compared to the grains treated with cypermethrin which recorded the lowest percentage weight loss due to high mortality effect exerted on the weevils' population. It can be observed that there was no statistical significant difference between the percentage weights losses between all the grains treated with the extracts compared with the standard insecticide at ($P \leq 0.05$) significant level, but a noticeable high statistical significant difference was observed between the treatments and control at ($P \leq 0.05$) level of significance. According to Mills (1989), the presence of insects in stored grains causes an additional rise in temperature because the insects' feeding behavior creates "hot spots" in the grains which allow a moisture build up inside the stored grains, leading to seed degradation and consequent weight losses. This was similar to the report of Santos et al. (1990) who found that in Brazil, the presence of Sitophilus zeamais and Sitotroga cerealella in maize grains caused a decline in germination as the insects' developmental levels increased from 13% on the egg stage for Sitophilus zeamais and 10.9% for Sitotroga cerealella to 93% and 85%, respectively, at the adult stage. Since H.indicum is not a food plant and can be used cheaply, the weed plant used in this project was appropriate. It is inexpensively accessible as undesirable plant that farmers frequently have to pay to remove. Some plant compounds may have an pesticidal effect by changing the osmotic and enzymatic activity required for organisms to survive, ultimately leading to their death. Chemical treatment was more effective in controlling pests than plant treatments; however H.indicum leaf extract showed better results after 96 h compared to 72 h. But there is a lot of criticism against the usage of chemicals because of the detrimental effects they exerted on both the environment and humans (Oyewole et al., 2018). Potential use of H. indicum against Sitophilus oryzae, Sitophilus granarius, and Sitophilus zeamais, has been suggested by the biopesticidal efficacy of the plant treatments on weevils of stored grains. This result aligns with the recommendation of Ogunnupebi et al. (2020) on the use of potential natural products for crop protection and food preservation. The reduction in adult emergence and seed weight loss upon treatment with methanol leaf extract of H.indicum suggested that S,zeamais is affected on exposure to methanol leaf extract of H.indicum.

Conclusion and recommendations

This study demonstrates the promising biopesticidal efficacy of Heliotropium indicum leaf extracts against weevils in stored rice, sorghum, and maize. The methanol extract was particularly effective, achieving up to 96.67% mortality, comparable to the standard insecticide, cypermethrin. The results indicate that H.indicum extracts could serve as natural alternatives to synthetic insecticides, offering an eco-friendly solution for grain protection. This novel research underscores the potential of using diverse solvent extracts for postharvest pest control. This study hereby recommends further studies to explore the long-term efficacy and safety of H.indicum extracts on grain quality, and to also investigate the potential of other medicinal plants for sustainable biopesticide development.

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Conflict of interest

We the authors of this original research paper declare no conflict of interest in this work. All authorities were duly cited in this work. It is an extract of the original PhD work of the lead author.

Data Availability Statement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethical Declaration

The plant, Heliotropium indicum L., was identified and Authenticated at Forestry Research Institute of Nigeria (FRIN) Ibadan, Oyo State by Mr.Egunjobi A.J, and Mr Adeyemo A in the Taxonomy Department, and a voucher specimen assigned numbers **FHN/113768** was deposited at their herbarium.

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References

Abbott WS (1925). A method of computing the effectiveness of an insecticide. Journal of Economic Entomology18 (2): 266-267.

Adedire, C. O and Lajide L. (1999) Toxicity and Oviposition deterrency of some plants extracts on cowpea storage bruchid. Callosobruchus maculatus Fabricius.I. Pl. Dis. Prof. 106, 647-653. .

Asawalam, E. F., Emosairue, S. O., Ekeleme, F., & Wokocha, R. C. (2006). Insecticidal effects of powdered parts of Eight Nigerian plant species against maize weevil Sitophilus zeamais motschulsk (Coleaoptera: Curculionidae). Nigeria Agricultural Journal, 37, 106-116.

Attia, M. A., Wahba, T. F., Shaarawy, N., Moustafa, F. I., Guedes, R. N. C., & Dewer, Y. (2020). Stored grain pest prevalence and insecticide resistance in Egyptian populations of the red flour beetle Tribolium castaneum (Herbst) and the rice weevil Sitophilus oryzae (L.). Journal of stored products research, 87, 101611. Benhalima, H., Chaudhry, M. Q., Mills, K. A., & Price, N. R. (2004). Phosphine resistance in stored-product insects collected from various grain storage facilities in Morocco. Journal of Stored Products Research, 40(3), 241-249.

Dhawan, A.K. and Peshin, R., (2009). Integrated pest management: concept, opportunities and challenges. Integrated Pest Management: Innovation-Development Process: Volume 1,.51-81.

Garud, A., Garud, N. and Tailang, M., (2015). Annona squamosa: A review on its larvicidal oviposition deterrent and insect repellent potency. World Journal of Pharmaceutical Research, 4(10), .452-463.

Gerson, U., Smiley, R.L. and Ochoa, R., 2003. Mites (Acari) for pest control (Vol. 558). Oxford: Blackwell Science.

Goselle, O. N., Gyang, D. A., Adara, O. F., Effiong, K. T., Nanvyat, N., Adulugba, I. A., ... & Mafuyai, H. B. (2017). A comparative Study of the Larvicidal Activity of Lemongrass (Cymbopogan citratus) from Different Methods of Extraction.

Hassanali, A., Lwande, W., Ole - Sitayo, N., Moreka, L; Nokoe, S and Chapya, A. (1990) Weevil repellent constituents of Ocimum suave leaves and Eugenia caryophylla cloves used as grain protectant in parts ofEastAfrica. Discov. Innov. 2, 91-95.

Isman, M. B. (2000). Plant essential oils for pest and disease management. Crop Protection, 19(8), 603-608

Isman, M. B. (2006). Phytochemicals in pest management. Phytoparasitica, 34(1), 35–54

Kedia, A., Prakash, B., Mishra, P. K., & Dubey, N. K. (2015). Plant essential oils as natural preservatives for stored food commodities: Efficacy and mechanisms. Food Control, 56, 62-73.

Koul, O., Walia, S., & Dhaliwal, G. S. (2008). Essential oils as green pesticides: Potential and constraints. Biopesticides International, 4(1), 63-84.

Mills, J. (1989). Spoilage and heating of stored agricultural products. Prevention, detection and control.101. Agric. Canada Pub.1823E.

Nayak, M. K., & Collins, P. J. (2008). Influence of prior exposure to phosphine on tolerance to phosphine in Sitophilus oryzae, Rhyzopertha dominica and Tribolium castaneum. Journal of Stored Products Research, 44(3), 316-320.

Ncube, N. S., Afolayan, A. J., & Okoh, A. I. (2008). Assessment techniques of antimicrobial properties of natural compounds of plant origin: current methods and future trends. African journal of biotechnology, 7(12).

Ogendo, J. O., Kostyukovsky, M., Ravid, U., Matasyoh, J. C., Deng, A. L., Omolo, E. O., & Shaaya, E. (2008). Bioactivity of Ocimum gratissimum L. oil and two of its constituents against five insect pests attacking stored food products. Journal of Stored Products Research, 44(3), 328-334.

Ogunnupebi, T. A., Oluyori, A. P., Dada, A. O., Oladeji, O. S., Inyinbor, A. A., & Egharevba, G. O. (2020). Promising natural products in crop protection and food preservation: Basis, advances, and future prospects. International Journal of Agronomy, 1-28.

Okwute, S.K (2012). Plants as potential sources of pesticidal agents: a review. Pesticides–Advances in chemical and botanical pesticides, 10, 208-232.

Oyewole, S. N., Olayemi, F. F., Gbabe, E. K., Ogunbiyi, O. A., & Peters, O. (2018). Development and Promotional Challenges of Inert Atmosphere Silo for Grain Storage in Nigeria. In The Proceedings 12th CIGR Section VI International Symposium Vol. 22, 25.

Santos, J. P., Maia, J. D. G., & Cruz, I. (1990). Damage to germination of seed corn caused by maize weevil (Sitophilus zeamais) and Angoumois grain moth (Sitotroga cerealella). Pesquisa Agropecuaria Brasileira, 25(12), 1687-1692.

Sarkar, C., Mondal, M., Khanom, B., Hossain, M. M., Hossain, M. S., Sureda, A. and Al-Rawahi, A. (2021). Heliotropium indicum L.: from farm to a source of bioactive compounds with therapeutic activity. Evidence-Based Complementary and Alternative Medicine, Vol. 1, 1-21.

Tripathi, A. K., Prajapati, V., Verma, N., & Bansal, R. P. (2002). Toxicity of plant essential oils against stored product pests. Journal of Economic Entomology, 95(1), 121-128.

THE EFFICACY OF BEAUVERIA BASSIANA AND NEEM AZAL T/S ON HYPERA POSTICA (GYLLENHAL) IN FIELD CONDITIONS

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ABSTRACT

Hypera postica (Gyllenhal, 1813) (Coleoptera: Curculionidae) is one of the most important pests of the alfalfa plant (Medicago sativa L.). Adults and larvae cause damage by feeding on every part of the plant except the root. This study was conducted to test the effects of two organic plant protection products against H. postica larvae in the alfalfa field in Aşağı Çiftlik village, Aralık district of Iğdır province. The experiment was established in a clover field in Aşağı Çiftlik village, Aralık district of Iğdır province, in April and May 2017, according to the factorial experimental design in randomized blocks with 4 replications. Each application parcel was determined as 100 m^2. In the sampling, the larvae were counted on the netting and on plant before spraying and on the 7th and 14th days after spraying. The net was sweeped up 5 times at 5 different points of the plot, and larvae were counted on 5 randomly selected plants by shaking them into the tray. In both counts, the larvae were released to the plots from which they were taken without being killed. As commercial organic plant protection products, 3 different doses of Beauveria bassiana and Neem Azal T/S were used. Percentage

effects of the preparations on larvae were calculated according to the Abbott formula. The obtained data were subjected to normality test in the JMP Pro 13 statistical package program and it was observed that the values conformed to normal distribution. Since there was a zero value in the data, it was analyzed by applying root transformation and the statistically significant ones were grouped according to the $LSD_{0.05}$ test. According to the counts 7 days after spraying, the percentage effects of the counts made on the 14th day were determined to be higher. A difference was found between both plant protection products and count methods. In this study, the effects of plant-based organic plant protection product and biological control agent B. bassiana on H. postica were investigated under field conditions. As a result of the experiments, it was determined that B. bassiana was more effective in counting than Neem Azal T/S. It was concluded that B. bassiana was successful as a biological control agent against the larvae of H. postica.
Key Words: Hypera postica; Beauveria bassiana; Neem Azal T/S; efficacy; alfaalfa

INTRODUCTION

Alfalfa is an important plant that meets the need for quality roughage in animal production. Alfalfa, which has a wide adaptation ability, is one of the forage plants with the largest growing area in our country. Its economic life is 7-10 years on average, and more than one (2-10) cutting can be done in a year, depending on the soil structure and climatic conditions (**Anonymous, 1999**). Producers use this plant to feed their own animals and also earn significant income by selling surplus production. There are many biotic and abiotic factors that negatively affect alfalfa production. Among the biotic factors, the Alfalfa weevil, Hypera postica (Gyllenhal, 1813) (Coleoptera: Curculionidae), is of primary importance. This pest causes significant problems not only in Turkey but also in all regions where alfalfa farming is practiced worldwide (Essig & Michelbacher, 1933; Clausen, 1977; Steffey & Armbrust, 1991; Metcalf & Luckman, 1994; Blodgett & Lenssen, 2004). The pest overwinters in alfalfa fields, typically in cracks and crevices of plant debris, as adults, and in dry and green plant stems as eggs. Depending on the climate, adults generally begin laying spring eggs in holes they make at the tips of stems and shoots starting in March, with each hole containing 1–29 eggs. Larvae hatch 2–3 weeks later, and the first two larval stages occur in buds, while the third and fourth larval stages are spent feeding openly on the plant. Climate-dependent, pupation typically occurs between late April and mid-May. New generation adults move to the field interior and edges to aestivate as temperatures rise and after alfalfa is harvested. They emerge again in the fall feed to mate and lay autumn eggs on plant stems, and as temperatures drop, they overwinter. This pest completes one generation per year (Gözüaçık and İreç, 2016). The damage caused by the larvae is more significant than that caused by the adults. The first and second instar larvae feed between the shoot tips and leaf axils. As they consume the buds and shoot tips, plant growth is slowed. In the last two larval stages, the larvae feed by chewing from the outside of the leaves, leaving only the midrib and lateral veins intact. The primary damage occurs before the first harvest. If control measures are not implemented during this period, damage can reach up to 40% (İreç et al., 2021). When larval density is high, the alfalfa field takes on a dull, silvery appearance (Anonymous, 2008). In practice, farmers prefer to use insecticides to prevent the damage caused by this pest. However, due to their inability to determine the optimal timing for control and to monitor the pest's biology, they often fail to achieve adequate success. As a result, they may increase the number of applications and doses of insecticide, or even use several unregistered insecticides. The use of these insecticides leads to environmental contamination, and the residues are passed on as feed to livestock. Consequently, farmers face significant product losses and increased economic costs. In alfalfa cultivation areas, the damage caused by H. postica is increasing day by day, as natural enemy pressure diminishes, leaving farmers helpless in the face of this pest. This study was conducted to evaluate the effects of two plant protection products, a biological and a botanical insecticide, against H. postica larvae in an alfalfa field in Aşağı Çiftlik village, Aralık district of Iğdır province.

MATERIAL AND METHODS

The trial was conducted in the alfalfa field of Aşağı Çiftlik village, Aralık district, Iğdır province, following a randomized blocks design with four replications during the months of April and May.Each experimental plot was set at 100 m². In the sampling, both sweep net and plant counts were performed on the 7th and 14th days before and after application. Larval counts were conducted by shaking traps five times at five different points in each plot, and for the plant count, five plants were shaken into a tray. In both cases, the larvae were returned to the plots from which they were collected without being killed. As commercial organic plant protection products, the following were applied: biological insecticide: Beauveria bassiana strain (Bb-1, 15%, $1x10^8$ CFU/ml minimum) at three different concentrations (150, 200, 250 ml/100 L) and botanical insecticide: Neem Azal T/S (790 g/L Neem oil + 0.3 g/L Azadirachtin) at three different concentrations (300, 400, 500 ml/100 L). Each treatment was applied with 15 L/100 m² of water per plot. The percentage effects of the treatments on the larvae were calculated using Abbott's formula. The data obtained were tested for normality using the JMP Pro 13 statistical software, which confirmed that the values followed a normal distribution. Since there were zero values in the data, a square root transformation was applied for analysis. Statistically significant differences were determined and grouped according to the $LSD_{0.05}$ test.

CONCLUSION AND DISCUSSION

Under field conditions, the results of larval counts from two counting methods-sweep net and individual plant sampling-using three different doses of the biological insecticide Beauveria bassiana strain (Bb-1, 15%, $1x10^8$ CFU/ml minimum) and the botanical insecticide Neem Azal T/S (790 g/L Neem oil + 0.3 g/L Azadirachtin) in the control of Hypera postica larvae are presented in Table 1.

Table 1. Values of counting results of different doses of Beauveria bassiana and Neem Azal-T/S against Hypera postica larvae with 2 different methods.

Products	**Aplication**	**Doses**	**Count times**		
			Before-treatment	**Post treatment (Day 7)**	**Post treatment (Day 14)**
Baeuveria bassiana	Sweep net count	1	67,0	8,3	3,5 cf
		2	81,5	18,8	6,8 b
		3	69,0	12,3	4,5 be
		Mean	72,5	13,1	4,90
	Single plant count	1	6,2	4	1,2 f
		2	14,4	6,6	0,8 f
		3	13,9	5,7	1,1 f
		Mean	11,5	5,4	1,00
	Mean	1	36,6	6,1 c	2,30
		2	48	12,7 ab	3,80
		3	41,4	9,0 bc	2,80
		Mean	42	9,2 b	3,0 b
Neem Azal	Sweep net count	1	42,0	26,8	10 a
		2	47,5	13,8	6,5 bc
		3	74,3	22,3	5,5 bd
		Mean	54,6	20,9	7,30
	Single plant count	1	6,6	5,9	1,8 ef
		2	7,5	6,6	3,4 df
		3	12,2	7,8	3 df
		Mean	8,8 c	6,7	2,70
	Mean	1	24,3	16,3 a	5,90
		2	27,5	10,2 ac	4,90
		3	43,2	15 ab	4,30
		Mean	31,7	13,8 a	5,0 a
Mean	Sweep net count	1	54,5	17,5	6,80
		2	64,5	16,3	6,60
		3	71,6	17,3	5,00
		Mean	63,5 a	17 a	6,1 a
	Single plant count	1	6,4	4,93	1,50
		2	11,0	6,6	2,00
		3	13,0	6,7	2,00
		Mean	10,1 b	6,1 b	1,9 b
	Mean	1	30,5	11,2	4,10
		2	37,7	11,4	4,40
		3	42,3	11,9	3,50
		Mean	36,8	11,5	4,00
Coefficient of Variation (%)			11,2	13,20	12,29
$LSD_{0,05}$	Aplication (A)		-	3,71*	1,25**
	Dose (D)		-	NI	NI
	Counting Method (CM)		6,99**	3,71**	1,25**
	A x D		-	6,42*	NI
	A x CM		-	NI	NI
	D x CM		-	NI	NI
	A x D x CM		-	NI	3,07*

Levels not connected by same letter are significantly different. **P<0,01, *P<0,05, NI = Not ımportant

As shown in Table 1, the overall average larval count before application was 36.8, which decreased to 11.5 on the 7th day post-application and to 4 on the 14th day. In the B. bassiana

treatment, the larval count, initially 42 before the application, dropped to 9.2 after 7 days and to 3 after 14 days. Similarly, in the Neem Azal T/S treatment, the larval count, initially 31.7 before the application, decreased to 13.8 after 7 days and to 5 after 14 days.
Although no significant differences were observed between doses in terms of the overall average, the Application × Dose interaction was statistically significant ($P<0.05$) for the 7th-day counts. In the B. bassiana treatment, the larval counts for doses 1, 2, and 3 were 6.1, 12.7, and 9, respectively. In the Neem Azal T/S treatment, the larval counts for doses 1, 2, and 3 were 16.3, 10.2, and 15, respectively. When considering the initial larval counts before the application (B. bassiana: 36.6, 48, 41.4; Neem Azal T/S: 24.3, 27.5, 43.2), it is evident that the post-application larval counts were much lower than the initial counts.
A significant difference of 1% ($P<0.01$) was observed between trap and individual plant counts at the beginning, on the 7th day, and on the 14th day. Before the application, 63.5 larvae were counted in the trap samples, and 10.1 larvae in the individual plant samples. The larval count was higher in the trap samples than in the individual plant samples. In the B. bassiana treatment, the pre-application trap count was 72.5, while in the Neem Azal T/S treatment, it was 54.6. In the individual plant samples, the pre-application counts were 11.5 for B. bassiana and 8.8 for Neem Azal T/S.
Significant differences between treatments were observed in the 7th-day counts at the 5% level and in the 14th-day counts at the 1% level. On the 7th day, the average larval count was 9.2 for B. bassiana and 13.8 for Neem Azal T/S. On the 14th day, the larval counts were 3 for B. bassiana and 5 for Neem Azal T/S.

Table 2. Percentage (%) effects of different doses of Baeuveria bassiana and Neem Azal applications on Hypera postica larvae numbers in alfalfa plants using the net count and single plant count method

Aplication	Doses (ml/100 lt water)	% Effects								
		Single Plant Count			Sweep Net Count			Mean		
		Day 7	Day 14	Mean	Day 7	Day 14	Mean	Day 7	Day 14	Mean
Baeuveria bassiana	150	3,1	80,8	41,95	80,40	91,70	86,05	41,75	86,25	64
	200	54,1	94,4	74,25	60,50	85,80	73,15	57,2	90,1	73,7
	250	59,0	92,4	75,70	83,50	94,00	88,75	71,25	93,2	82,23
	Average	**38,7**	**89,2**	**63,96**	**74,80**	**90,50**	**82,65**	**56,77**	**89,85**	**73,3**
NeemAzal	200	11,3	72,7	42,00	73,50	85,10	79,30	42,4	73,5	60,65
	250	12,5	55,0	33,75	83,10	92,00	87,55	47,8	78,9	60,65
	300	36,4	75,4	55,90	67,80	92,20	80,00	52,1	83,82	67,95
	Average	**20,1**	**67,7**	**43,88**	**74,80**	**89,77**	**82,28**	**47,43**	**78,73**	**63,08**
Mean	1.Dose	7,2	76,75	41,98	76,95	88,40	82,68	42,08	82,58	62,33
	2. Dose	33,3	74,70	54,00	71,80	88,90	80,35	52,55	81,8	67,18
	3. Dose	47,7	83,90	65,80	75,65	93,10	84,38	61,68	88,5	75,09
	Average	**29,4**	**78,45**	**53,93**	**74,80**	**90,13**	**82,47**	**52,1**	**84,29**	**68.2**

In terms of sampling times, the general average larval counts were 11.5 on the 7th day and 4 on the 14th day. For B. bassiana, the larval counts were 9.2 on the 7th day and 3 on the 14th day, while for Neem Azal T/S, the counts were 13.8 on the 7th day and 5 on the 14th day.
The percentage efficacy rates, calculated using Abbott's formula (Karman, 1971), based on the larval counts from the 7th and 14th-day evaluations following the application of B. bassiana and Neem Azal T/S on H. postica larvae, are presented in Table 2.
In Table 2, the effects of B. bassiana application on H. postica larvae are presented. In the individual plant count, the efficacy was 38.7% on day 7 and 89.2% on day 14, while in the trap count, the efficacy was 74.8% on day 7 and 90.5% on day 14. In dose 1 (150 ml), the effect was 41.95% in the individual plant count and 82.65% in the trap count. In dose 2 (200 ml), the effect was 74.25% in the individual plant count and 73.15% in the trap count. In dose

3 (250 ml), the effect was 75.70% in the individual plant count and 88.75% in the trap count. The average efficacy in the first count was 56.77%, while in the second count it was 89.85%. The overall average effect of B. bassiana was 73.3%. Yücel et al. (2018) tested B. bassiana isolates and B. pseudobassiana isolates obtained from H. postica larvae and adults at concentrations of 1×10^5, 1×10^6, 1×10^7, and 1×10^8 conidia/ml. The highest mortality rate in larvae was observed with B. bassiana isolate HpA-5 (100%) and B. pseudobassiana isolate HpI-4 (97%) at 1×10^8 conidia/ml after 14 days. The highest mortality rate in adults was observed at 1×10^8 concentration with mortality rates of 98% and 95%, respectively, for HpA-5 (B. bassiana) and HpI-4 (B. pseudobassiana). Mustafa et al. (2014) reported that two isolates of B. bassiana caused 100% mortality in H. postica adults 6 days after application at a concentration of 1×10^7 conidia/ml.

In the Neem Azal treatment, the efficacy was 20.1% in the individual plant count on day 7 and 67.7% on day 14, while in the trap count, the efficacy was 74.8% on day 7 and 89.77% on day 14. In dose 1 (200 ml), the effect was 42% in the individual plant count and 79.30% in the trap count. In dose 2 (250 ml), the effect was 33.75% in the individual plant count and 87.55% in the trap count. In dose 3 (300 ml), the effect was 55.90% in the individual plant count and 80% in the trap count. The average efficacy on day 7 was 47.43%, while on day 14 it was 78.73%. The overall average effect of Neem Azal was 63.08%. Hemin et al. (2016) tested extracts from Azadirachta indica (Meliaceae), Nerium oleander (Apocynaceae), and Eucalyptus camaldulensis (Myrtaceae) plants against H. postica under laboratory conditions, at concentrations of 0, 10, 20, and 40. They found that, after 2–4 days, the larvae mortality was recorded, and for adults, the mortality was observed between 2–8 days after application. In their study, Neem leaf extract caused 73.33% mortality in larvae after 4 days and 96% mortality in adults after 8 days. When the averages of dose applications were examined, no significant differences were observed, with effects of 62.33% for dose 1, 67.18% for dose 2, and 75% for dose 3. This suggests that the lowest dose could be selected for economic reasons. Regarding sampling times, the average efficacy was 52.1% in the first sampling and 84.29% in the second, indicating that the efficacy increased approximately two weeks after the application.

Entomopathogenic species belonging to the genera Beauveria, Metarhizium, Lecanicillium, and Isaria are commercially produced (Vega et al., 2009). Among these, B. bassiana is known to infect 707 insect species from 149 families, belonging to 521 genera and 15 subfamilies (Imoulan et al., 2017). The seeds of Azadirachta indica are preferred as an insecticidal product due to their low environmental residue and low toxicity to mammals (Sundaram, 1996; Raizada et al., 2001; Kleeberg, 2004). Both of these products are used as natural insecticides. The lethal effects of these products on H. postica have generally been tested under laboratory conditions. In our study, however, the effects of both commercially available plant protection products were evaluated under field conditions.

REFERENCES

Anonymous, 1999. Çayır Mera Amenajmanı ve Islahı. Tarım ve Köyişleri Bakanlığı, Tarımsal Üretim ve Geliştirme Genel Müdürlüğü, Ankara, 314.

Baysal, E., Atay, T. & Yanar, Y. (2018). Efficacy of some local isolates of the fungus Beauveria bassiana (Balsamo) Vuillemin on the alfalfa weevil Hypera postica (Gyllenhal) (Coleoptera: Curculionidae) larvae, under laboratory conditions. Egyptian Journal of Biological Pest Control, 28, 65.

Blodgett, S.L. & Lenssen, A.W., 2004. Distribution of alfalfa weevil (Coleoptera: Curculionidae) larvae among post cutting locations. Journal of Economic Entomology, 97:1319-1322.
Clausen, C.P., (Ed.) 1977. Introduced parasites and predators of arthropod pests and weeds-alfalfa weevil. US Dep. Agric. Handbook No. 480: 266–271.
Essig, E.O. & Michelbacher, E. (1933). The alfalfa weevil. Univ. Calif. Agric. Exp. Stn. Bull. 567, 99 pp.
Hemin, A., Rebwar, N. & Mustafa, A. (2016). Insecticidal effect of some plant extracts on the Alfalfa Weevil Hypera postica (Coleoptera: Curculionidae). Journal of Entomology and Zoology Studies;4(6):545-549.
İrec, A., Gözüaçık, C. & Gültekin, L. (2021). The effect of chemical control on the yield of wet grass performed in different height of alfalfa plant against alfalfa weevil, Hypera postica (Gyllenhal, 1813) (Coleoptera: Curculionidae). Fresenius Environmental Bulletin, 30(6), 7700-7704.
Imoulan A, Hussain, M., Kirk, P.M., El Meziane, A, & Yao, Y.J. (2017). Entomopathogenic fungus Beauveria: host specificity, ecology and significance of morpho-molecular characterization in accurate taxonomic classification. J Asia Pac Entomol 20:1204–1212.
Karman, M. (1971). Bitki Koruma Araştırmalarında Genel Bilgiler. Denemelerin Kuruluşu ve Değerlendirme Esasları. Bölge Ziraî Mücadele Araştırma Enstitüsü, İZMİR-Bornova, 279.
Kleeberg, H. (2004) Neem based products: registration requirements, regulatory processes and global implications. Neem: Today and in the New Millennium (ed. by O Koul & S Wahab), pp. 109– 123. Kluwer Academic Publishers, Dordrecht, The Netherlands.
Metcalf, R.L. & Luckman, W.H. (1994). Introduction to insect pest management. 3rd ed. Wiley, New York.
Mustafa, R.A., Assaf, L.H. & Abdullah, S.K. (2014). Comparative pathogenicity of Beauveria bassiana, Clonostachys rosea, Metarhizium anisopliae, and Lecanicillium lecanii to adult, alfalfa weevil Hypera postica Gyllenhal (Coleoptera: Curculionidae). 3rd International Conference on Applied Life Sciences (ICALS2014), Malaysia, pp 1–14.
Raizada, R.B., Srivastava, M.K., Kaushal, R.A. & Singh, R.P. (2001). Azadirachtin, a neem biopesticide: subchronic toxicity assessment in rats. Food and Chemical Toxicology, 39:477-483.
Steffey, K.L.& Armbrust, E.J. (1991). Pest management systems for alfalfa insects, pp. 475-504. In D. Pimentel (ed.), CRC handbook of pest management in agriculture (2nd Ed.). CRC Press. Boca Raton, Fl.
Sundaram, K.M.S. (1996). Azadirachtin biopesticide: a review of studies conducted on its analytical chemistry, environmental behavior and biological effects. Journal of Environmental Science and Health B 31: 913– 948.
Yücel, B., Gözüaçık, C., Gencer, D., Demir, I. & Demirbağ, Z. (2018). Determination of fungal pathogens of Hypera postica (Gyllenhall) (Coleoptera: Curculionidae): isolation, characterization, and susceptibility. Egyptian Journal of Biological Pest Control, 2018: 28-39.
Vega, F.E., Goettel, M.S., Blackwell, M., Chandler, D., Jackson, M.A., Keller, S., Koike, M., Maniania, N.K., Monzo, N. A., Ownley, B.H., Pell, J.K., Den, R. & Roy, H.E. (2009). Fungal entomopathogens: new insights on their ecology. Fungalecology, 2:149 –159

EFFECTS OF GARLIC AND GINGER EXTRACTS ON MICROBIAL LOAD OF LOCUST BEAN SEEDS (Parkia biglobosa)

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ABSTRACT

This study was carried out to examine the extracts that inhibited the growth of all the isolates tested, fungi, aspergillus, the result of the present study showed that the aqueous extract has more activity. Additionally, the result showed that the methanol extract of Garlic has good activity against both the fungal strains (0.237 mg/ml) and A. niger. Aqueous extract was found to be less potent against E. coli with 2mm diameter of inhibition respectively. For all extracts tested, the Garlic extract exhibited maximum antimicrobial activity against the tested organisms, fungal strain showed more sensitivity to the extracts as compared to bacterial strain. All the extracts tested indicated the antimicrobial nature, but the degree varies among extracts.

Introduction

The high cost of animal protein has directed interest towards several leguminous seed proteins as potential sources of vegetable protein for human food and livestock feed. Among the plant species, grain legumes are considered as the major source of proteins. They are consumed worldwide, especially in developing and underdeveloped countries where consumption of animal protein may be limited as a result of economic, social, cultural or religious factors (Esenwah and Lkenebomeh, 2008). Locust bean is proteins, Protein-Energy-Malnutrition (PEM) is a serious problem facing most developing nations as a result of inadequate intake of good quality protein source such as meat, fish and poultry product, which are out of reach to many populaces due to poor economy, increase in population pressure, and others natural calamities such as drought and flood Ladeji et al., 1995; Nordeide et al, 1996). In these nations about 60% of the population suffers PEM, which results to high rate of mortality, permanent brain damage and decrease in learning capability of children (Abdullahi, 2000).

Apart from protein, legumes provide a high proportion of complex carbohydrates, starch, edible oil and fibre (Pirman et al, 2001, Chau et al; 1998). African locust bean seeds are rich in protein and usually fermented to a tasty food condiment called (dawadawa) which is used as a flavour intensifier for soups and stews and also adds protein to a protein–poor diet.

Among the leguminous plants used by man particularly in some African countries, is the African locust bean tree (Parkia biglobosa). The seeds are well known for their uses in the production of local condiment commonly known as Dadadawa (Hausa) or Iru (Yoruba) Ugba (Igala). Furthermore, Parkia biglobosa is such plant legumes with an outstanding protein quality and its protein and amino acid composition has been reported (Nordeide et al., 1996; Ega et al., Glew et al., 1997; Cook et al., 2000; Lockeett et al., 2000).

In recent times, much research work has been done on the effects of preservative of soy-Iru with either ginger or garlic but not on processed Iru Parkia biglobosa with different spices. In locust bean, spoilage is deterioration of food by bacteria or fungi then, locust can be contaminated with pathogenic bacteria or fungi which leads to food intoxication and infection (Adams and Moss, 1999). Therefore, these is needed to reduce the load and harmful effect of these pathogenic bacteria in locust bean in other to fit for consumption and to enhance its safety in consumer. This could be done by using different spices extract (ginger and garlic in locust beans).

GARLIC (Allium sativum)

Garlic (Allium Sativum) commonly known as garlic is a species in the onion genus, Allium. Its close relatives include the onion, shallot, leak, chive, (Ensminger, 1994) and rakkyo. With a history of human use of over 7,000 years, garlic is native to central Asia and has long been a staple in the Mediterranean region, as well as a frequent seasoning in Asia, Africa and Europe. It was known to Ancient Egyptians and has been used for both culinary and medicinal purposes, (Simonetti, 1990). Allium sativum is a bulbous plant. It grows up to 1.2 m (4 ft) in height. It’s hardiness is USDA Zone 8. It produces hermaphrodite flowers.

Pollination occurs by bees and other insects. Also, it is used as a flavouring in cooking and pickling, sometimes in the form of whole or grated cloves and sometimes in the form of a cooked extract, as in sauces and dressings. Garlic has a characteristic pungent, spicy flavour that mellows and sweetens considerably with cooking, locally, garlic is often paired with ginger to make stews and soups. Generally, garlic is used as condiment and in the preparation of baked goods, puddings gravies, soups, stew, meat product, non-alcoholic beverages and soft candy. In medicine garlic is used as a digestive stimulant, diuretic and anti-spasmodic.

There are different types of subspecies of garlic, most notably hard-neck garlic and soft-neck garlic. The latitude where the garlic is grown affects the choice of type as garlic can be day-length sensitive. Hard-neck garlic is generally grown in cooler climate; soft-neck garlic is generally grown closer to the equator. (Zohary and Hopf, 2000).

GINGER (Zingiber officinale)

Ginger or ginger root is the rhizome of the plant Zingiber officinale consumed as a delicacy, medicine, or spice. It lends its name to its genus and family (zingiberaceae). Other notable members of this plant family are turmeric, cardamom, and galangal. The distantly related dicots in the Asarum genus have the common name with ginger because of their similar taste. (Ernest and Pittler, 2000).

Ginger produces clusters of white and pink flower buds that bloom into yellow flowers. Because of its aesthetic appeal and the adaptation of the plant to warm climates, ginger is often used as landscaping around subtropical homes. It is a perennial reed-like plant with annual leafy stems, about a meter (3 to 4 ft) tall. Traditionally, the rhizome is gathered when the stalk withers; it is immediately scalded or washed and scrapped, to kill it and prevent sprouting. The fragrant perisperm of zingiberaceae is used as sweetmeats by bantu, also as a condiment and sialagogues.

Ginger produces a hot, fragrant kitchen spice. Young ginger rhizomes are juicy and fleshy with a very mild taste. They are often pickled in vinegar or sherry as a snack or just cooked as an ingredient in many dishes. They can also be steeped in boiling water to make ginger tea, to which honey is often added; sliced orange or lemon fruit may also be added. Ginger can also be made into candy, or ginger wine which has been made commercially since 1740, (Wood and Pittler, 2000). The taste and pungency of ginger increases with the maturity of the plant, thus young rhizomes are juicy and flashy with a very mild taste while juice from old rhizomes are extremely potent and sharp and is often used as a spice in Chinese cuisines.

Ginger is used as ingredient in making soup, as a spice in ginger bread and other recipes and can be stewed in boiling water to make ginger tea. It can also be made into candy or used as flavouring for cookies, crackers and cake. It helps to alloy motion sickness and is used, especially in the far east, as a digestive aid and a food preservative. In Nigeria, ginger is used to flavour a local drink called Kunu. (Abdulaziz et al., 2013).

Materials and method

Study Area

This research was conducted at Lokoja, Kogi State. It is a settlement located at the confluence of River Niger and Benue in Nigeria. It is well connected and accessible through State and Federal highways; the area is sandwiched between a water body and a hill which is River Niger and Mount Patti respectively which has streamlined the settlement to a linear one and has a modifying effect on the climate. The climate is characterized by wet and dry season.

The annual rainfall is between 1016mm and 1524mm with the mean annual temperature of 27^0C.Lokoja is the capital of Kogi State usually known as the Confluence state. It is located on latitude 7.45°N- 7.51°N and longitude 6.41°N- 6.45°N and lies at an altitude of 45 to 125 metres above sea level.

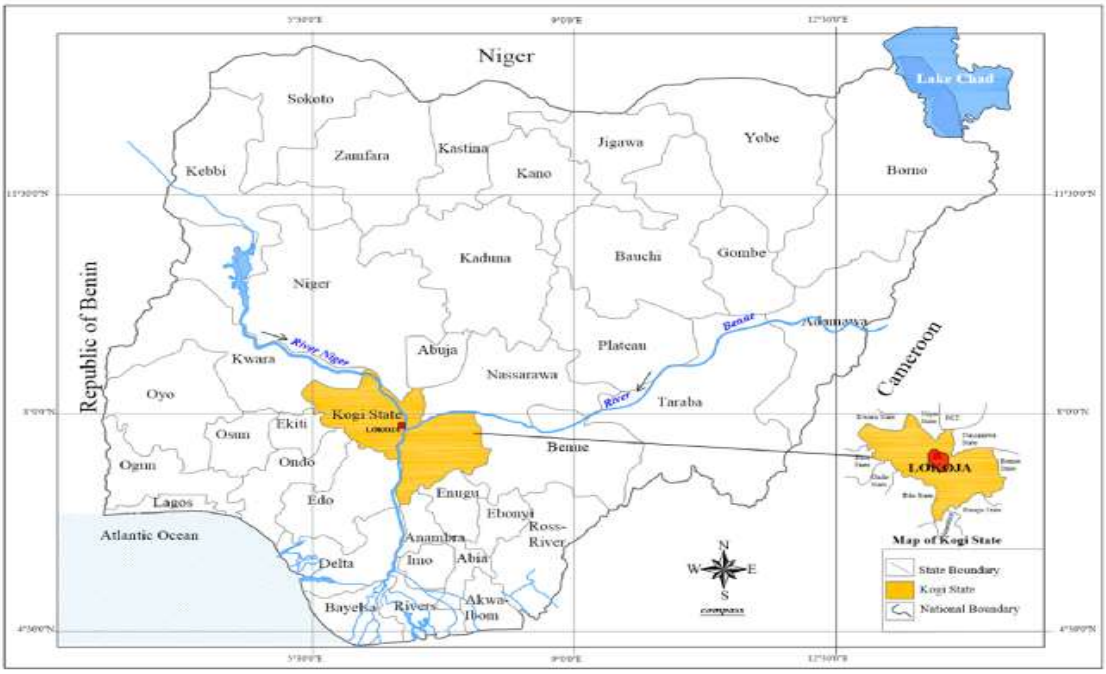

Fig. 1 Map of Nigeria showing Kogi State and Lokoja in the National Setting (**Source**: Kogi State Ministry of Land and Environment)

Iru Preparation Techniques

The materials used (Africa Locust bean seed) was purchased from an accredited vendor at the international market, Felele, lokoja in Kogi State while other materials like ginger, Garlic, Potassium Carbonate (K_2CO_3), Jute bag and Calabash were obtained in Lokoja. The production of Iru (Parkia biglobosa) African locust bean when processed into condiments using "Iru" or "Dawadawa" or Soumbella depending on the locality. The production of the processed locust bean “Iru” involves; sorting, wishing, first boiling, dehulling, second boiling, draining, fermentation which make it to develop its characteristic flavour due to the presence of essential oils.

The production process is explained in flow chart in Figure 2. With respect to the iru preparation process, forty grams of the beans was thoroughly washed in clean water and then soaked in distilled water (5l) for 24 hrs. The nuts were dehulled manually by pressing in between fingers. The dehulled beans was boiled in d7istilled water for 15mins. The boiled water was decanted, and the nuts was spread on ethanol-sterilized tray to dry for 30 min and wrap with leaves of banana (Musa-sapientum) which had been previously washed, cleaned and surface sterilized with 75% ethanol (Odunfa, 1981). The wrapped beans were transferred into ethanol-sterilized calabash which were covered with another sterile calabash and finally placed in a sterile black polythene bag and tied firmly. The set-up was kept on a surface sterilized laboratory bench to ferment naturally at room temperature (30+2°C) for 96 hours.

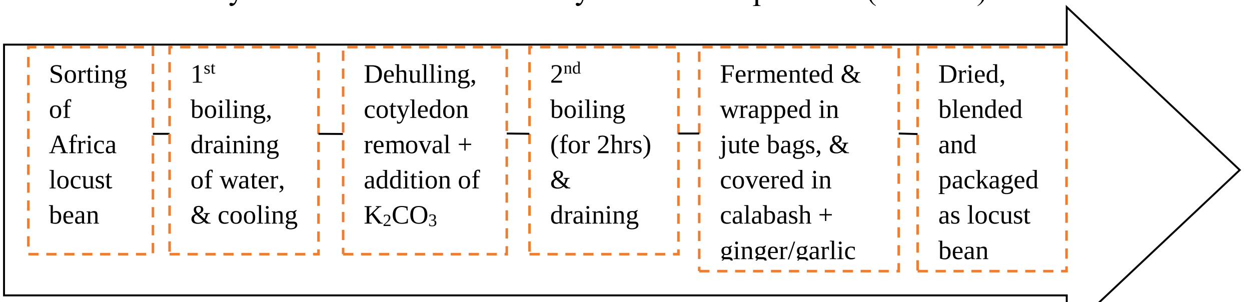

Fig. 2: Processing Flowchart of Iru (Locust bean)

Microorganism preparation and Isolation

One gram of each sample (Parkia biglobosa) was transferred aseptically into 10ml of sterile distilled water in a test-tube and shaken vigorously to dislodge the associated microorganism. The homogenate was serially diluted with sterile distilled water and 1mil of 10^{-} had taken one plated on petri dishes containing sterile molten nutrient agar. The incubation was carried out at room temperature 30+2°C. The plates were examined for growth and microbial load was determined by colony counting machine. The pure cultures were obtained by streaking repeatedly.

Media, Potato Dextrose Agar (PDA) and Nutrient Both Agar (NBA) preparation

Media was prepared according to manufacturer's standards. The media turned into organized in step with manufacturer's instruction. 65g of the media powder changed into weighed the use of weighing balance. After which the powder may be dissolve in1000ml of distilled water. The suspension changed into stirred lightly till homogenous combination turned into received. The media turned into autoclave at 1210C for 15 minutes.

The autoclaved media changed into allowed for to chill for two hours earlier than pouring in to sterilized plates. 20ml of the media turned into poured in every sterilized plate, due to the fact fungi grows slowly extra media can be required to be poured into the plates in order that the fungi will develop well without the media drying up. The same procedure was repeated for the preparation of nutrient agar (NA) and potato dextrose agar (PDA) at 28 and 39 grams of NA and PDA per 1000ml of distilled water for each respectively.

The nutrient broth agar (NBA) became organized in keeping with manufactures instruction. I.e. 25g of the media powder became weighed the use of weighing balance. After which the powder became dissolve in 1000ml of sterilized distilled water. The suspension became stirred lightly till homogenous aggregate turned into acquired. The media turned into autoclaved at 121^{0}C. 1ml of the media may be poured in every sterilized test tube and plugged with cotton wool and capped with aluminium foil. The same procedure was ensured for peptone water preparation at 15g of peptone per 100ml of distilled water.

Extraction Techniques

Plant extracts was obtained using maceration method. Powdered plant materials were extracted with chloroform, hexane and aqueous separately at room temperature for 48h using muslin cloth. Crude extracts were subjected to dryness in a hot air oven at 3°C for 24h. The dried crude extracts were kept at -5°C until evaluated. Each of the plant resultant extract was weighed and stored in the refrigerator until use.

Percentage yield was calculated using the formula suggested by (Patil et al., (2010).

Where:

Extract yield %= W_1/W_2x100

w_1= Net weight of powder in grams after extraction

w_2=Total weight of wood

Extraction of Samples with Chloroform and with Ethanol

Air-dried and powdered plant materials were extracted with chloroform (CH3Ci,) using Maceration method. The maceration extraction procedure is a semi-continuous process, which has been found to yield an optimal extraction of similar products and prevent loss of some bioactive compounds as a result of heat. The protocol followed was the standard method of extraction published by Current Protocols. 100g of each of powdered plant materials were weighed into conical flask. Plant material was soaked with 250ml chloroform at and covered with foil paper. The solvent was stored at room temperature and kept for 24hours. After 24 hours the solution was filtered using muslin cloth.

Filtered extract was concentrated by using a hot plate at low temperature (40-50˚C). Dried extract was weighed and expressed in percentage of original sample. All extracts were stored at 40˚Cuntil used. Air-dried and powdered plant materials were extracted with ethanol using Maceration method.

The maceration extraction procedure is a semi-continuous process, which has been found to yield an optimal extraction of similar products and prevent loss of some bioactive compounds as a result of heat. The protocol followed was the standard method of extraction published by Current Protocols. 100g of each of powdered plant materials were weighed into conical flask. Plant material was soaked with 250ml ethanol at and covered with foil paper. The solvent was stored at room temperature and kept for 24hours. After 24 hours the solution was filtered using muslin cloth.

Filtered extract was concentrated by using a hot plate at low temperature (40-50˚C). Dried extract was weighed and expressed in percentage of original sample. All extracts were stored at 40˚C until used. The same procedure was followed for aqueous (H_20) extraction.

Preparation of Extracts Concentration

Stock solution was prepared by dissolving 20g of the solid extracts in 100mls of normal saline, making a stock of 200mg/ml. The concentration was prepared from the stock solution using dilution formula as follows:

$C_1V_1=C_2V_2$

Where:

$C_{1=}$ present concentration

$V_{1=}$ volume to use

$C_{2=}$ required concentration

$V_{2=}$ required volume

A working solution of 100mg/ml, 300mg/ml and 500mg/ml concentration was used to test for the antimicrobial effect of the extracts.

Determination of Antimicrobial Activities of the Extracts

Determination of antimicrobial activity of plants extract was performed using agar well method. Using a hand gloves, and wire loop, microorganisms were sub-cultured on a Petri-dish containing different agar medium using streak method and a well was dig on different section of the inoculums plate using a pipette. Some percentages of stock solution were introduced to the well created and the plate was covered and incubated for 24 hours for bacteria and 48 hours for fungi at temperature of 27°C. After incubation time the plates were examined to check the result of the growth of microorganisms on different plates of different stock solution concentration for the used solvents. The procedure for this was done aseptically to avoid contaminations and error. The statistical analysis was done by subjecting the data through software (SPSS), Analysis of variance (ANOVA) was then carried on the data to separate the mean using the Duncan multiple range test (DMRT)

Results and Discussion

Aqueous extract of garlic juice with highest inhibition zone of 7 mm diameter at 100 mg/ml, the lowest zone of inhibition of 2 mm was observed at 25 mg/ml. Garlic juice showed to have less sensitivity to E. coli. Aqueous extract of ginger juice shows the highest zone of inhibition 6mm at 100 mg/ml while the lowest zones of inhibition recorded at 75 mg/ml working concentration was 1mm diameter. Ginger juice showed to have less sensitivity to Aspergillus niger. than garlic juice extract against Aspergillus niger at 75 mg/ml. with respect to the MIC of the extracted juice: The MICs of the aqueous extract against the test organisms; E. coli showed to be at 75 mg/ml while demonstrated to be 0.5 mg/m aspergillus niger at 50 mg/ml while demonstrated to be 0.05 mg/m

Table 1: Zones of inhibition of Garlic and ginger juice against E. coli and Aspergilus niger

Concentration (mg/ml)	Mean zone of inhibition (mm) ± Standard error			
	Control	GNJE	GAJE	GNJAN GAJAN
100	10±0.0	6±0.2	7±0.05	4±0.01
				2±0.01
75	10 ± 0.05^{a}	4±0.04	5 ± 0.2^{a}	2±0.04
50	10±0.04	3±0.01	3±0.05	1±0.05
25	10±0.04	1±0.01	2±0.05	0±0.05
				0±0.05
				0±0.05

Values are mean ±standard error (n=3). Mean values with the same superscript in a raw are not significantly different ($P<0.05$)

GNJE=ginger juice E. coli

GAJE=garlic juice E. coli

GNJAN=ginger juice aspergillus niger

GAJAN= garlic juice aspergillus niger

MM= minimeter

Table 2: MIC of the extracts of Garlic and ginger juice against E. coli and Aspergillus niger

Extracts		Concentration(mg/ml)			
		100	75	50	25
GNJE	MIC	-	-	+	+
GAJE	MIC	-	-	+	+
GNJAN	MIC	-	-	-	+
GAJAN	MIC	-	-	-	+

Key: Growth: (positive +) , No Growth: (Negative -)

1. Discussion, Conclusion and Recommendation

4.1 Discussion

Allium sativum (Garlic): extracts inhibited the growth of the all isolates tested; fungi; Aspergillus, the result of the present study showed that the aqueous extract has more activity. This result is comparable to that of (Pooja et al., 2012), which showed that the methanol extract of Garlic has good activity against both the fungal strains, (0.237 mg/ml) and A. niger. Aqueous extract was found to be less potent against E. coli with 2 mm diameter of inhibition respectively. The result is in line with the findings of (Shweta et al., 2016). which showed that 95% of chloroform extract inhibit the growth of bacteria; S. aureus, Salmonella spp., Shigella and E. coli with zone of inhibition of 21, 22, 19 and 25 mm diameter respectively.

1.2 Conclusion

Among all extracts tested, the Garlic extracts exhibited maximum antimicrobial activity against the tested organisms, fungal strain showed more sensitivity to the extracts as compared to bacterial strain. All the extracts tested shows the antimicrobial nature but the degree varies among extracts.

1.3 Recommendation

Extracts of Ginger and Garlic which serve as natural preservatives tends to improve the shelf life of processed Parkia biglobosa seeds by reducing the number of microbial loads on the samples. Therefore, increase in the study of Garlic and ginger of its properties to identify the potential antimicrobial activity capable of inhibiting this pathogen is recommended as this plant are readily available and the cost of purchase is affordable

REFERENCES

Ennjiugha, V. N., and Ayodele-Oni, O. (2003). Evaluation of Nutrients and some Antinutrients in lesser Known, Underutilized Oil Seeds. International journal of food science and technology. **38**(10):525-528.

Ega, R. A. I., Kapu, M. M., Muazu, S., and Olumu, J. M. (1988). Effect of Fermentation on Distribution of Nutrients in the Seed of African locust bean (Parkia clappertoniana. Keay) and (Tamarind indica). Nigerian Journal of Basic and Applied Science **2**(11):87-94.

Odunfa, S. A. (1985). Biochemical Changes During "Iru" fermentation. Journal of food Technology.**20**(31):295-303.

Omafuvbe, B. O., Falade, S. O., Osuntogun, B. A., and Adewusi, R. A. (2004). Chemical

and Biochemical Changes in African Locust Beans (Pakia biglobossa) and Melon (Citrullus vilgaris) Seeds During Fermentation to Condiments. Parkistan Journal of nutrition. **3**(9):140-145.
Abdul, A.B., Abdelwahab, S.I., Al-Zubairi, A.S., Elhassan, M.M., Murali, S.M. (2008). Anticancer and antimicrobial activities of Zerumbone from the rhizomes of Zingiberzerumbet. Int. J. Pharm. 4: 301–304.
Chong, K. L., (2009). High content of zerumbone in volatile oils of Zingiber zerumbet from southern India and Malaysia. Flavour Fragr. J., 24: 301–308.
Batubara, I., Suparto, I.H., Sadiah, S., Matsuoka, R., Mitsunaga, T. (2013). Effect of Zingiber zerumbet essential oils and zerumbone inhalation on body weight of Sprague Dawley rat. Pak. J. Biol. Sci. 16, 1028–1033.
Bhuiyan, M.N.I., Chowdhury, J.U., Begum, J. (2009). Chemical investigation of the leaf and rhizome essential oils of Zingiber zerumbet (L.) Smith from Bangladesh. Bangladesh J. Pharmacol. 4:9–12.
Clinical Laboratory Standards Institute, (2006). Performance Standards for Antimicrobial Disk Susceptibility Tests, 9th Edition, M2-A9, 26(1).
Clinical Laboratory Standards Institute (CLSI). (2012). Performance Standards for Antimicrobial Susceptibility Testing, 22nd Informational Supplement Testing M100-S15. CLSI, Wayne, PA.
Chane-Ming, J., Vera, R., Chalchat, J.C. (2003). Chemical composition of the essential oil from rhizomes, leaves and flowers of Zingiber zerumbet Smith from Reunion Island. J. Essent. Oil Res. 15, 202–205.
Dai, D.N., Thang, T.D., Chau, L.T.M., Ogunwande, I.A. (2013). Chemical constituents of the root essential oils of Zingiber rubens Roxb.: and Zingiber zerumbet (L.) Smith. Am. J.Plant Sci. 4, 7–10.
Damodaran, N.P., Dev, S. (1968). Studies in sesquiterpenes-XXXVII: Sesquiterpenoids from the essential oil of Zingiber zerumbet Smith. Tetrahedron 24, 4113–4122.
Devi, N.B., Singh, P.K., Das, A.K. (2014). Ethnomedicinal utilization of Zingiberaceae in the valley districts of Manipur. J. Environ. Sci. Toxicol. Food Technol. 8, 21–23.
Dung, N.X., Chinh, T.D., Rang, D.D., Leclercq, P.A. (1993). The constituents of the rhizome oil of Zingiber zerumbet (L.) Sm. from Vietnam. J. Essent. Oil Res. 5, 553–555.
Dung, N.X., Chinh, T.D., Leclercq, P.A. (1995). Chemical investigation of the aerial parts of Zingiber zerumbet (L.) Sm. from Vietnam. J. Essent. Oil Res. 7, 153–157.
Duve, R.N. (1980). Highlights of the chemistry and pharmacology of wild ginger (Zingiber zerumbet Smith). Fiji Agric. J. 42, 41–43.
Hadian, J., Esmaeili, H., Nadjafi,F., Khadivi-Khub, A. (2014). Essential oil characterization of Satureja rechingeri in Iran. Ind. Crops Prod. 61, 403–409.
Jen, S.K., Ved, P. (1995). 22 genera and 178 species in India concentrated mainly in north eastern and peninsular region (Zingiberaceae in India) phytogeography and endemism. Rheedea 5, 154–165.
Joseph, L., George, M., Sreelakshmi, R. (2015). Phytochemical and pharmacological studies on Zingiber Zerumbet hydro-alcoholic extract for anticonvulsant activity. Int. J. Ther. Appl. 29, 19–23.
Kitayama, T., Nagaoa, R., Masuda, T., Hill, R.K., Morita, M., Takatani, M., Sawada, S., Okamoto, T. (2002). The chemistry of zerumbone IV: asymmetric synthesis of zerumbol. J. Mol. Cat. B: Enzymatic 17, 75–79.

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Ethical Approval

All authors hereby declare that "Principles of laboratory animal care" (NIH publication No. 85- 23, revised 1985) were followed, as well as specific national laws where applicable. All experiments have been examined and approved by the appropriate ethics committee.

Competing Interests

Authors have declared that no competing interests exist.

References:

1. Ogwueleka, T. C., Idris, S. B., Olusola, K. O., Adeoti, A. I., & Salau, O. A. (2022). Comparative analysis of biogas production from cow dung and poultry droppings. Environmental Science and Pollution Research.
2. Nwokoye, C., Akpan, M. N., Alfa, M. I., & Abdullahi, Y. S. (2021). Solar radiation potential for biogas production in Nigeria. Renewable Energy.
3. Adeniyi, A. O., Awulu, F. N., Lawal, S. O., & Bijman, J. (2020). Biogas as an alternative to conventional fuels in Nigeria. Journal of Renewable Energy.
4. Okpara, B. O., Ogugbue, C. J., & June, J. (2022). Impact of wood fuel dependency on environmental degradation in rural Nigeria. Environmental Management.
5. Alfa, M. I., Akpan, M. N., Oyebisi, T. O., & Bijman, J. (2020). Applications of biogas produced from animal manure in Nigeria. International Journal of Energy and Environmental Engineering.
6. Akpan, M. N., Ogugbue, C. J., & Olusola, K. O. (2021). Utilization of manure-derived biogas for sustainable agriculture. Journal of Sustainable Agriculture.
7. Awulu, F. N., Lawal, S. O., & Bijman, J. (2020). Environmental benefits of biogas as an alternative energy source in Nigeria. Environmental Technology & Innovation.
8. Lawal, S. O., Adeniyi, A. O., & Awulu, F. N. (2021). Biogas production and its environmental implications in developing countries: A review. Journal of Environmental Management.
9. Oyebisi, T. O., Ogugbue, C. J., & Akpan, M. N. (2021). Composition and characteristics of biogas produced from organic waste in Nigeria. Waste Management & Research.
10. Ogugbue, C. J., Oyebisi, T. O., & Alfa, M. I. (2021). Global biogas market trends and prospects. Renewable and Sustainable Energy Reviews.
11. Idris, S. B., Awulu, F. N., & Lawal, S. O. (2021). Biogas production from poultry droppings: Optimization and challenges. Journal of Environmental Science and Engineering.
12. Olusola, K. O., Adeoti, A. I., & Salau, O. A. (2023). Optimization of biogas production from poultry droppings using response surface methodology. Journal of Environmental Management.
13. Abdullahi, Y. S., Alfa, M. I., & Bijman, J. (2021). Enhancing biogas production from cow dung: A review. Journal of Renewable and Sustainable Energy.
14. Bijman, J., & June, J. (2014). Biogas production from organic waste: Challenges and opportunities. Waste Management & Research.

USE OF GYPSUM MIXED IRRIGATION WATER TO IMPROVE SALINE-ALKALI SOILS

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ABSTRACT

Introduction and Purpose: Soil salinity and sodicity are serious problems threating food security worldwide. There are several ways to improve conditions of saline-alkali soils. Mixing gypsum in the soil and washing the soil with irrigation water is perhaps the most widely used method. This technique is highly time and labor consuming as mixing the material and then washing the soil with plenty amount of water takes long time especially in the clayey soils. This study aimed to evaluate effectiveness of irrigation water-mixed gypsum on productivity and improvement of saline-alkali soils in both field and laboratory conditions.
Materials and Methods: Alfalfa (*Medicago sativa*), sainfoin (*Onobrychis viciifolia* Scop.), tall fescue (*Festuca arundinacea* Schreb.) and birdsfoot trefoil (*Lotus corniculatus* L.) were tested in the field conditions in a completely block design. The data presented are the first year's preliminary results on the plant height and dry weight.
Results: The results of first two harvests showed that the water mixed gypsum appeared having positive influence on the plant height, moist weight, and dry weight, while this effect was not statistically significant.
Discussion and Conclusion: The results suggest that as the trial progresses and more gypsum-treated water is applied, leading to further reactions between the gypsum and the soil, the impact of the gypsum will become increasingly noticeable. The field trial is set to continue for an additional two years.
Key Words: Alfalfa, Birdsfoot trefoil, Gypsum mixed irrigation water, Sainfoin, Tall fescue

INTRODUCTION

Saline, saline-alkali, and alkali soils cover extensive areas globally. These soils typically form in low-lying wetlands, ancient lakebeds, inland sea basins, and concave alluvial plains, often resulting from disruptions in natural balance due to various factors. The rapid expansion of saline and sodium-affected areas has been accelerated by increased irrigation and poor agricultural practices. While these soils, characterized by slopes under 3% and favorable topography for irrigation, have significant agricultural potential, they often remain uncultivated. Rehabilitating such soils has become a priority both globally and in Türkiye (Kelley, 1951; Saltalı, 2015).

Saline soils contain sufficient salts to hinder plant growth under normal conditions but lack sodium to a degree that would negatively affect soil physical properties. The salts in these soils typically comprise neutral salts of Na, Ca, and Mg as chlorides (Cl) and sulfates (SO_4). Saline soils are characterized by electrical conductivity (EC) of the saturation extract exceeding 4 dS/m, a pH below 8.5, and exchangeable sodium percentage (ESP) under 15% (Saltalı, 2015).

Saline-alkali soils comprise both high salts and sodium, negatively affecting plant growth. Their EC is greater than 4 dS/m, ESP exceeds 15%, and pH is below 8.5. When washed, they exhibit properties similar to nonsaline-alkali soils (Saltalı, 2015).

Alkali soils have high sodium levels, leading to colloidal dispersion and degraded physical properties. These soils have low dissolved salt concentrations, with EC below 4 dS/m, ESP over 15%, and pH ranging from 8.5 to 10.0. High sodium levels in these soils cause dispersion of organic matter, often giving them a dark blackish hue, earning them the name “black alkali” or “solonetz” (Saltalı, 2015).

In Türkiye, saline and alkali soils cover 1,518,722 hectares, representing 0.2% of the total area and 11.5% of the country's irrigable land potential (2.5 million hectares). The total area of land with inadequate drainage is 2,775,115 hectares, and problematic soils occupy 32.5% of the irrigable land, roughly one-third of the irrigable terrain (Saltalı, 2015). In the Iğdır Plain, saline and alkali soils are widespread, necessitating the identification of suitable plant species for utilization.

Saline soils are often reclaimed by leaching. Due to their low permeability, drainage during leaching is generally not an issue unless the natural drainage system is inadequate, requiring the installation of open or closed drainage systems. Salt-tolerant crops such as rice, barley, cotton, alfalfa, and grasses like bermudagrass and tall fescue are recommended for cultivation. These plants not only help reduce salinity by absorbing salts but also improve soil aeration through root channels (Saltalı, 2015).

For alkali soils, high sodium content necessitates physical property improvement and sodium removal. Common reclamation agents include acids and acid-forming chemicals like sulfur (S), calcium sulphate ($CaSO_4$), sulfuric acid (H_2SO_4), and ferrous sulfate ($FeSO_4$), although high costs limit their use in Turkey (Saltalı, 2015).

Salinity affects plants through: 1) Osmotic stress: High salt levels hinder water uptake, causing physiological drought. 2) Toxic ion effects: Excess Na can be toxic to almonds and avocados, while Cl harms fruits, and high sulfate concentrations impede calcium absorption. 3) Indirect effects: High carbonate and bicarbonate levels precipitate Ca and Mg, increasing Na concentrations and leading to alkalization, which degrades soil structure and limits plant growth (Bresler & Charter, 1982). 4) Alkali soils further reduce the availability of essential macro (e.g., Ca, Mg, K) and micro (e.g., Fe, Cu, Zn, Mn) elements, leading to deficiencies in plants (Qadir & Schubert, 2002).

Crops must be chosen based on their tolerance to salinity and alkalinity. Tolerance rankings for salinity show barley > sugar beet > cotton > wheat > soybean > rice > maize > chickpea. Barley is the preferred crop for highly saline areas, while other options depend on the severity of the issue (Saltalı, 2015).

In the Iğdır Plain, the combination of high groundwater levels, impermeable soil layers, and evapotranspiration exacerbates salinization and alkalization, affecting nearly all irrigated lands (Temel et al., 2016). Effective management includes selecting salt-tolerant plants, improving soil physical properties, preventing salt movement, and implementing proper land leveling and irrigation techniques.

Traditionally, $CaSO_4$ is incorporated into soil in certain depths and leached with known amount of irrigation water to remove excess Na from the soil. This processes is highly costly and often time consuming as water flow in alkali soil is considerably low in most of the cases. We hypothesized that $CaSO_4$ may be applied to soil via irrigation water instead of mixing it with soil. A continuous application of $CaSO_4$ may help maintaining the soil to be productive. Therefore, this study aims to evaluate effectiveness of irrigating four different forage crops with gypsum ($CaSO_4$)-enriched water to rehabilitate saline-alkali soils at the "Agricultural Application and Research Center" of Iğdır University.

MATERIAL AND METHODS

The field trial was carried out at the "Agricultural Application and Research Center" of Iğdır University (Fig. 1). The majority of the soils in the area are highly saline, saline-alkali, or alkali. However, certain spots exhibit relatively lower levels of salinity and sodicity.

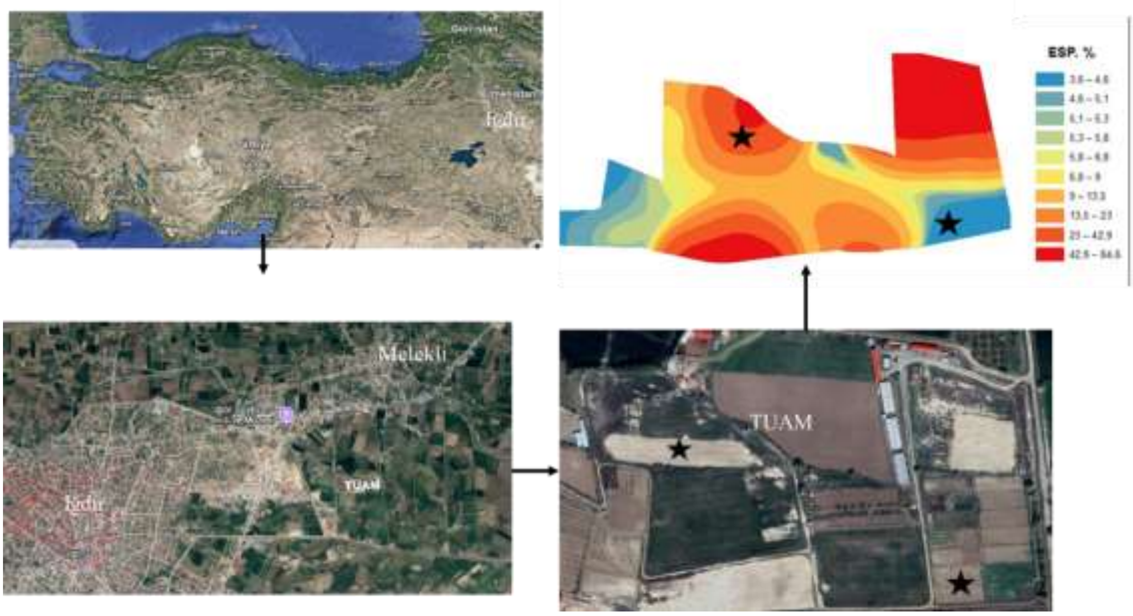

Fig. 1. Location of the study area. The stars indicate the field trial sites within the "Agricultural Application and Research Center" of Iğdır University. The top-right inset illustrates the spatial distribution of exchangeable sodium percentage (ESP) in the TUAM soils (Sarı et al., 2019).

A split-field trial using a completely randomized block design was established. The main plots consisted of two irrigation treatments: gypsum-enriched irrigation water and untreated irrigation water, while the subplots were divided into four forage crop types. Each plot measured 2 × 3 m (6 m^2), with a 2-m buffer zone separating the plots. Seeding was done between March 15 and 30, 2024.

The plots were irrigated either with standard irrigation water or with gypsum-mixed water ($CaSO_4$ solution). The gypsum-enriched irrigation water (JEIW) was applied using a 10-m^3 capacity water tank (Fig. 2), while untreated water was supplied through the farm's irrigation system. A total of five irrigations were conducted between May 15 and October 15, 2024, based on crop water requirement.

The plants were harvested twice during the trial. At each harvest, plant height was recorded from 10 randomly selected plants per plot, and a 1-m^2 section of each plot was sampled. Dry and fresh weights of the plant samples were measured, and the samples were preserved for subsequent chemical analysis.

Fig. 2. Water tank used for supplying $CaSO_4$-enriched water (left) and an alfalfa block being irrigated (right). A known amount of $CaSO_4$ was dissolved in water and pumped from the ground into the tank. The $CaSO_4$-enriched water was then delivered to the blocks via gravity. The tank's base is positioned 3.5 m above ground level, with the top reaching 5.5 m.

Statistical Analysis

The data were analyzed using ANOVA for a split-plot design within a completely randomized block framework. This analysis evaluated the effects of the main plot factor (irrigation treatments), the subplot factor (forage species), their interaction, and the block effect. The significance level of 0.05 was used for all variables unless otherwise specified.

RESULTS

The combined results of two harvests are given in Table 1. In general, irrigating with gypsum-enriched irrigation water (JEIW) generally increased the plant variables positively, while this effect was inconsistent across the study plants. Application of JEIW increased plant height (PH) in alfalfa, sainfoin and birdsfoot trefoil (BF) and decreased in tall fescue (TF); increased fresh herbage yield (FHY) in alfalfa, TF, and BF and decreased in sainfoin; and increased percent dry matter (PDM) in sainfoin and TF and decreased in alfalfa and BF.

The standard deviation values show no consistent pattern for PH, FHY or PDM across the forage species, suggesting that the irrigation treatments did not consistently influence the variability of these plant variables among the study forages.

Table 1. Descriptive statistics of some plant variables. The statistical parameters were calculated on combined data from two harvest

Variable	Irrigation water type			
	Untreated irrigation water		$CaSO_4$-enriched irrigation water	
	Mean	SD	Mean	SD
	Alfalfa (*Medicago sativa*)			
PH	76.87	11.51	80.98	11.25
FHY	2073.67	474.24	2195.17	381.63
PDM	25.84	1.39	25.31	1.66
	Sainfoin (*Onobrychis viciifolia* Scop.)			
PH	49.42	14.56	51.18	11.70
FHY	865.33	427.98	784.50	453.42
PDM	21.61	3.60	23.89	2.66
	Tall fescue (*Festuca arundinacea* Schreb.)			
PH	34.87	4.53	33.73	7.19
FHY	560.50	182.78	399.33	131.09
PDM	23.62	1.97	24.72	3.10
	Birdsfoot trefoil (*Lotus corniculatus* L.)			
PH	45.75	7.07	47.93	5.91
FHY	658.33	351.15	815.33	461.16
PDM	21.81	1.66	21.05	1.76

PH: Plant height (cm), FHY: Fresh herbage yield (g m^{-2}), PDM: Percent dry matter

CONSLUSION AND DISCASSION

Gypsum is primarily used for the reclamation of alkali soils (Kelley, 1951; Saltalı, 2015; Weil & Brady, 2017). Traditionally, it is applied to the soil surface, mixed into the soil at a specified depth, and then followed by extensive irrigation to replace and leach excess sodium from the soil profile (Saltalı, 2015). However, this process can be time-consuming, particularly in clayey soils with poor hydraulic conductivity.

This study investigates the effectiveness of applying gypsum through irrigation water for rehabilitating alkali soils. To our knowledge, this is only the second study undertaken for this purpose worldwide. Initial results from the first year indicate a positive, albeit statistically insignificant, effect of gypsum application on plant variables. The experiment will continue in 2025 and 2026, with additional data collection and analysis expected to provide more robust insights. We anticipate significant improvements in both plant yield and soil alkality by the end of the study.

Research on the use of gypsum-dissolved water for sodic soil rehabilitation is limited. For instance, Davidson and Quirk (1960) demonstrated that gypsum applied via irrigation water facilitated pasture development on alkali soils, achieving satisfactory establishment.

This study was conducted on both slightly alkali and strongly alkali sites. The data presented here are from the slightly alkali site, as plants showed poor emergence at the strongly alkali site. However, gypsum-enriched irrigation water was applied to plant-empty plots on strongly alkali site to prepare the soils for future trials. We anticipate that the reduced soil alkality will result in improved plant emergence on this site in 2025.

REFERENCES

Bresler, E., Charter, D. L. (1982). *Saline and Sodic Soils*. Springer Verlag. Berlin Heidelberg, New York. 227.

Davidson, J.L. & Quirk, J.P. (1960). The influence of dissolved gypsum on pasture establishment on irrigated sodic clays. Australian Journal of Agricultural Reserach. 12(1): 100-110.

Kelley, W.P. (1951). *Alkali Soils, Their Formation, Properties and Reclamation*. Reinhold Pub.. New York, USA.

Qadir, M. & Schubert, S. (2002). Deration processes and nutrient constraints in sodic soils. Land Degradation and Development, 13, 275-294

Saltalı, K. (2015). Çorak Toprakların Oluşumu, Islahı ve Kullanımı, in: Ersahin, S., Öztaş, T., Namlı, A., Karahan, G. (Eds.), Toprak Amenajmanı. Gazi Kitabevi, Ankara.

Temel, S, Keskin, B, Şimşek, U, İbrahim Hakkı Yılmaz, I.H. (2016). The effect of soils having different salt content on mineral accumulations of some forage legume species.

Weil, R. & Brady, N. (2017). *The Nature and Properties of Soils*. 15th ed. Pearson, Boston, MA.

DETERMINATION OF AKDAĞ (ADIYAMAN/MALATYA) HABITAT DIVERSITY ACCORDING TO EUNIS HABITAT CLASSIFICATION SYSTEM

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ABSTRACT
It is in the form of European Nature Information System (EUNIS) codes identified in the study area C1.6, C2.6, D5.3, E5.12, E5.13, E5.14, F5.131, F5.14, F6.24, F6.27, F6.28, F6.2E, F9.1, F9.31, FB.4, G1.112, G1.38, G1.7C5, G1.D2, G1.D3, G1.D4, G2.135, G5.4, H1.1, H3.5, I1.1, I1.13, J1.1, J1.2, J2.1, J2.2, J2.4, J2.51, J2.52, J4.6, J4.7, J5.31. C1.6 coded habitta, C1.242- Although there are communities in shallow water [Ranunculus], Alisma lanceolatum was preferred because of its species density, characteristic feature and better representation of the Zivar Lake. In habitats coded C3.21, C3.23, [Phragmites australis-Reed] beds and [Typha-Wicker grass] beds better represent the C2.6 habitat.
Keywords: Adıyaman, Akdağ, Malatya, EUNIS,

INTRODUCTION

The European Nature Information System (EUNIS) emerged in Europe. It is the classification of two different and more recently multiple elements (plant, animal, climate, rock and ecological environment) by relating them to each other through the interaction of plant associations (syntaxonomy) (Vlaams Institute voor de Zee, 2016).

EUNIS is a system that defines habitat types at the European Union (EU) scale according to standardized terminology, allowing the analysis of habitats based on their effects on soil, environment, climate and ecological zones, and comparison with information from other countries (Moss and Roy, 1998).

Studies in the excellent literature on EUNIS conducted in Turkey between 2011 and 2020 were scanned. As a result, a total of 140 EUNIS habitat types were identified in the 3rd stage. In addition, it has been determined that there are 26 new habitat types that are not defined in EUNIS, without any level restrictions (Çakmak, 2021).

In the case study carried out based on field observations and satellite images in Işıklı lake and Gökgöl wetlands in Denizli Province, Çivril District, which is one of the important wetlands of Turkey and a lake system rich in aquatic plants, Işıklı Lake and Gökgöl wetlands and their immediate surroundings. It is coded and classified according to EUNIS. While agricultural areas and reed areas increased between 1990 and 2018, lake surface area and forest areas decreased (Özen, 2020).

The feature of this classification, which has a hierarchical structure, is that keys have been created for the definition of habitats, similar to the diagnostic keys created for the definition of species. The criteria were developed for the first three hierarchical levels of the classification. The aim of the EUNIS classification is to create a common European habitat language in Europe. Below are the habitat systems identified in the study area. Table 1 includes the defined habitat types and characterized plants.

METHOD AND MATERIAL

The study area, Akdağ, is located on the Southeastern Taurus Mountains between Adıyaman and Malatya. It has the highest peak in Adıyaman and is between the borders of the Eastern and Southeastern regions (Figure 1). The study of this area is important because the area is high, a transitional region and has a different geographical climate. Therefore, first of all, after the identification of the collected plants according to the seasons and rainfall conditions in the area, the plants characterizing the area and the ecological structure were used in the findings section by considering the data on the geological structure, soil structure and climate, and the EUNIS habitat system was used to represent the ecological structure.

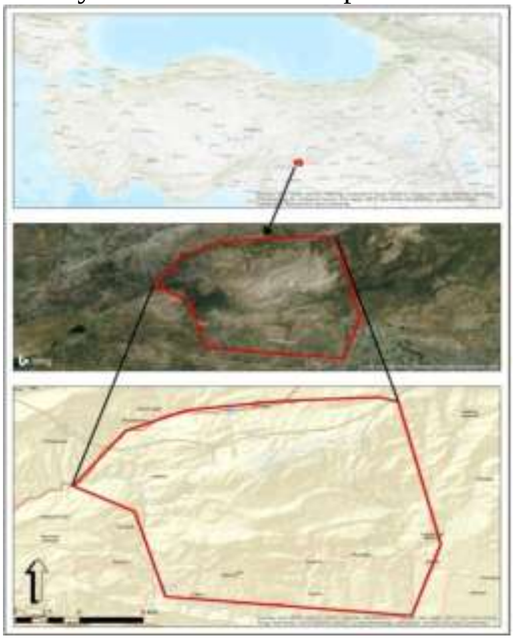

Figure 1. Geographical location (modified from HGM)

RESULTS and CONCLUSION

C- Far from the sea surface water habitats
 C1- surface stagnant waters
  C1.24- Structural floating vegetation of mesotrophic water bodies
   C1.242- [Ranunculus] communities in shallow water
  C3.21- [Phragmites australis] beds
  C3.23- [Typha] beds
D- Mud, swamp habitats
 D5- Sedge and reedbeds, normally without free-standing water
  D5.3- Swamps and marshes dominated by [Juncus effusus] or other large [Juncus] spp.
E- Forest fringes and clearings and tall herbaceous flowering plant habitats
  E5.12- Thistle fields
  E5.13- [Phlomis] brushes
  E5.14- [Ferula] stands
F- Heathland, scrub and tundra habitats
  F5- Maquis, matorral and thermo-Mediterranean brushes
  F5.1- Arborescent matorral
   F5.13- [Juniper] matorral
   F5.131- [Juniperus oxycedrus] arborescent matorral
   F5.14- [Pinus] matorral

F6- Garrigue
F6.2- Eastern garrigues
F6.24- Eastern [Euphorbia] garrigues
F6.27- Eastern [Teucrium] and other labiates garrigues
F6.28- Eastern [Paliurus spina-christi] garrigues
F6.2E- Eastern [Globularia] garrigues
F9- Riverine and fen scrubs
F9.1- Riverine and lakeshore [Salix] scrub
F9.3- Southern riparian galleries and thickets
F9.31- [Nerium oleander], [Vitex agnus-castus] and tamarix galleries
FB.4- Vineyards
G- Woodland and forest habitats and other wooded land
G1.1- Riparian [Salix], [Alnus] and [Betula] woodland
G1.112- Mediterranean tall [Salix] galleries
G1.3- Mediterranean [Populus], [Fraxinus], [Ulmus] and related riparian woodland
G1.38- [Platanus orientalis] woods
G1.7C- Mixed thermophilous woodland
G1.7C5- [Celtis australis] woods
G1.D- Fruit and nut tree orchards
G1.D2- [Juglans] groves
G1.D3- [Prunus amygdalus] groves
G1.D4- Fruit orchards
G2- Broadleaved evergreen woodland
G2.13- [Quercus coccifera] and [Quercus alnifolia] woodland
G2.135- Anatolian [Quercus coccifera] forest
G5- Lines of trees, small anthropogenic woodlands, recently felled woodland, early-stage woodland and coppice
G5.4- Small coniferous anthropogenic woodlands
H- Inland unvegetated or sparsely vegetated habitats
H1- Terrestrial underground caves, cave systems, passages and waterbodies
H1.1- Cave entrances
H3- Inland cliffs, rock pavements and outcrops
H3.5- Almost bare rock pavements, including limestone pavements
H3.511- Limestone pavements
I- Regularly or recently cultivated agricultural, horticultural and domestic habitats
I1- Arable land and market gardens
I1.1- Intensive unmixed crops
I1.13- Small-scale intensive unmixed crops (<1ha)
I2- Cultivated areas of gardens and parks
I2.2 Small-scale ornamental and domestic garden areas
I2.23- Small parks and city squaresJ- İnşa Edilmiş, Endüstriyel ve diğer Habitatlar
J1- Buildings of cities, towns and villages
J1.1- Residential buildings of city and town centres
J1.2- Residential buildings of villages and urban peripheries
J2- Low density buildings
J2.1- Scattered residential buildings
J2.2- Rural public buildings
J2.4- Agricultural constructions
J2.41- Agricultural buildings (not isolated)
J2.5- Constructed boundaries

J2.51- Fences
J2.52- Field walls
J4- Transport networks and other constructed hard-surfaced areas
J4.6- Pavements and recreation areas
J4.7- Constructed parts of cemeteries
J5- Highly artificial man-made waters and associated structures
J5.3- Highly artificial non-saline standing waters
J5.31- Ponds and lakes with completely man-made substrate

Tablo 1. EUNİS Habitat tipleri

Code	EUNIS Habitat System	Habitat	Dominant (Character) Types
C1.6	Temporary lakes, ponds and pools (wet phase)	Zivar Lake is fed by snow water and valley waters flowing in the winter, and begins to dry up in the summer months.	The species Alisma lanceolatum is predominantly found on the water surface.
C2.6	[Phragmites australis] beds [Typha] beds	Species found in temporary and flowing waters fed by springs or mountain waters on the roadside between 900-1200 m before reaching the Gürlevik stream.	Typha shuttleworthii, Phragmites australis
D5.3	Extreme wetlands and swamps dominated by [Juncus effusus] or other large [Juncus] spp.	Erkenek south slope, waterside, 1530 m,	Juncus infexus
E5.12	Thistle fields	Before reaching the Gürlevik stream, on the west road from Adıyaman, Cankara road towards to Erkenek	Carduus nutansL.subsp. nutans, C. nutans L. subsp. leiophyllus
E5.13	[Phlomis] brushes	Malatya, south of Erkenek	Phomis sp.
E5.14	[Ferula] stands	Adıyaman, above the Gürlevik drinking water source, mountainous slopes	Ferulago blancheana
F5.131	[Juniperus oxycedrus] arborescent matorral	The eastern and western slopes of the study area are 1400-1600 m.	Juniperus oxycedrus L.subsp. oxycedrus
F5.14	[Pinus] matorral	Adıyaman, Cankara south mountain slopes	Pinus sylvestris L. var. hamata
F6.24	Eastern [Euphorbia] garrigues	Adıyaman, Cankara south mountain slopes	Euphorbia anacampseros var. anacampseros , E. craspedia vder Euphorbia sp.
F6.27	Eastern [Teucrium] and other labiates garrigues	Opposite slope of Öğütlü village, southern slopes of Erkenek, above Tut	Teucrium chamaedrys L. subsp. sinuatum, T. chamaedrys L. subsp. tauricola, T. multicaule, T. polium
F6.28	Eastern [Paliurus spina-christi] garrigues	Adıyaman- Tut the roadside 800-1000 m.	Paliurus spina-christi
F6.2E	Eastern [Globularia] garrigues	Adıyaman, 1 km west of the left road before reaching the Gürlevik stream, 1340-1370 m.	Globularia trichosantha

F9.1	Riverine and lakeshore [Salix] scrub	Tut district center, waterside, south of Erkenek, 2-3 km upstream from the petrol station	Salix alba, S. babylonica, S. bornmuelleri,
F9.31	[Nerium oleander], [Vitex agnus-castus] and tamarix galleries	Before reaching Yaylımlı village, on the roadside, along the Göksu River, along the stream	Vitex agnus-castus, Tamarix smyrnensis
FB.4	Vineyards	Between Adıyaman and Tut, on the road	Vitis vinifera yards
G1.112	Mediterranean tall [Söğüt] galleries	Söğüt galleries are lined up along the road from Adıyaman mountain road to Erkenek.	Populus sp.
G1.38	[Platanus orientalis] trees	In the study area, there are individual or several trees together on the waterfront, roadside, and residential areas. There is a plane tree registered as a monumental tree in Tut district.	Platanus orientalis
G1.7C5	[Celtis australis] trees	Malatya, Erkenek south side, upwards, 1600 m.	Celtis tournefortii
G1.D2	[Ceviz] groves	Waterside and wetlands in villages of Erkenek and Tut districts, roadside wetland in Adıyaman Dandırmaz village.	Juglans regia
G1.D3	[Prunus amygdalus] groves	In the villages of Tut district, on the southern slopes of the study area.	Amygdalus sp.
G1.D4	Fruit orchards	Gardens established to meet commercial and basic needs in central and rural settlements in the study area.	Pistacia vera orchards, Morus sp. Malus sp. orchards
G2.135	Anatolian [Quercus coccifera] forest	On the eastern slopes of the study area, there are sparsely covered forests, sometimes densely covered forests.	Quercus coccifera, Q. sp.
G5.4	On the eastern slopes of the study area, there are sparsely covered forests, sometimes densely covered forests.	Slopes located on the East, West and Adıyaman-Malatya right side of the study area.	Pinus sp.
H1.1	Cave entrances	Adıyaman-Tut road 6-7 km roadside cave inside, 800 m.	Hyoscyamus aureus, Fibigia clypeata var. eriocarpa
H3.5	Nearly bare cliffs containing limestone.	Limestone debris falling from the slopes in some places on the top and eastern slopes of the study area.	Ricotia aucheri
I1.1	Intensive unmixed crops	All agricultural areas, vineyards, agricultural areas where they produce in and around rural settlements, orchards, vineyards and gardens within the study area are also collected under this artificial habitat type.	Poa bulbosa,Vitis vinifera, Malus sylvestris subsp. mitis, Morus alba, M. nigra, Pistachio vera, Prunus divaricata, Pyrus malus
I1.13	Small-scale intensive unmixed crops (<1ha)	Tobacco and bean cultivation in Erkenek and surrounding rural areas.	Nicotiana tabaccum, Phaseolus vulgaris
J1.1	Residential buildings of city	Tut district, Erkenek of Doğanşehir	

J1.2	and town centres Residential buildings of villages and urban peripheries	district, Tepecik, Yalankoz , Yaylakonak, Akçatepe and other villages in the study area.	
J2.1 J2.2	Scattered residential buildings Rural public buildings	Schools in the villages in the study area.	
J2.4	Agricultural constructions	Pistachio shelling factory in Tepecik village, boreholes opened for fruit and vegetable irrigation in villages and gardens.	
J2.51 J2.52	Çitler Tarla duvarları	Köylerde ve Erkenek, Tut gibi büyük yerleşim yerlerinde evler genellikle çitlerle örülmüştür. Bununla beraber arazinin eğimli olması, tarlaların teras şeklinde düzenlenmesi için, tarla duvarları inşa edilmiştir, Tarla sınırlarında çitler inşa edilmiştir.	Ficus sp., Pistacia sp. Rubus sp., Rosa sp., Hedera helix, Morus sp.
J4.6 J4.7	Pavements and recreation areas Constructed parts of cemeteries	Erkenek is located on the K.maraş-Malatya highway. Tut district is connected to Adıyaman via the mountain road. Tepecik, Akçatepe, Kaşlıca, Dandırmaz, Yaylakonak villages are located on this road. Tut road connects to Adıyaman-Gölbaşı highway in the west. Interlocking pavements and sidewalks have been laid on the roadside by the municipalities in settlements such as Erkenek and Tut. In the south of Tut district, a cemetery was built and surrounded by walls.	Ficus sp., Pistacia sp. Rubus sp., Rosa sp., Hedera helix, Morus sp.
J5.31	Ponds and lakes with completely man-made substrate	The construction of a pond for irrigation purposes continues beyond the Erkenek settlement center.	The pond is still under construction and water retention has not started.

Although C1.242- Shallow water [Ranunculus] communities were also found in the habitat coded C1.6, Alisma lanceolatum was preferred due to its species density, characteristic features and better representation of Zivar Lake.

In habitats coded C3.21, C3.23, [Phragmites australis-Reed] beds and [Typha-Straw grass] beds better represent the C2.6 habitat.

There are almost no studies in the region regarding the EUNIS habitat system. This study is important as it provides guidance for future studies.

REFERENCES

Çakmak, M.H., Aytaç, Z. (2021). EUNIS Habitat Sınıflandırmasının Türkiye Durum Değerlendirmesi. Bilge International Journal of Science and Technology Research, 5(2): 157-163.

http://cografyaharita.com/haritalarim/4o-adiyaman-konum-haritasi.png

Moss, D., Roy, D. (1998). Towards a European Habitat Classification (Rapor No. 42). Kopenhag, European Environment Agency.

Özen, A., Ürker, O., (2020), Erzincan University Journal of Science and Technology 2020, 13(2), 518-531 2020, 13(2), 518-531

Vlaams Instıtuut voor de Zee, (2020). Vlaams Instıtuut voor de Zee.

EFFECT OF FDM-IMPREGNATED HEMP FIBERS ON PHYSICAL, MECHANICAL AND THERMAL PROPERTIES IN CALCIUM SULFATE MATRIX COMPOSITES

KALSİYUM SÜLFAT MATRİSLİ KOMPOZİTLERDE FDM EMDİRİLMİŞ KENEVİR LİFLERİNİN FİZİKSEL, MEKANİK VE TERMAL ÖZELLİKLERE ETKİSİ

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ÖZET
Giriş ve amaç: Son yıllarda sürdürülebilir ve çevre dostu malzemelerin kullanımı inşaat sektöründe büyük bir önem kazanmıştır. Bu bağlamda, doğal liflerin kompozit malzemelerde kullanımı, hem çevresel etkileri azaltmak hem de geleneksel malzemelerin performansını artırmak amacıyla yoğun olarak araştırılmaktadır. Kenevir lifleri, yüksek mukavemeti, esnekliği ve sürdürülebilirliği nedeniyle bu alanda oldukça ilgi çeken bir doğal lif türüdür. Diğer taraftan faz değiştiren malzemeler termal enerji depolama performansları nedeniyle hergeçen gün daha fazla kullanım alanı bulmaktadır. Bu çalışmada FDM impregne edilen kenevir liflerinin kalsiyum sülfat esaslı kompozitlerim fiziksel mekanik ve termal enerji depolama özelliklerine etkileri incelenmiştir.

Materyal ve Metod: Atık kağıt lifi (AKL) takviyeli kalsiyum sülfat esaslı kompozit karışımının içerisine parafin impregne edilmiş kenevir lifleri AKL ağırlığına %0, 15 ve 30 oran ile yerdeğiştirilerek katılmıştır. Hazırlanan karışım yüksek basınçlı filtrasyonlu preslerde sıkıştırılarak 60x60x3 cm ebadında kompozit levhalar elde edilmiştir. Fırında kürleme işlemine tabi tutulan levhalardan alınan örnekler üzerinde yoğunluk, su emme yüzdesi, sertlik, eğilme dayanımı ve termal enerji depolama özellikleri ölçülmüştür.

Sonuçlar: Sonuç olarak üretilen kompozitlerin FDM impregne edilmiş kenevir lif oranı arttıkça yoğunluk değerlerinin düştüğü, su emme oranlarının azaldığı ve yüksek miktarda parafinin kuruma sonrasında sertleşerek malzemeyi gevrekleştirdiği veya fiber-matris arayüzünü olumsuz yönde etkilemesine bağlı olarak eğilme dayanımını düşürdüğü gözlemlenmiştir. Diğer taraftan termal enerji depolama özellikleri bakımından önemli artışlar sağlandığı tespit edilmiştir.
Anahtar Kelimeler: Alçı, atık kağıt lifi, kenevir lifi, eğilme, termal enerji depolama, yoğunluk.

ABSTRACT

Introduction and purpose: In recent years, the use of sustainable and environmentally friendly materials has gained great importance in the construction sector. In this context, the use of natural fibers in composite materials is intensively researched in order to both reduce environmental impacts and increase the performance of traditional materials. Hemp fibers are a type of natural fiber that attracts considerable attention in this field due to their high strength, flexibility and sustainability. On the other hand, phase change materials are increasingly used due to their thermal energy storage performance. In this study, the effects of FDM impregnated hemp fibers on the physical, mechanical and thermal energy storage properties of calcium sulfate-based composites were investigated.

Material and Method: Paraffin impregnated hemp fibers were added to the waste paper fiber (AKL) reinforced calcium sulfate-based composite mixture by replacing them with 0, 15 and 30% of the AKL weight. The prepared mixture was compressed in high-pressure filtration presses and composite sheets of 60x60x3 cm were obtained. Density, water absorption percentage, hardness, bending strength and thermal energy storage properties were measured on samples taken from the panels subjected to oven curing process.

Results: As a result, it was observed that as the FDM impregnated hemp fiber ratio of the produced composites increased, the density values decreased, the water absorption rates decreased and the high amount of paraffin hardened after drying and made the material brittle or decreased the bending strength due to the negative effect it had on the fiber-matrix interface. On the other hand, it was determined that significant increases were achieved in terms of thermal energy storage properties.

Keywords: Gypsum, waste paper fiber, hemp fiber, bending, thermal energy storage, density.

GİRİŞ

Kenevir liflerinin alçı kompozitlerde kullanımı, inşaat malzemeleri alanında sürdürülebilirlik ve genişleme etkisi açısından önemli bir tercih olmaktadır. Kenevir liflerinin alçı ile birleşimi, hem fiziksel hem de mekanik özelliklerin iyileştirilebilmesine olanak sağlayabilmektedir. (Fernea ve ark., 2017; Hussain ve ark., 2019) . Kenevir liflerinin alçı kompozitlerinde kullanımı, malzeme bilimi açısından da ilgi çekici bir tercihtir. Kenevir lifleri, yüksek dayanım ve dayanıklılık özellikleri ile bilinmekte olup bu özellikleri onları kompozit malzemelerin mukavemetini artırmada ideal bir seçenek haline getirmektedir (Shahzad, 2011) .

Cannabis sativa bitkisinden elde edilen kenevir lifleri, cam elyaflarına benzer olan 1.100 MPa'ya kadar ulaşabilen çekme mukavemetleri sergiler ve bu sayede otomotiv, inşaat ve tüketim malları gibi endüstrilerdeki çeşitli uygulamalar için çekici bir seçenek haline gelmektedir Shahzad, 2011). Ayrıca kenevir liflerinin kullanımı, kompozit malzemelerin geri dönüştürülebilirliğini arttırmaktadır (Boccarusso ve ark., 2021; Fantilli ve ark., 2021). Ayrıca kenevir liflerinin alçı ile birleşimi, kompozitlerin ısı ve ses izolasyon özelliklerini de önemli ölçüde iyileştirmektedir (Števulová ve ark., 2018; Arizzi ve ark., 2015). Kenevir lifleri ile güçlendirilmiş alçı kompozitlerinin bir diğer avantajı da daha hafif olmaları olup, bu özellik, inşaat sektöründe taşıma ve uygulama kolaylığı sağlamaktadır (Števulová ve ark., 2018; Števulová ve ark., 2013).

Kenevir lifleri doğal bir malzeme olarak, çevre dostu bir alternatif sunmakta ve inşaat sektöründe sürdürülebilir kullanım açısından avantaj sağlamaktadır (Števulová ve ark., 2018; Fantilli ve ark., 2021). Bu nedenle çeşitli uygulamalarda kenevir elyaf takviyeli kompozitlerin geliştirilmesi ve karakterizasyonuna odaklanan artan sayıda çalışmada gözlemlenmektedir. Örneğin hafif ve sürdürülebilir biyokompozitler geliştirmek için

polikaprolakton (PCL) gibi biyolojik olarak parçalanabilir matrislerin kenevir elyaflarıyla birlikte kullanımı araştırılmıştır (Dhakal ve ark., 2018).
Kenevir liflerinin kimyasal modifikasyonu, liflerin yüzey özelliklerini optimize ederek, kompozit matris malzemeleri ile daha iyi etkileşimin sağlanmasına yardımcı olmaktadır (Liu ve ark., 2017). Bu tür modifikasyonlar ile, liflerin su emme davranışları azaltırken, mikroorganizmalara karşı kompozitlerin dayanımı artırılarak kullanım ömürleri uzatılabilmektedir (Liu ve ark., 2017; Sandrine ve ark., 2015). Alkali ön işlemin kenevir elyaf takviyeli PLA kompozitlerinin mekanik ve yangın performansını iyileştirdiği gösterilmiştir (Alao vd., 2022). Bu ön işlem, elyafın yüzey özelliklerini iyileştirerek polimer matrisle daha iyi yapışmasına ve genel kompozit performansının iyileştirilmesine yol açmaktadır. İşlem aynı zamanda kompozitlerin nem direncini ve yangına tepkisini de etkileyebilmektedir (Alao vd., 2021) . Lif ön muame işlem süreçlerinin dikkatli bir şekilde seçilmesi ve optimize edilmesi, kenevir elyaf takviyeli kompozitlerin işlevselliğini artırmada önemli bir rol oynayabilir. Diğer taraftan faz değiştiren malzemeler (FDM) termal enerji depolama performansları nedeniyle hergeçen gün daha fazla kullanım alanı bulmaktadır. Son yıllarda, enerjinin daha verimli ve tasarruflu kullanılması amacıyla enerji depolama teknolojileri üzerine birçok çalışma yapılmıştır. Bu teknolojilerin başında gizli ısı depolama son zamanlarda dikkat çeken ve umut vadeden bir enerji depolama yöntemidir. FDM adı verilen enerji malzemeleri kullanılarak, enerji gizli ısı formunda depolanabilir. FDM'ler uygulanacakları sistemin özelliklerine ve çalışma aralıklarına uygun olarak çok çeşitli yapılarda ve formlarda tasarlanıp üretilebilirler (Mert ve ark., 2018; Mert ve ark.,2019a; Mert ve ark., 2019b; Sarı ve ark., 2012; Karaipekli ve ark., 2016). Bununla birlikte, FDM özelliği gösteren maddeler, doğrudan kullanılabildikleri gibi farklı malzemeler ile karıştırılarak veya mikro/makro boyutlarda kapsüllenerek kullanılabilirler.
Bu çalışmada FDM impregne edilen kenevir liflerinin kalsiyum sülfat esaslı kompozitlerin fiziksel mekanik ve termal enerji depolama özelliklerine etkileri incelenmiştir. Sürdürülebilir malzemelere olan talep artmaya devam ettikçe, kenevir elyaf takviyeli kompozitlerin çevre dostu ürünlerin geliştirilmesinde giderek daha önemli bir rol oynaması muhtemeldir.

MATERYAL ve METOT

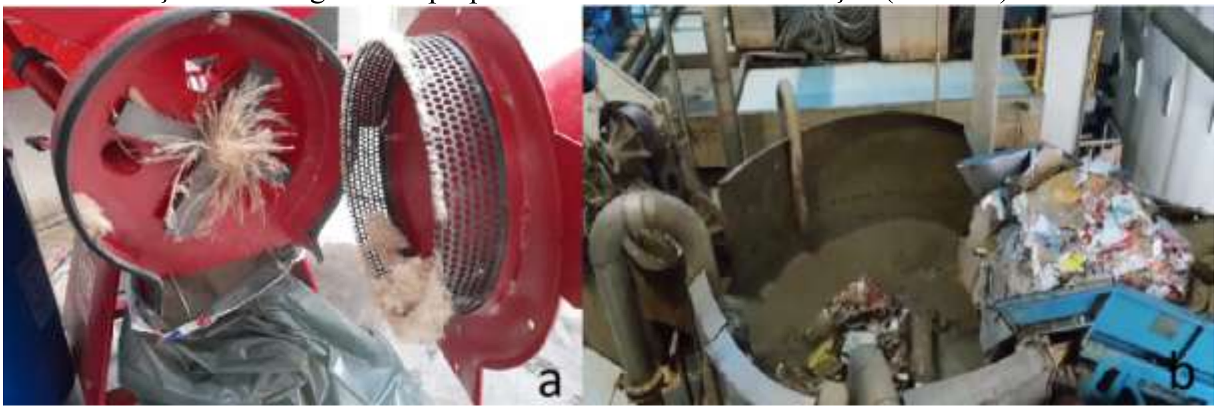
Materyal

Çalışma kapsamında lifsel hammadde kaynağı olarak atık kağıt lifleri ve kenevir lifleri kullanılmıştır (Resim 1). Kenevir liflerine FDM (faz değiştiren malzeme) emdirme çalışmalarında -kaprik asit kullanılmıştır[ss1].

Resim 1. Çalışmada kullanılan lifsel hammadde kaynakları (a: kenevir, b: atık kağıtlar).

Metot

Çalışma kapsamında kenevir lifleri öncelikle mekanik liflendirici kullanılarak liflendirilmiştir. Atık kağıtlar ise pulper kullanılarak liflendirilmiştir (Resim 2).



Resim 2. Kenevir (a) ve atık kağıtların (b) liflendirme işlemleri.

Alçı kompozit panel üretiminde kullanılacak olan kenevir liflerinin FDM emdirme çalışmalarında 0,2 g (fırın kurusu) kenevir örneği alınıp örneğe 1-1, 1-2.5 ve 1-5 oranında FDM ilave edilmiştir (Örneğin 1 g tam kuru kenevir lifine oranla 1 g tam kuru parafin). FDM ilavesinden sonraki aşama çözücünün katılmasıdır. Çözücü miktarı (etanol) kenevirin ve kullanılan FDM'nin tamamının ıslanması ile yeterli görülmüştür. Hazırlanan örnekler 70 °C ve 25°C'de 6 saat çalkalanarak muamele edilmiştir. Bu süre sonunda örnekler süzülerek 50 ml etanol ile yıkama işlemine tabi tutulmuşlardır. Süzülen örnekler süzme kâğıdı ile 70 °C'de kurutma fırınında ortalama 16 saat kurumaya bırakılmıştır.

Optimum FDM emdirme işlemi sonrasında elde edilen modifiye kenevir lifleri Tablo 1'de gösterildiği üzere kullanılan atık kağıt lifinin %15 ve 30'u oranlarında alçı kompozit panel üretimlerinde kullanılmışlardır. Ayrıca referans olarak FDM emdirilmiş kenevir lifinin katılmadığı kontrol panelleri de elde edilen değişimleri gözlemlemek amacıyla üretilmiştir. Test numunelerinin hazırlanmasında yüksek basınçlı pres, 60x60 cm ebatlarında drenajlı test kalıbı ve mikser kullanılmıştır (Resim 3).

Tablo 1. FDM emdirilmiş kenevir lifi katkısız/katklı alçı kompozit panel üretimi üretim deseni.

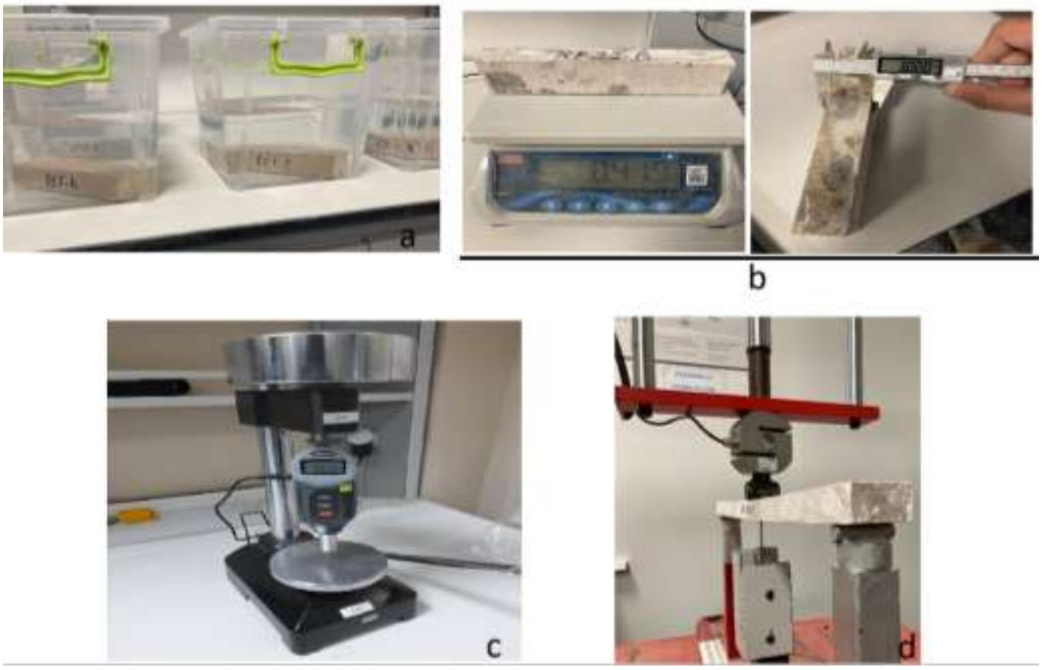
0% Kenevir		**%15 Kenevir**		**%30 Kenevir**	
REF		**KF15**		**KF30**	
Selüloz Hamuru		**Selüloz Hamuru**		**Selüloz Hamuru**	
Su	**Atık Kağıt**		**Atık Kağıt**	**Su**	**Atık Kağıt**
10750	1750	10750	1487.5	10750	1225
Kenevir Lifi Miktarı		**Kenevir Lifi Miktarı**		**Kenevir Lifi Miktarı**	
0		262.5		525	
FDM Miktarı		**FDM Miktarı**		**FDM Miktarı**	
0		656.25		2625	

Resim 3. Test numunelerinin hazırlanmasına ait örnek görüntü (a) ve Test numunelerinin hazırlanmasına ait örnek görüntü (hazırlanan karışımın prese sürülmesi) (b).

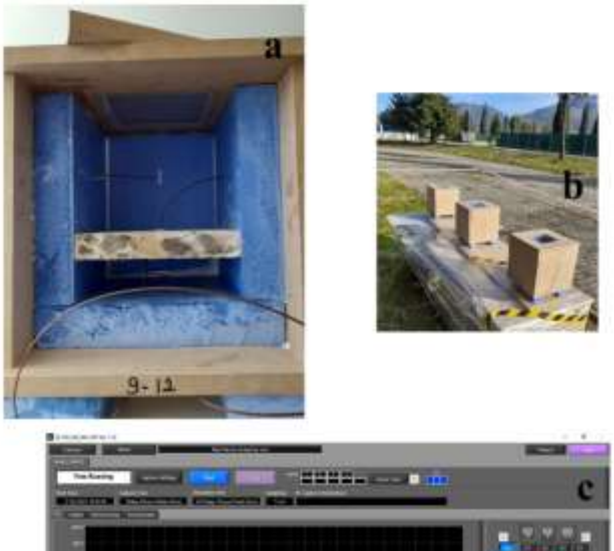
2’şer adet üretilen levha test numuneleri, laboratuvardaki etüvde 3 gün boyunca 40 C^{o} sıcaklıkta kurutularak fazla suyu giderilmiştir (Resim 4).

Resim 4. Test numunelerinin hazırlanmasına ait örnek görüntü (Etüvde kurutma işlemi).

Elde edilen panellerin fiziksel, mekanik ve termal özellikleri belirlenerek FDM modifikasyonlu kenevir lifi katkısı değerlendirilmeye çalışılmıştır. Bu kapsamda panellerde su emme (a), yoğunluk (b), sertlik (c) ve eğilme dayanım testleri (d) gerçekleştirilmiştir (Resim 5). Enerji depolama performans ölçümleri ise Resim 6’da gösterilmiştir.



Resim 5. Levhalarda gerçekleştirilen fiziksel ve mekanik testler.



Resim 6. (a) Enerji depolama performans ölçümü için hazırlanan odanın iç görünümü ve Termokupl'ların yerleşimi, (b) Enerji depolama performans ölçümü için hazırlanan deney düzeneğinin görüntüsü, (c) Enerji depolama performans ölçümü için sıcaklık verilerini 5 sn aralıklarla kaydeden Data Logger arayüzü.

BULGULAR ve TARTIŞMA

Kenevir liflerine parafin emdirme sonuçları incelendiğinde parafin oranı arttıkça tutunma oranının arttığı ve en iyi tutunma sonuçlarının 25 °C'de elde edildiği gözlemlenmiştir (Tablo 2). Kenevir liflerinin 5 katı kadar parafin kullanılarak 25 °C'de 6 saat muamele edilen örnekler optimum olarak kabul edilmiş ve alçı kompozit panel üretiminde kullanılmışlardır.

Tablo 2. Kenevir liflerine FDM emdirme işlemleri sonrası elde edilen tutunma değerleri.

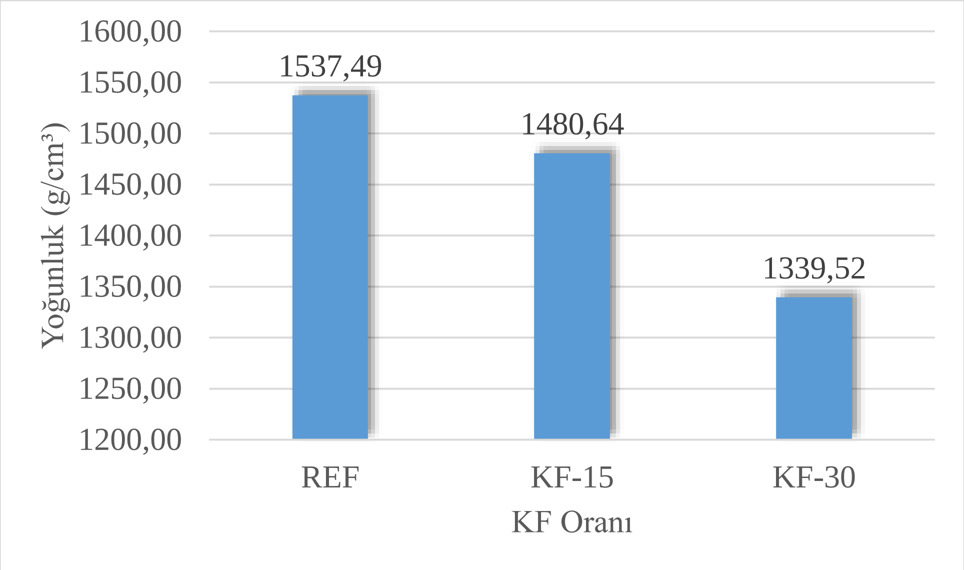
	Tutunma (%)		
	1-1	1-2,5	1-5
25 °C	44,9±1,46	70,4±0,28	82,8±0,11
70 °C	45,9±4,01	69,7±1,20	82,8±0,51

Yoğunluk analizleri ile malzemelerin yoğunluklarına ait parametreler incelenmiştir (Tablo 3).

Tablo 3. Üretilen levhaların yoğunluk değerleri.

Numune Kodu	Ağırlık (g)	Yoğunluk gr/dm³
REF-A	1800	1538.46
REF-B	1798	1536.52
KF15-A	1764	1484.85
KF15-B	1754	1476.43
KF30-A	1538	1307.82
KF30-B	1629	1371.21

Yoğunluk testi için öncelikle numunelerden düzgün dikdörtgen prizma parçalar kesilmiş, dijital kumpas ile ölçüler belirlenmiş, hassas terazi ile ağrılıkları belirlenerek yoğunlukları hesaplanmıştır. REF numuneleri, standart panel üretimleriyle eşdeğer yoğunlukta bulunmuş, KF15 malzemesinde karışıma katılan FDM emdirilmiş kenevirin, yoğunluğu yaklaşık %3 oranında düşürdüğü, KF30 numunesinde ise karışıma katılan FDM emdirilmiş kenevirin homojen karışmayı zorlaştırdığı, dolayısıyla değişken yoğunluklar gösterdiği ve ortalama %12,8 oranında yoğunlukta azalmaya sebep olduğu görülmüştür (Şekil 1[ss2]).



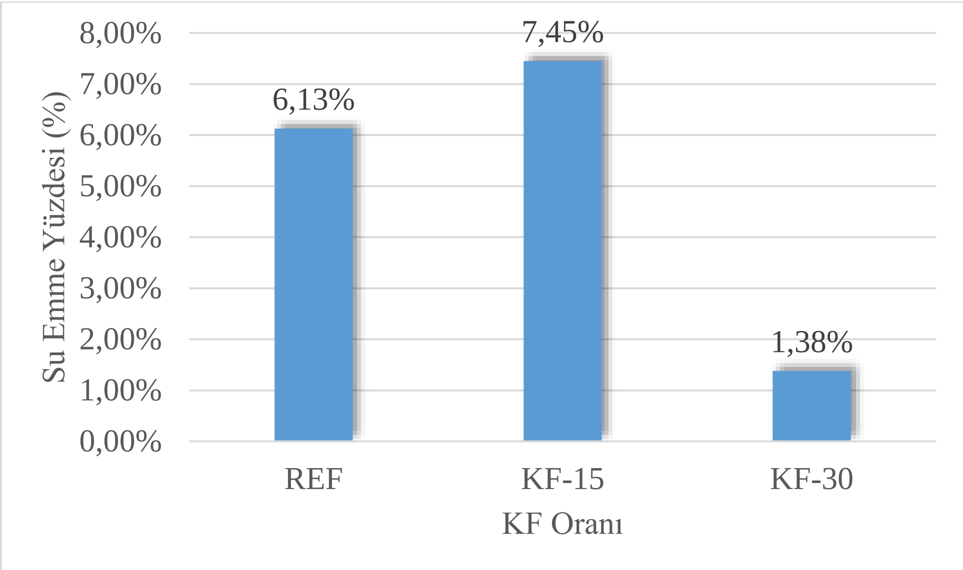
Şekil 1. Levhalarda elde edilen yoğunluk değerleri.

Su emme analizi ile üretilecek test numunelerinin su emme davranışlarına yönelik parametreler incelenmiştir (Tablo 4).

Tablo 4. Üretilen levhaların 2 saat suda bekletme sonucu elde edilen su emme değerleri.

	Hacim dm³	İlk ağırlık g	Son ağırlık g	Su Emme %
REF-A	0.32	500	532	6.40%
REF-B	0.31	478	506	5.86%
KF15-A	0.32	476	517	8.61%
KF15-B	0.31	445	473	6.29%
KF30-A	0.27	351	359	2.28%
KF30-B	0.29	419	421	0.48%

Test numunelerine yapılan su emme deneyi sonuçlarına göre, REF numunesinin performansı standart sonuçlarda olduğu görülmüş, KF15 numunesinde karışıma katılan FDM emdirilmiş kenevirin anlamlı sonuçlar göstermediği ve malzemeyi suya daha duyarlı hale getirdiği anlaşılmış, KF30 numunesinde ise artan parafin oranının kurutma sıcaklığıyla birlikte yapıda mikro ölçekte nüfuz etmesiyle, hidrofobik özelliğini deney numunesine taşıdığı ve böylece deney numunelerinin su emme oranlarını ciddi anlamda düşürdüğü görülmüştür (Şekil 2[ss3]).



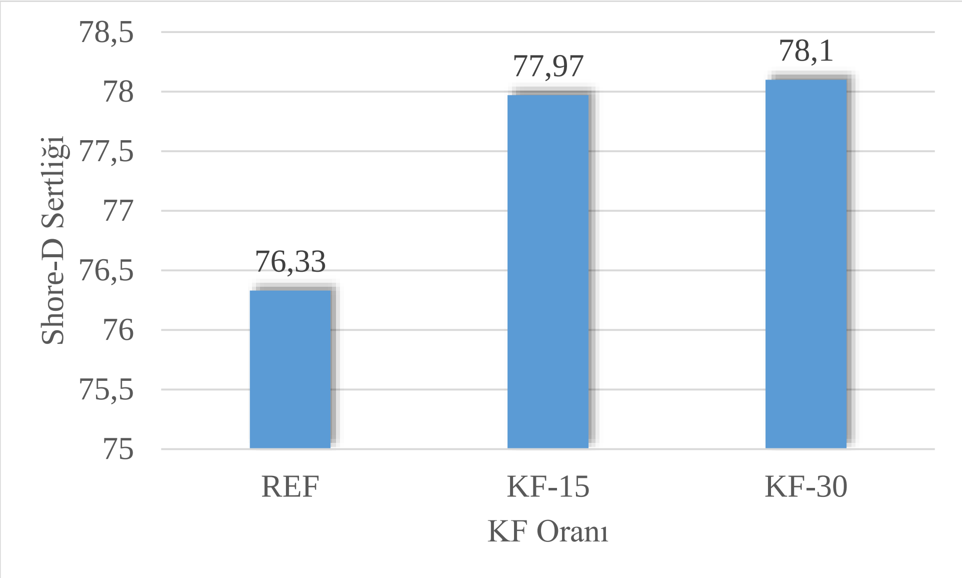
Şekil 2. Levhalarda 2 saat suda bekletme sonucu elde edilen su emme değerleri.

Sertlik testi ile üretilecek test numunelerinin sertlik değerleri incelenmiştir (Tablo 5).

Tablo 5. Üretilen levhaların sertlik değerleri.

Shore D	1.Ölçüm	2.Ölçüm	3.Ölçüm	4.Ölçüm	5.Ölçüm	Ortalama
REF-A	76	79	67.7	79	77.8	75.9
REF-B	70.2	75	79.4	80.2	79	76.76
KF15-A	73.6	78	83.3	72	79	77.18
KF15-B	81	79	79.4	74.4	80	78.76
KF30-A	79.8	77.8	80.6	80.2	77.4	79.16
KF30-B	77.8	76	76.2	74.8	80.4	77.04

Deneysel üretim kapsamında elde edilen numunelere Shore-D sertlik ölçümü yapılmış ve sonuçlar grafikte gösterilmiştir. Üretilen deney numuneleri görsellerinden de görüleceği gibi karışım malzemelerinin homojen dağıtılamadığı ve yüzeylerin standart olmayışından kaynaklı olarak; yapılan sertlik testlerinden anlamlı sonuç çıkarılamamıştır (Şekil 3).
Dayanım deneyleri ile test numunelerinin eğilme dayanımı, elastikiyet modülü, özellikleri incelenmiştir (Tablo 6).

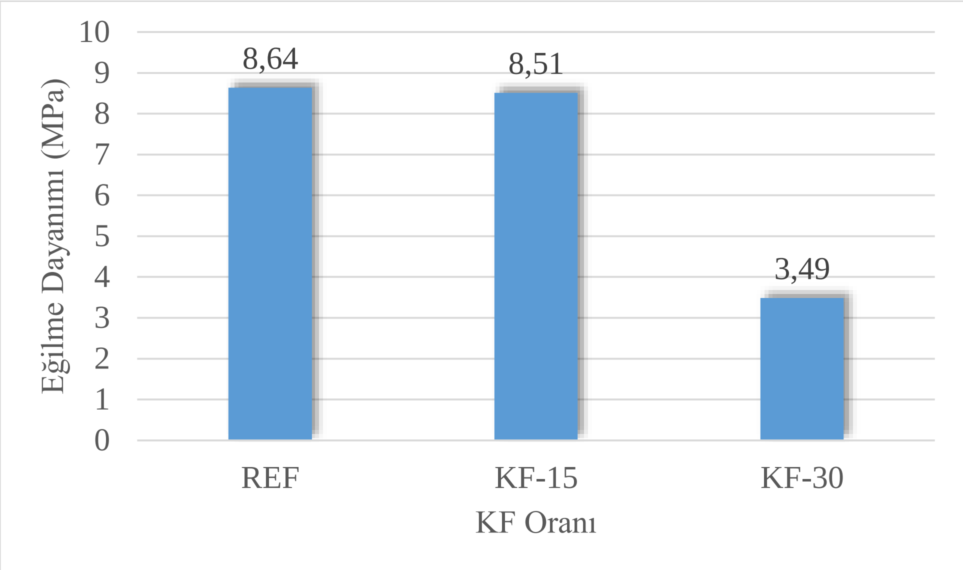


Şekil 3. Levhalarda elde edilen sertlik değerleri.

Tablo 6. Üretilen levhaların eğilme dayanım değerleri.

Numune		Kırılma Kuvveti (kgf)	Sehim (mm)	Eğilme Dayanımı (kgf/cm²)
REF-A	REF-A1	53.841016	5.062	92.25
	REF-A2	45.3773715	4.484	77.03
REF-B	REF-B1	41.0945634	4.644	70.41
	REF-B2	46.4990593	3.736	81.19
KF15-A	KF15-A1	36.4038688	3.955	63.56
	KF15-A2	53.9429877	4.313	95.09
KF15-B	KF15-B1	50.9858107	4.0207	89.88
	KF15-B2	37.1176702	4.675	64.20
KF30-A	KF30-A1	17.233204	2.614	30.97
	KF30-A2	13.9701121	2.218	25.11
KF30-B	KF30-B1	32.6309188	3.282	56.44
	KF30-B2	7.6478716	3.093	14.31

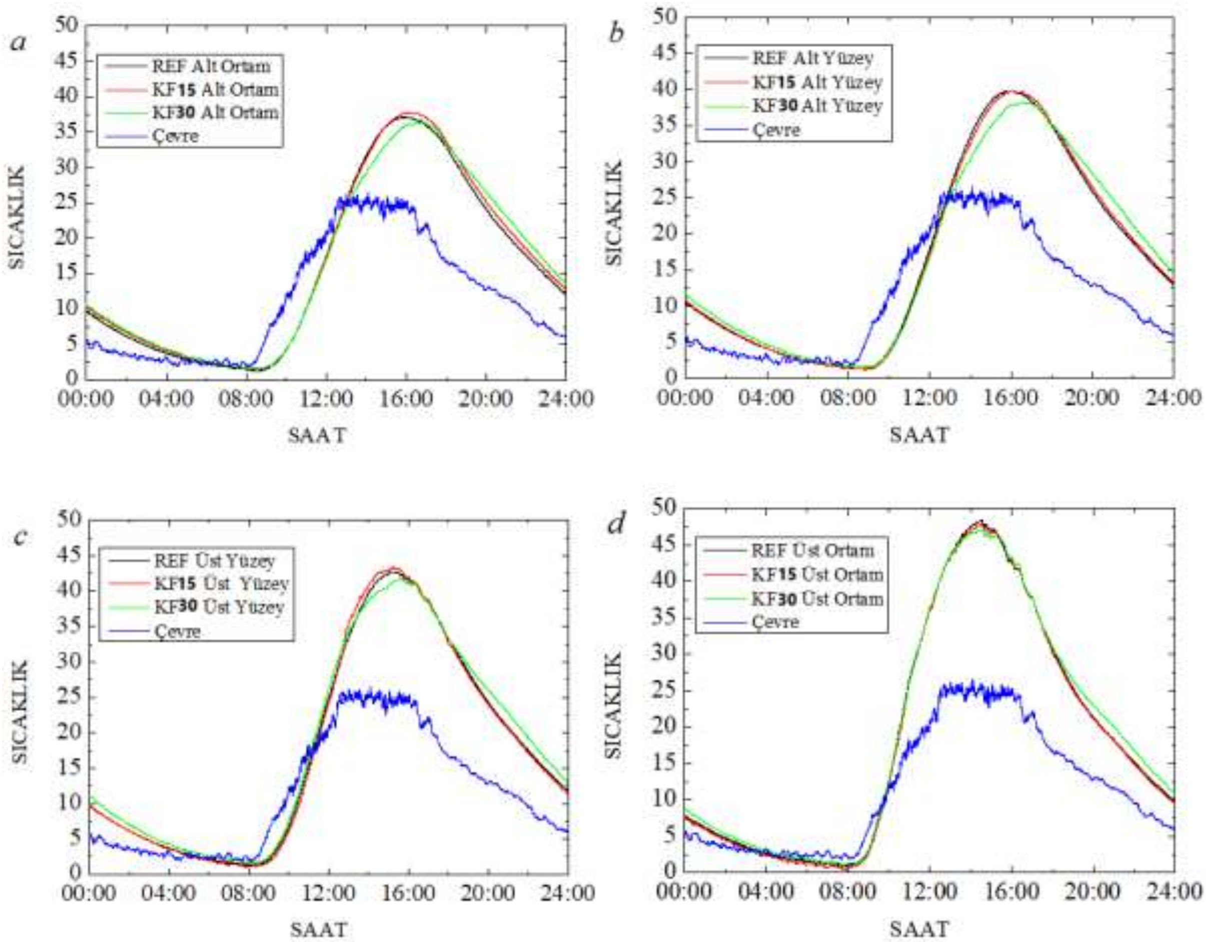
Dayanım ve sehim ölçüm test cihazında yapılan eğilme dayanımı test sonuçları incelendiğinde, REF ve KF15 test numunelerinin birbirleri arasında yakın değerler gösterdikleri, ancak KF30 test numunelerinde eğilme dayanımının ciddi oranda değer kaybettiği görülmektedir. Her ne kadar liflendirilmiş kenevir katkısının, malzemenin mekanik davranışlarını iyileştirmesi beklense de; eğilme dayanımdaki bu düşüşün, KF30'de bulunan yüksek miktarda parafinin kuruma sonrasında sertleşerek malzemeyi gevrekleştirdiği veya fiber-matris arayüzünü olumsuz yönde etkilediği için gerçekleştiği değerlendirilebilir (Şekil 4).



Şekil 4. Levhalarda elde edilen eğilme dayanım değerleri.

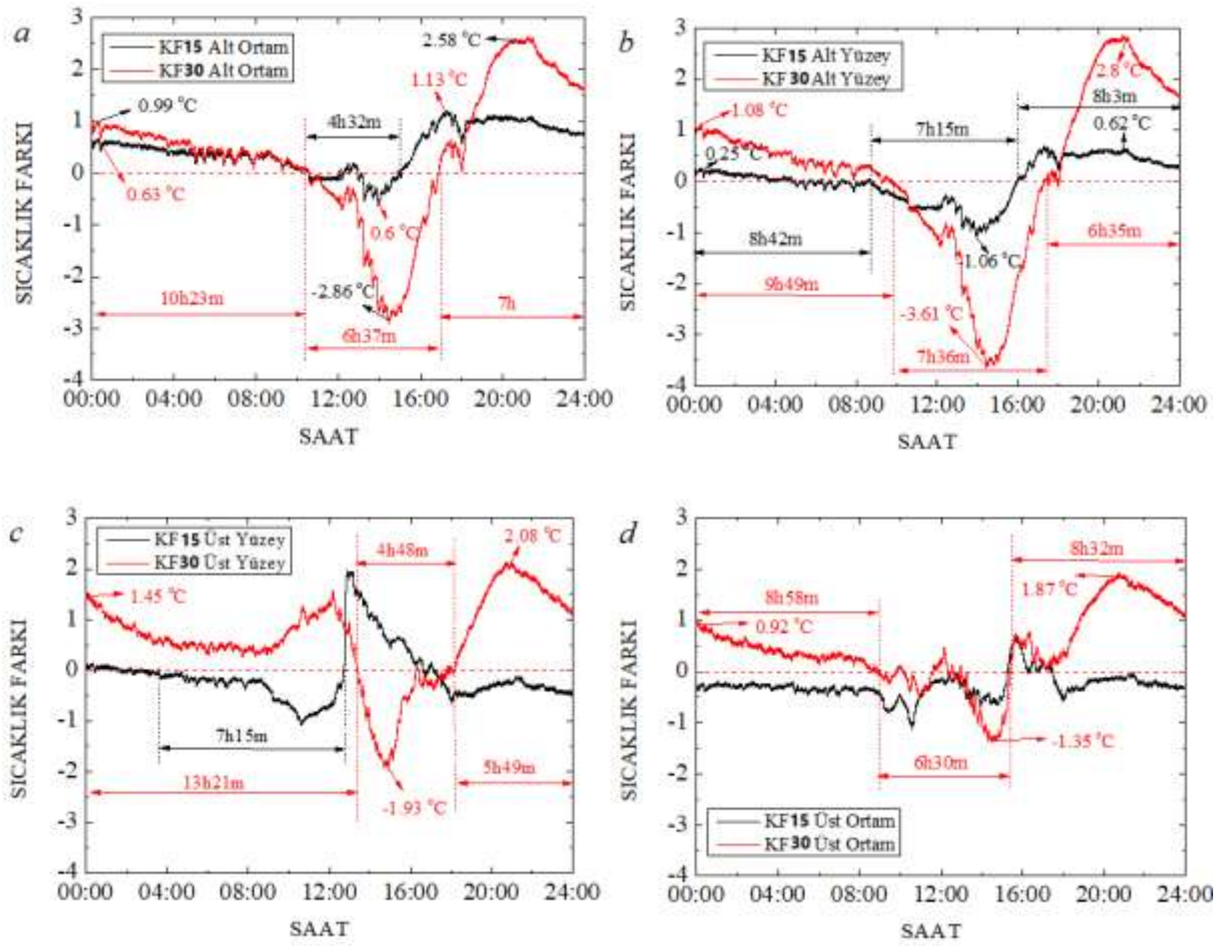
Şekil 5'te referans, KF15 ve KF30 malzemelerinin bulunduğu deney düzeneğinin alt ortam merkez, malzeme alt yüzey, malzeme üst yüzey ve üst ortam sıcaklıkları çevre sıcaklıkları ile birlikte gösterilmiştir.

En yüksek sıcaklıklar üst ortamda gözlemlenmiştir. Daha sonra sırasıyla malzeme üst yüzey, malzeme alt yüzey ve alt ortam şeklinde gerçekleşmişti. Çevre sıcaklığı gece yarısından sabah 8:00 civarlarına kadar 2.5-5 °C arasında değişmiştir. Güneşin doğuşu ile birlikte ortam sıcaklığı gittikçe artmıştır ve saat 12:26da ortam sıcaklığı 25 °C civarlarına ulaşmıştır. Çevre sıcaklığı saat 16:10 civarlarına kadar büyük bir değişiklik gerçekleşmemiş. Bu saatten sonra gece yarısına kadar sıcaklık gittikçe azalmıştır. Deney iç ortam sıcaklıkları güneşin doğumu ile birlikte hızlı bir şekilde yükselmiştir. Maksimum üst ortam sıcaklığına saat 14:30da ulaşılırken, maksimum üst yüzey sıcaklığına 15:17da, maksimum alt yüzey sıcaklığına 16:04de ve maksimum alt ortam sıcaklığına 16:20 civarlarına ulaşılmıştır. Bunun sebebi gelen güneş ışınımının öncelikli üst ortamı sonra sırasıyla malzemeyi ve alt ortamı ısıtmasından kaynaklanmaktadır. Güneş öğlesinde iç ortam sıcaklığı çok artmıştır. Bu süreçte ortam FDM emdirilmiş malzemelerin faz değişim sıcaklıklarının üzerine çıktığından dolayı referans oda ile karşılaştırıldığında teklif edilen malzemeler daha serin bir ortam sağlamıştır. Bununla birlikte güneş doğumu öncesinde ve güneş batma sonrasında ortam sıcaklığı azalırken depolanan enerji FDM nin ermesi sonucu çevreye yayılmakta ve soğuma işlemini göreceli olarak geciktirmektedir. KF30, KF15 ile karşılaştırıldığında daha etkin olduğu gözlemlenmiştir. KF15 ile referans arasındaki fark belirgin bir şekilde gözlemlenememiştir. Telif edilen KF15 ve KF30 malzemelerinin referans malzemeye göre avantajının daha açık bir şekilde incelenebilmesi için FDMli malzemeler ile referans numune arasındaki sıcaklık farklı dört ölçüm noktası için incelmemiştir.



Şekil 5. Referans, KF15 ve KF30 malzemelerinin bulunduğu deney düzeneği alt ortam merkez (a), malzeme alt yüzey (b), malzeme üst yüzey (c) ve üst ortam sıcaklıkları (d)

Şekil 6 alt ortam merkez, malzeme alt yüzey, malzeme üst yüzey ve üst ortam merkez noktalarında Referans ile FDM emdirilmiş KF15 ve KF30 malzemeleri arasındaki sıcaklık farklarını göstermektedir. Negatif sıcaklık bölgeleri referansa göre daha serin bir ortam elde edildiğine işaret etmektedir. Alt ortam sıcaklıkları incelendiğinde gece yarısından sabah vakitlerine kadar geçen 10 saat 23 dk lık bir süreçte KF15 ve KF30 referans duruma göre daha sıcak bir ortam sağlamıştır. Gece yarısında bu sıcaklık farkı KF30 için 0.99 ℃ civarlarında iken KF15 için 0.63 ℃ değerlerine ulaşabilmiştir. Referans ve FDM durumları arasındaki sıcaklık farkı gece yarısından gün doğumuna kadar gittikçe azalmış ve saat 10:23 de sıcaklıklar eşitlenmiştir.



Şekil 6. Alt ortam merkez (a), malzeme alt yüzey (b), malzeme üst yüzey (c) ve üst ortam merkez (d) noktalarında Referans ile FDM emdirilmiş KF15 ve KF30 malzemeleri arasındaki sıcaklık farkları.

Daha sonraki süreçte iç ortam ve yüzey sıcaklıkları artmıştır. Bununla birlikte FDM eklentisi alt oda sıcaklığı için KF30 de 2.86 °C lik bir serinlik elde edilirken KF15 de maksimum fark 0.6 °C civarlarına çıkabilmiştir. KF30 durumunda alt ortam sıcaklığı yaklaşık 6 saat 37 dakika kadar serin kalabilirken KF15 de bölüntülü olarak 4 saat 32 dk ya kadar çıkabilmiştir. Alt ortamda KF30 için 17:00'den sonra sıcak bir ortam elde edilebilirken KF15 de 15:00 dan sonra ısınmaya başlamıştır. Güneş battıktan sonra gece yarısına kadar geçen süreçte sıcak ortam KF30 de 7 saat kadar sağlanmıştır. 2.58 °C lik maksimum sıcaklık farkı 20:30-21:30 saatleri arasında gözlemlenmiştir. Bu saatten sonra sıcaklık gitgide azalmıştır. Alt yüzey sıcaklıkları incelendiğinde KF30 durumunda gece yarısından sabah saatlerine kadar yaklaşık 9saat 49 dk boyunca sıcak bir ortam sağlamıştır. 1.08 °C lik maksimum sıcaklık farkı gece yarısı gözlemlenmiştir. Bu sıcaklık farkı KF15 durumunda 0.25 °C civarlarına çıkabilmiştir. Güneş doğuşu öncesinde KF15 durumunda referans durumuna göre göreceli olarak daha sıcak bir ortam olmasına rağmen saat 4:50 den sonra fark neredeyse tamamen yok olmuştur. Oda sıcaklıklarının gittikçe arttığı güneş öğlesinde KF30 7 saat 36 dk'lık serin bir yüzey sağlarken KF15 7 saat 15 dk'lık serin bir yüzey sağlamıştır. Ancak maksimum sıcaklık farkı KF30 durumunda 3.61 °C ye ulaşırken KF15 de bu sıcaklık 1.06 °C civarlarına çıkmıştır. Hava sıcaklığının tekrar azaldığı zamandan gece yarısına kadar geçen süreçte KF30 6 saat 35 dk lık sıcak bir ortam sağlarken KF15 de bu oran 8 saat civarlarına çıkmıştır. Ancak KF15 de elde edilen maksimum fark 0.62 °C civarlarına ulaşırken KF30 de bu sıcaklık 2.8 °Cye ulaşmaktadır. Üst yüzey sıcaklıkları incelendiğinde KF15in referans malzemeye göre herhangi bir avantajı gözükmemektedir. Gece yarısından güneş öğlesine kadar geçen 13 saat

21 dk lık süreçte KF30 serin bir yüzey sıcaklığı sağlamıştır. Bu fark gece yarısında 1.45 ℃ civarlarında iken 3:40 ile 9:15 arasında ortalama 0.4 ℃ civarlarındadır. Güneş doğuşu ile birlikte fark tekrar artmakta ve 1.54 civarlarına çıkmaktadır. Maksimum sıcaklık zamanlarında KF30 maksimum 1.93 ℃'lik serinlik sağlamıştır. Bu serinlik yaklaşık 13:20 ile 18:10 arasında gerçekleşmiştir. Saat 18:10 dan sonraki süreçte KF30 üst yüzey sıcaklığı referans durumuna göre 5 saat 49 dk lık sıcak yüzey sağlamıştır. Maksimum sıcaklık farkı 2.08 ℃ civarlarına ulaşmıştır. Şekil 2d üst ortam için sıcaklık farklarını göstermektedir. Üst ortamda KF15 malzemesinin referans malzemeye göre avantajı tamamen yok olmuştur. Bununla birlikte KF30 gece yarısından sabah 9 civarlarına kadar sıcak bir iç ortam sağlamıştır. 0.92 ℃'lik maksimum sıcaklık farkı gece yarısı gözlemlenmiştir. KF30 gündüz 9:00 ile 15:30 saatleri arasında aralıklı olarak serin bir ortam sağlayabilmiştir. Bu aralıkta KF30 1.35 ℃ lik maksimum serinliğe 14:30 civarlarında ulaşmıştır. 15:30 dan sonra gece yarısında kadar sıcak bir ortam sağlanabilmiştir. Bu aralıkta 1.87 ℃'lik maksimum sıcaklık farkına ulaşılabilmiştir. Sonuç olarak KF30 gece saatlerinde daha sıcak bir iç ortam sağlayabilirken gündüz sıcaklık artışı ile birlikte daha serin bir ortam sağlayabilmektedir. Bu durumda binanın gece saatlerinde ısıtma yükünde azalma sağlarken gündüz soğutma yükünde önemli bir tasarruf sağlanabilecektir. Bina enerji tüketimini azaltılması ile birlikte ısıtma ve soğutmaya bağlı karbon salımında da önemli ölçüde azalma sağlanabilecektir. Sonuç olarak enerjetik, ekonomik ve çevresel açıdan büyük avantajlar sağlanabilecektir.

SONUÇLAR

Çalışma kapsamında kenevir liflerine faz değiştiren malzemelerden biri olan parafin emdirilermiş ve elde edilen lifler alçı kompozit panel üretiminde değerlendirilerek elde edilen levhaların fiziksel ve mekanik özelliklerinde meydana gelen değişimler belirlenmiştir. FDM emdirilmiş kenevir lifleri ile modifiye edilen alçı panellerin yoğunluk değerlerinin düştüğü, su emme oranlarının azaldığı ve yüksek miktarda parafinin kuruma sonrasında sertleşerek malzemeyi gevrekleştirdiği veya fiber-matris arayüzünü olumsuz yönde etkilemesine bağlı olarak eğilme dayanımını düşürdüğü gözlemlenmiştir. Enerji depolama analiz sonuçları ise alçı kompozit panellerde kenevir lifi kullanımıyla gece saatlerinde daha sıcak bir iç ortam sağlanabildiğini gündüz sıcaklık artışı ile birlikte daha serin bir ortam sağlanabildiği ortaya koymuştur. Bu durum ise binanın gece saatlerinde ısıtma yükünde azalma, gündüz soğutma yükünde ise önemli bir tasarruf sağlayabilecektir.

TEŞEKKÜR

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KAYNAKLAR

Alao, P., Press, R., Kallakas, H., Ruponen, J., Poltimäe, T., & Kers, J. (2022). Investigation of efficient alkali treatment and the effect of flame retardant on the mechanical and fire performance of frost-retted hemp fiber reinforced pla. Polymers, 14 (11), 2280.

Alao, P., Marrot, L., Kallakas, H., Just, A., Poltimäe, T., & Kers, J. (2021). Effect of hemp fiber surface treatment on the moisture/water resistance and reaction to fire of reinforced pla composites. Materials, 14 (15), 4332.

Arizzi, A., Brümmer, M., Martín-Sánchez, I., Cultrone, G., & Viles, H. (2015). The influence of the type of lime on the hygric behaviour and bio-receptivity of hemp lime composites used for rendering applications in sustainable new construction and repair works. Plos One, 10 (5), e0125520.

Boccarusso, L., Mocerino, D., Durante, M., Iucolano, F., Minutolo, F., & Langella, A. (2021). Recyclability process of gypsum reinforced with hemp fabrics: impact and flexural behaviour. 24th International Conference on Material Forming.

Fantilli, A., Jóźwiak–Niedźwiedzka, D., & Denis, P. (2021). Bio-fibres as a reinforcement of gypsum composites. Materials, 14 (17), 4830.

Dhakal, H., Ismail, S., Zhang, Z., Barber, A., Welsh, E., Maigret, J., … & Beaugrand, J. (2018). Development of sustainable biodegradable lignocellulosic hemp fiber/polycaprolactone biocomposites for light weight applications. Composites Part A Applied Science and Manufacturing, 113, 350-358.

Fernea, R., Tămaş-Gavrea, D., Manea, D., & Aciu, C. (2017). Physical and mechanical property characterization of hemp shive reinforced gypsum composite board. Advanced Engineering Forum, 21, 262-271.

Hussain, A., Calabria-Holley, J., Lawrence, M., & Jiang, Y. (2019). Hygrothermal and mechanical characterisation of novel hemp shiv based thermal insulation composites. Construction and Building Materials, 212, 561-568.

Karaipekli, A., Sarı, A. (2016). Development and thermal performance of pumice/organicPCM/gypsum composite plasters for thermal energy storage in buildings, Solar Energy Materials & Solar Cells, 149, 19–28.

Liu, M., Thygesen, A., Summerscales, J., & Meyer, A. (2017). Targeted pre-treatment of hemp bast fibres for optimal performance in biocomposite materials: a review. Industrial Crops and Products, 108, 660-683.

Mert, M.S., Sert, M., Mert, H.H. (2018). Isıl Enerji Depolama Sistemleri İçin Organik Faz Değiştiren Maddelerin Mevcut Durumu Üzerine Bir İnceleme. Mühendislik Bilimleri ve Tasarım Dergisi, 6 (1), 161-174.

Mert, H.H., Mert, M.S. (2019a). Preparation and characterization of encapsulated phase change materials in presence of gamma alumina for thermal energy storage applications. Thermochimica Acta, 681,178382.

Mert, M.S., Mert, H.H., Sert, M. (2019b). Microencapsulated Oleic–Capric Acid/Hexadecane Mixture as Phase Change Material for Thermal Energy Storage. Journal of Thermal Analysis and Calorimetry, 136, 1551-1561.

Sandrine, U., Vroman, I., Hoang, M., & Maalouf, C. (2015). Influence of chemical modification on hemp–starch concrete. Construction and Building Materials, 81, 208-215.

Sarı, A., Karaipekli, A. (2012). Fatty acid esters-based composite phase change materials for thermal energystorage in buildings, Applied Thermal Engineering, 37, 208-216.

Shahzad, A. (2011). Hemp fiber and its composites – a review. Journal of Composite Materials, 46 (8), 973-986.

Števulová, N., Cigasova, J., Schwarzova, I., Sičáková, A., & Junak, J. (2018). Sustainable bio-aggregate-based composites containing hemp hurds and alternative binder. Buildings, 8 (2), 25.

Števulová, N., Kidalova, L., Cigasova, J., Junak, J., Sičáková, A., & Terpáková, E. (2013). Lightweight composites containing hemp hurds. Procedia Engineering, 65, 69-74.

CLIMATE CHANGE AND URBAN FARMING IN OJO LOCAL GOVERNMENT AREA, LAGOS STATE, NIGERIA: ADAPTING AND MITIGATING CLIMATE CHANGE IMPACTS

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ABSTRACT
Globally, urban farming is a crucial component of food security and livelihoods in cities which face many challenges ranging from food scarcity to urban population increase, limited land resources, high resource use and climate change risks. This paper reviews the potentials of urban farming in contributing to sustainable food production under climate change. Data for the maximum/minimum temperature and rainfall of the Ojo Local Government Area for a period of 31 years (1991 – 2021) and annual crop yield of Lagos State between 1999 and 2015 were used to analyse the impact of climate change on crop yield. Structured Questionnaires were administered to urban farmers to acquire data on the impact of climate change on urban farming activities as well as the mitigation and adaptation strategies adopted. The data obtained were analysed using descriptive and inferential statistical methods. The results of the climate trend analysis showed a steady rise in the annual maximum/minimum temperature and rainfall of the study area. The major impacts of climate change include, destruction of farmlands, post-harvest losses, choking of crops by weeds and more cost incurred on urban farming activities. The farmers adopted mulching, cover cropping, mixed cropping, rainwater harvesting to cope with the impact of climate change. The major mitigation strategies implemented by the farmer include: raising of farm beds, crop diversification, Nitrogen, planting more densely, smart water management and engaging in different means of livelihood. The study recommends climate change awareness programmes to sensitize farmers on the impact of climate change and adaptive/mitigating strategies to adequately abate the impacts of climate change, as well as the creation of farmers’ markets to help the urban farmers in the study area generate more income.
Keywords: Climate Change, Urban Farming, Food Security, Climate Change Mitigation, Sustainability

INTRODUCTION
Climate change refers to long-term shifts in temperatures and weather patterns which may be natural such as through variations in the solar cycle (UN, 2020). Climatic change has been found to occur due to natural variability or as a result of human activities. This means that there are both natural and human factors causing climate change (Adebayo, 2011; Farauta & Apagu, 2011). The natural factors include terrestrial causes such as the alternation in the orientation of the earth, extra-terrestrial causes, such as in solar activities (variability), planetary motion, cloud formation and albedo, Bio-thermostat and ocean currents. The human causes include the emission of greenhouse gases (GHGs) and aerosols changes in land use and depletion of the ozone layer through various human activities such as industrialization, agriculture and land clearance (Adebayo, 2011). These activities of man-induced global warming is the visible evidence of climate change. Scientists reported that the human induced global warming is caused by increase in greenhouse gas (GHG) emission, particularly carbon dioxide (CO_2) (IPCC, 2001 and FAO, 2008). From shifting weather patterns that threaten

food production, to rising sea levels that increase the risk of catastrophic flooding, the impacts of climate change are global in scope and unprecedented in scale. Globally, the climate change and variability discourse have occupied centre stage in recent times due to the associated rising risks, dangers, and universality of its impacts (Scheffers et al., 2016). Climate change is majorly characterized by prevalence of severe weather and temperature events, and varying rainfall patterns.

The evidences of climate change in Nigeria are already manifesting in the form of changes in the intensity and seasonality of rainfall, increase in average annual temperatures and rising frequency of extreme weather events (Okon et al., 2021). According to Odjugo (2010), between 1901 and 2005 (105 years), the temperature of Nigeria increased by 1.1^{o}C while rainfall amount dropped by 81mm. However, the coastal region of Nigeria has been experiencing slightly increasing rainfall since the early 1970s even as rainfall amount is generally decreasing in the country. The short-dry-season popularly known as August break is currently being experienced more in the month of July as against August. Sea-level rise is observed to have inundated 3400km^2 of Nigeria's coastal region while desert encroachment is reducing arable lands from the northern part of the country by 1 - 10km a year.

Urban Farming also referred to as Urban Gardening is the practice of cultivating, processing, and distributing food in or around urban areas (Bailkey & Nasr, 2000). It encompasses a complex and diverse mix of food production activities including fisheries and forestry in many cities of developed and developing countries (FAO, 2022). Urban farming involves the production and processing of farming products primarily for food and other domestic use within a city or a town and its environs. As a result of the increasing demand for food and jobs for many urban dwellers in Nigeria, it has become necessary for urban households to embark on urban farming as a means of filling the food demand and supply gap and providing income for other households' requirements. The rise in food price, unemployment and inflation brought by the structural and the decline in the average real income of urban households have compelled many urban dwellers into farming in the urban areas (Kareem et al., 2012). Urban residents in Nigeria have undergone exploration of the urban environment for farm enterprise production for home consumption and sometimes income generation. The practice is common among the average to low income earners (Okanlade, 2017).

Urban farming is often done in the core areas, wedge areas and corridors out of the Lagos metropolis, as well as the outskirts of Lagos like Ojo, Ikorodu and Epe (Adedeji, et. al., 2009). The majority of the areas used for urban farming are unauthorized plots within or outside the city. These unauthorized farms can be found in many parts of the Lagos metropolis, especially along the many wetland areas like Ojo. Part of the reason for the growth in urban farming practice in Lagos is its adaptability and mobility compared with rural agriculture. Urban farming activities in Lagos state tend to be in small scale and labour intensive; characterised by the cultivation of vegetables such as spinach, lettuce, cabbage, carrot etc. often by Hausa or migrant farmers who cannot secure alternative jobs within the city. This type of farming system can be highly productive and has environmental, economic and social advantages, as the crops are usually produced using crude implements and are destined for local consumption; thus, contributing to feeding the city's population and serve as a source of income.

Urban farming in Lagos, Nigeria like in many other developing countries is constrained by a number of factors. These factors, are primarily man-made which include inadequate finance, poor pricing of urban produce, prohibitive cost of farm inputs, and competition from other land uses and inadequate access to land (Odewumi, et al., 2013). However, over the past few years, climatic factors have played a more important role than the man-made factors, which is compounded by the heavy reliance on rain-fed agriculture in most developing countries particularly among the rural and urban peasant farmers. The change in climate has nevertheless forced farmers to adopt new practices in response to altered conditions.

Urban farming is vital for the food security and economic stability of Lagos, Nigeria's largest city. However, the city is highly vulnerable to the adverse effects of climate change, including temperature increases, altered precipitation patterns, and sea level rise. These climatic changes threaten agricultural productivity, food supply chains, and livelihoods dependent on farming within the urban environment. Unfortunately, urban farming activities in Nigeria are largely climate dependent, therefore, irregularities and/or changes in the climate may affect the overall crop yield and productivity. In tropical regions like Lagos, increased temperatures can lead to heat stress on crops, altered growing seasons, and higher evaporation rates, exacerbating water scarcity. Changes in precipitation patterns can cause droughts or flooding, impacting soil health and crop yields. Sea level rise poses additional risks through saltwater intrusion and coastal erosion. Urban farming serves as a means to ensure food security for the residents of Lagos and augment their income. However, changes in the climatic conditions may affect this activity, urban farmers have long devised coping strategies to minimise these impacts on their farming activities and farmlands (Odewumi et al., 2013).

Odewumi et al. (2013) examined the impacts of climate change on urban farming in Ibadan, Oyo state, Nigeria and observed that urban farmers are aware of the changing climate and reported that drought, poor rain, changes in the rainfall pattern and increased temperature are the perceived signs of climate change. Increased cost of fertilizer, poor crop yield, water scarcity, outbreak of pests and diseases and delay/change in harvesting period were the impacts of the changing climate on urban farming activities in Ibadan. Odewumi et al. (2013) also reported that the strategies adopted by the urban farmers in Ibadan to cope with the changing climate included irrigation, application of fertilizer; to improve and enhance drop yield, dry mulching and application of chemicals like pesticide and insecticides to ward of pests and diseases.

Similarly, Yaro (2010) indicated that climate variability may be the leading cause of the decline in food crop production amongst other constraints of urban farming, and that farmers' adaptive behaviours and coping strategies revolve around the knowledge of climate rather than human environmental variables. Ayoade (2005) observed that climate change will affect crop yield directly because of alterations in temperature and rainfall and indirectly through changes in soil quality, pests and diseases.

Despite the numerous attempts by scholars to examine the impacts of climate change on urban farming, there seems to be little or no research done on Lagos state specifically. Therefore, crucial issue in this study is to determine whether urban farming output supply can keep pace with the population increase in Lagos state under climate change. This will depend both on the scope for raising urban farming productivity, availability of inputs used in the agricultural sector (land, labour, machinery, water resources, fertilizers, etc.) and having sufficient information on climatic variables for possible effective adaptation and mitigation strategies. It is against this background that this research intends to examine the impact of climate change on urban farming in Lagos state, Nigeria, a case study of Ojo Local Government Area.

CONCEPTUAL FRAMEWORK

Climate

Climate is commonly defined as the weather averaged over a long period. Climate also includes statistics other than the average, such as the magnitudes of day-to-day or year-to-year variations (Wikipedia, 2022). According to the Intergovernmental Panel on Climate Change (IPCC, 2001) Climate defined as the "average weather," or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities or variable over a period ranging from months to thousands or millions of years. However, the classical period is 30 years, as defined by the World Meteorological Organization (WMO). The meteorological variables that are commonly measured are temperature, humidity, atmospheric pressure, wind, and precipitation. In a broader sense, climate is the state of the components of the climate system, including the atmosphere, the hydrosphere, the cryosphere, the lithosphere and the biosphere and the interactions between them. The climate of a location is affected by its latitude/longitude, terrain, altitude, and nearby water bodies and their currents (Matthews et al., 2021).

Climate Change

IPCC (2007) defines climate change as a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and /or the variability of its properties, and that persists for an extended period typically decades or longer. The National Geographic Society (2022) also defined Climate change as the long-term alteration of temperature and typical weather patterns in a place. Climate change could refer to a particular location or the planet as a whole. According to NASA (2022), Climate change is a long-term change in the average weather patterns that define Earth’s local, regional and global climates. These changes have a broad range of observed effects that are synonymous with the term. Changes observed in Earth’s climate since the early 20th century are primarily driven by human activities, particularly fossil fuel burning, which increases heat-trapping greenhouse gas levels in Earth’s atmosphere, raising Earth’s average surface temperature. These human-produced (anthropogenic) temperature increases are commonly referred to as global warming.

Natural processes can also contribute to climate change, including internal variability (e.g., cyclical ocean patterns like El Niño, La Niña and the Pacific Decadal Oscillation) and external forces such as human activities, volcanic activity, changes in the Sun’s energy output and variations in Earth’s orbit (NASA, 2022). After more than a century and a half of industrialization, deforestation, and large-scale agriculture, quantities of greenhouse gases in the atmosphere have risen to record levels not seen in three million years. As populations, economies and standards of living grow, so does the cumulative level of greenhouse gas (GHGs) emissions. Examples of greenhouse gas emissions that are causing climate change include carbon-dioxide (CO_2) and methane, which result from using gasoline for driving a car or coal for heating a building, clearing land and forests can also release carbon dioxide. Landfills for garbage are a major source of methane emissions. Energy, industry, transport, buildings, agriculture and land use are among the main emitters of greenhouse gases.

Greenhouse Effect

Greenhouse Effect is the rise in temperature that the Earth experiences because certain gases in the atmosphere (water vapour, carbon dioxide, nitrous oxide, ozone, methane, for example) trap energy that comes from the sun (Toxipedia, 2011). These gases are usually called greenhouse gases since they behave much like the glass panes in a greenhouse. The glass panels of the greenhouse let in the light but keep heat from escaping and this is similar to the effect these gasses have on earth. Sunlight enters the Earth's atmosphere, passing through the greenhouse gases. The Sun powers Earth’s climate, radiating energy at very short wavelengths, predominately in the visible or near-visible (e.g., ultraviolet) part of the spectrum. Roughly one-third of the solar energy that reaches the top of Earth’s atmosphere is reflected directly back to space.

The remaining two-third of the sunlight energy is absorbed by the Earth's surface; land, water, and biosphere. Once absorbed, this energy is sent back into the atmosphere. Some of the energy passes back into space, but much of it remains trapped in the atmosphere by the greenhouse gases and the atmosphere. To balance the absorbed incoming energy, the Earth must, on average, radiate the same amount of energy back to space. Because the Earth is much colder than the Sun, it radiates at much longer wavelengths, primarily in the infrared part of the spectrum. Much of this thermal radiation emitted by the land and ocean is absorbed by the atmosphere, including clouds, and reradiated back to Earth (IPCC, 2022). Greenhouse effect is a completely natural process and without these gases all the heat would escape back into space and Earth's average temperature would be about 30°C colder. It is a very important process, because without the greenhouse effect, the Earth would not be warm enough for humans to live. But if the greenhouse effect becomes stronger, it could make the Earth warmer than usual. Even a little extra warming may cause problems for humans, plants, and animals (EPA, 2022).

Global Warming

Global warming is the long-term warming of the planet’s overall temperature (National Geographic, 2022). Global warming is the unusually rapid increase in Earth’s average surface temperature over the past century primarily due to the greenhouse gases released as people burn fossil fuels. The global average surface temperature rose 0.6 to 0.9°C (1.1 to 1.6°F) between 1906 and 2005, and the rate of temperature increase has nearly doubled in the last 50 years, temperatures are certain to go up further (NASA, 2010). Global warming is a phenomenon of climate change characterized by a general increase in average temperatures of the Earth, which modifies the weather balances and ecosystems for a long time. It is directly linked to the increase of greenhouse gases in our atmosphere, worsening the greenhouse effect (Solar Impulse Foundation, 2022). Since the Industrial Revolution, the global annual temperature has increased in total by a little more than 1°C (about 2°F). The average temperature of the planet has increased by 0.8°C (33.4°F) compared to the end of the 19th century. Each of the last three decades has been warmer than all previous decades since the beginning of the statistical surveys in 1850. Since 1981, however, the rate of increase has more than doubled: we’ve seen the global annual temperature rise by 0.18oCelsius, or 0.32oF, per decade for the last 40 years.

At the pace of current CO_2 emissions, there is expected to be an increase of between 1.5° and 5.3°C (34.7° to 41.5°F) in average temperature by 2100. Global warming occurs when carbon dioxide (CO_2), and other air pollutants collect in the atmosphere and absorb sunlight and solar radiation that have bounced off the earth’s surface. Normally this radiation would escape into space, but these pollutants, which can last for years to centuries in the atmosphere, trap the heat and cause the planet to get hotter. These heat-trapping pollutants (specifically carbon dioxide, methane, nitrous oxide, water vapour, and synthetic fluorinated gases) are known as greenhouse gases, and their impact is called the greenhouse effect. Though natural cycles and fluctuations have caused the earth’s climate to change several times over the last 800,000 years, our current era of global warming is directly attributable to human activity; specifically burning of fossil fuels such as coal, oil, gasoline, and natural gas, which results in the greenhouse effect. In the United States, the largest source of greenhouse gases is transportation (29%), followed closely by electricity production (28%) and industrial activity (22%).

Urban Farming

Bailkey and Nasr (2000) defined Urban Farming or Urban Gardening as the practice of cultivating, processing, and distributing food in or around urban areas. It encompasses a complex and diverse mix of food production activities, including fisheries and forestry, in many cities in both developed and developing countries (FAO, 2022). Simply put urban farming focuses more in selling produce, produce grown as sold as opposed to being grown for personal consumption or sharing. Urban farming involves the growing of plants and the rearing of animals primarily for food and other domestic use within a city or a town and its environs. It also involves activities such as the production, processing, marketing, and delivery of farming products. Urban agriculture consists of a number of production systems. They vary from domestic production and household level processing to large scale agriculture; usually done within the city peripherals. Urban agriculture shows great potential in the fulfilment of basic human needs, it not only provides food but also ensures a sustainable distribution and production system thereby creating employment opportunities and regular income for individuals. It also helps countries in the protection of their environment and saving upon their foreign currency and transportation costs.

METHODOLOGY

Primary and Secondary data were used for this research. The primary data were obtained from field survey and geographic co-ordinates of the urban farms while the secondary data were sourced from the Nigerian Meteorological Agency (NIMET) and Lagos Digest of Statistics.

Structured questionnaire was designed to obtain information on the socio-demographic characteristics of the respondents; data on the type of farming system practiced by urban farmers in Ojo LGA, impact of climate change on the urban farming practices of the respondents, knowledge of farmers towards climatic variations and change, and techniques adopted by urban farmers in dealing with the changes in climatic variables and the impacts of climate change.

Climate data for Ojo LGA under Ikeja climate district were obtained from the Nigerian Meteorological Agency (NIMET) for a period of 31 years (1991 – 2021). The data obtained were maximum temperature, minimum temperature and rainfall. Crop yield data for Lagos state from 1999 to 2015 (17 years) were obtained from Lagos State Digest of Statistics. The data included the yield of crops such as pumpkin leaf, amaranthus, okra, carrot, lettuce, tomato, maize, cassava and other leafy vegetables.

A reconnaissance survey was carried out in order to ascertain urban farming areas within Ojo LGA. The survey revealed that the areas where urban farming activities are practiced include: Lagos State University (LASU), Ojo Army cantonment (Barracks), sparingly along Lagos-Badagry expressway (Ojo LGA section) and both sides along the Iyanaba-LASU-Isheri expressway. Mixed sampling method was adopted; using the purposive/selective sampling technique to select the most active farming locations and the simple random sampling technique to select practicing urban farmers for administration of structured questionnaires. A total of 80 copies of structured questionnaire were administered and retrieved.

The retrieved structured questionnaires were coded and analyzed via SPSS version 18.0, using descriptive and inferential statistics; whereby questions like marital status was coded as 1 for divorced/separated and 3 for single; farm size of respondents was coded as 1 if the respondent has a farmland that is less than one plot and 5 if the respondent has a 4 plot farmland; length of farming experience was coded less than 5 years as 1 and above 15 years as 5, while farmers' awareness of change in the climate was coded into I don't know as 1 and awareness as 3 (Yes). GIS ArcMap 16.0 software was used to plot the map using the co-ordinates obtained. The climate and crop yield data were analyzed via SPSS as well. The results were presented using tables and charts using Excel software version 2019.

CONCLUSION AND DISCUSSION

Trend Analysis of the Climate of Ojo

The result of the trend analysis for the annual mean maximum temperature pattern of Ojo showed that there is a positive trend, indicating steady rise in the annual mean maximum temperature between 1991 and 2021. The average annual mean maximum temperature of Ojo over the 31-year period is 31.6^{o}C; the lowest annual maximum temperature was recorded in 1991 (30.9^{o}C), while 2020 has the highest annual mean maximum temperature at 32.7^{o}C. However, there have been fluctuations in the annual mean maximum temperature of Ojo, indicating decrease and increase, for instance between 1998 and 1999, between 2014 and 2016. It is therefore observed that the annual mean maximum temperature of Ojo has increased by 1.6^{o}C between 1991 and 2021. here has been a steady rise in the annual maximum temperature.

The trend analysis for the annual mean minimum temperature of Ojo also showed a positive trend, indicating that minimum temperature in Ojo has increased over the years. The average annual mean minimum temperature over the 31-year period is 23.3^{o}C; the lowest annual minimum temperature occurred in 1991 (22.1^{o}C), while the highest annual minimum temperature occurred in 2016 (24.2^{o}C). Therefore, increase of 2.1^{o}C in the annual minimum temperature was observed in Ojo between 1991 and 2021.

Lastly, the result of the trend analysis for the annual mean rainfall of Ojo showed that there is a positive trend with fluctuations recorded between 1992 and 1999. However, there has been a steady increase in the mean annual rainfall of Ojo from 2000 till 2021. This indicates increased variability of the annual rainfall in Ojo over the 31-year period. The average annual mean rainfall is 127.8mm; the lowest annual rainfall (77.2mm) was recorded in 1999, while the highest annual rainfall (176.4mm) was recorded in 2014. The fall in the annual mean rainfall of Ojo between 1998 and 1999 corresponds with the fluctuation in the annual maximum temperature over the same period (1998 – 1999).

Level of Impact of Climate Change on Crop Yield and Urban Farming Activities

The results analysed showed that there was strong positive correlation between maximum temperature and Lettuce ($r = 0.502^{*}$, $p < 0.05$) and Carrot ($r = 0.496^{*}$, $p < 0.05$), therefore, high frequencies of maximum temperature is associated with higher yields of Lettuce and Carrot. Therefore, that the annual maximum temperature is a major factor in affecting the yield of the crops cultivated. The results further revealed that about 66% of the crop yields show a positive correlation with annual minimum temperature, which suggests that annual minimum temperature is a major factor that affects the yields of the crops. For instance, positive correlation exists between minimum temperature and Carrot ($r = 0.725^{**}$, $p < 0.05$) and Pumpkin Leaf ($r = 0.311$, $p < 0.05$), therefore, high frequencies of minimum temperature is associated with more yield of carrot and pumpkin leaf.

The results further showed that there was a strong positive correlation between rainfall and Cassava ($r = 0.496^{*}$, $p < 0.05$) and Amaranthus ($r = 0.375$, $p < 0.05$), therefore high frequencies of rainfall is associated with more yield of Cassava and Amaranthus. This suggests that rainfall is a major factor that affects the yield of the crops. The results analysed showed that climate change has major impacts on urban farming activities in the study area. 93.75% of the respondents have observed moderate to very extreme changes in the climate of Ojo, with majority of the respondents affirming that there has been an increase in the amount of rainfall and temperature in recent years. The changes observed have resulted in environmental impacts such as erratic rainfall amount, excessive rainfall, increase in flooding and erosion.

The results also revealed that climate change has negatively impacted urban farming activities, as over 97.5% of the respondents affirmed that the increased frequency of flooding caused by excessive rainfall has resulted in the destruction of farmlands and crops. 92.5% of the respondents claimed that weeds grow more on the farmlands in recent years, which end up competing with the crops for soil nutrients and even choke up the crops resulting crop failure and eventual decrease in crop yield and poor harvest. Also, unfavourable weather conditions such as increased temperature (heat wave) have led to the rotting and drying of farm produce, as affirmed by 73.75% of the respondents. Furthermore, there is prevalence of diseases, increase in pest infestation and spread of pests and diseases on the farms due to the changing climate. The negative impacts dealt upon urban farming activities by climate change have compelled the respondents to incur more cost in order to adapt and mitigate the impacts.

Adaptation Techniques Implemented by the Farmers to Cope with the Impact of Climate Change

The results analysed revealed that 78.75% of the respondents have made adjustments to the farming practices in order to adapt to the changing climate in Ojo. Most of the respondents have had no formal education beyond the primary level, which may have been the reason why some of them do not know if they implement adaptation techniques or not. The respondents practice mulching and cover cropping in order to protect the soil and crops from erosion and evaporation/evapotranspiration brought about by excessive rainfall and increased temperature. Mixed cropping is practiced by the respondents as a strategy to reduce the risk of crop failure caused by environmental stress, increase soil fertility to improve crop yield and supress weeds.

During periods of excessive rainfall, many of the farmlands are waterlogged due to flooding; this compels the farmers to move their activities to higher grounds (areas with higher altitude) in order to reduce the risk of having their farms destroyed by flooding and erosion. In order to boost crop yield, the respondents apply manure (animal dung, compost) and chemical fertilizers such as Nitrogen fertilizer. Herbicides and pesticides are applied to combat the incidence of weeds and pests on the farmlands.

Mitigation Strategies Adopted by the Farmers to Abate the Impact of Climate Change

The results showed that most of the respondents make use of local technologies and crude implements, therefore they do not engage in advanced farming practices such as greenhouse farming. However, smart water management is a go-to strategy in order to avoid water shortage. Also, most of the respondents plant more densely in order to cushion the resultant negative impact of climate change on crop yield.

Furthermore, the respondents use more Nitrogen in order to boost soil fertility and crop yield. Also, it was revealed that the respondents raise their farm beds in order to mitigate the effects of flooding and erosion. The respondents affirmed that they engage in different means of livelihood, alongside farming in order to their vulnerability to climate change income losses. The results also revealed that the respondents sell their farm produce themselves right from the farm and even in market places. The time series for the annual maximum temperature of the study area is presented in figure 4 below. The result of the trend analysis for the annual mean maximum temperature pattern of Ojo showed that there is a positive trend, indicating steady rise in the annual mean maximum temperature between 1991 and 2021.

Recommendations

Based on the findings of this research, the following recommendations have been made:

1. Crop yield data recorded should be specific to farming communities within Lagos state instead of having a generalised record of the entire state.
2. Enlightenment programmes for the farmers to be aware of the incidence of climate change and it impacts on their farming activities.
3. Farmers should have proper insight and knowledge on sustainable farming practices to ensure optimum crop yield and production while combating the impact of climate change.
4. Provision of grants to farmers to assist them in their farming activities.
5. Creation of farmers' markets to help the farmers generate more income.

REFERENCES

Adebayo. A. A. (2011). Climatic Change Impact on Education. Vunoklang Multidisciplinary Journal
of Science and Technology Education. 1(1):6-11.
Adedeji, Oludare, H. & Ademuluyi, I.A. (2009). Urban Agriculture and Urban Land Use Planning:
A Need for a Synthesis in Metropolitan Lagos, Nigeria. Journal of Geography and Regional Planning. Vol. 2(3). Pp. 943-050. http://www.academicjournals.org./JGRP. ISSN 2070-1845
Ayoade, J.O. (2005). Introduction to Agro-Climatology (2nd Edition). Ibadan University Press Plc.
Farauta, K. & Apagu, V. V. (2011). Impact of Climate Change on the Teaching and Learning of
Agriculture in Secondary School of Adamawa state, Nigeria. Vunoklang Disciplinary Journal of science and Technology Education. 1(1): 27-31.
FAO, (2008). Food and Agricultural Organization of the United Nations. Climate Change and Food
Security: A Frame Work Document. 107pp.
Intergovernmental Panel on Climate Change (IPCC) (2001). Climate change 2001: Impacts, Adaption and Vulnerability. GRID Arendal.
Intergovernmental Panel on Climate Change (IPCC). (2007): The Physical Science. Contribution of
Work Group 1 to the Fourth Assessment Report of IPCC. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA
Kareem et al. (2012). A Review of Urban Agriculture as a Tool for Building Food Security in Nigeria:
Challenges and Policy Options. Journal of Sustainable Development in Africa. Vol. 14. No. 3. ISSN:1520-5509. Clarion University of Pennsylvania, Clarion, Pennsylvania
Odewumi, S.G., Awoyemi, O.K., Iwara, A.I. & Ogundele, F.O. (2013). Farmer's Perception on the
Effects of Climate Change and Variation on Urban Agriculture in Ibadan Metropolis, South-Western Nigeria. Academic Journal of Geography and Regional Planning. 6(6):209-217. DOI: 10.5897/JGRP2013.0370. Retrieved from http://www.academicjournals.org/JGRP
Odjugo, P.A.O. (2010). General Overview of Climate Change Impacts in Nigeria. Journal of Human
Ecology. 29(1):47-55. DOI: 10.1080/09709274.2010.11906248
Okon, E.M. et al. (2021). Systematic Review of Climate Change Impact Research in Nigeria: Implications for Sustainable Development. https://doi.org/10.1016/j.heliyon.2021.e07941
Scheffers. B.R. et al. (2016). The Broad Footprint of Climate Change from Genes to Biomes to

People. Science. 354:6373
Yaro, M.A. (2010). Environmental Change and Urban Agriculture: Implications for Food Security in
Calabar, Nigeria. Published Abstract in Dissertation Initiative for the Advancement of Climate Change Research. Department of Geography and Regional Planning, University of Calabar, Nigeria. P. 325
https://www.climate.nasa.gov/resources/global.warming.vs.climate.change
https://www.education.nationalgeographic.org/resource/la-nina
https://www.epa.gov/climatechange
https://mepb.lagosstate.gov.ng
https://www.toxipedia.net
https://veggieconcept.ng/greenhousefarming.in.nigeria
https://www.un.org/en/global-issues/climate-change

FONKSİYONEL GIDALAR: SAĞLIK VE EKONOMİK BÜYÜME ANAHTARI

FUNCTIONAL FOODS: THE KEY TO HEALTH AND ECONOMIC GROWTH

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ABSTRACT

Functional foods are foods that provide health benefits beyond basic nutrition. These foods, which contain bioactive compounds such as antioxidants, probiotics, and omega-3 fatty acids, play a crucial role in disease prevention and overall health improvement. Examples include polyphenols-enriched olive oil and vitamin-enriched beverages. As consumer awareness grows, there is a rising global demand for functional foods, driven by a shift towards preventive healthcare. Recent technological advancements have greatly improved the production of functional foods. Techniques such as microencapsulation, fermentation, and nanotechnology enhance the stability and bioavailability of bioactive compounds. For example, probiotics can now survive harsh conditions in the digestive system due to protective coatings, while nanoemulsions improve the absorption of fat-soluble vitamins. These innovations increase product quality, extend shelf life, and meet the evolving needs of both consumers and the food industry. Moreover, functional foods offer solutions to global challenges such as malnutrition and chronic diseases. Fortified cereals and "golden rice" are examples of products developed to address micronutrient deficiencies, particularly in underserved populations. Economically, the functional food sector fosters innovation and market diversification, providing new opportunities for local and international markets. In Turkey, functional foods derived from regional ingredients like carob and black cumin seeds have gained international recognition. In conclusion, functional foods hold significant potential for improving health and stimulating economic growth. However, challenges such as regulatory standards, cost-effective production, and consumer education must be addressed to unlock their full potential.
KEYWORDS: Functional foods; Fortified foods; Malnutrition.

ÖZET

Fonksiyonel gıdalar, temel beslenmenin ötesinde sağlık faydaları sunan gıdalar olarak tanımlanır ve hem sağlık hem de tarım sektörlerinde önemli bir segment haline gelmiştir. Antioksidanlar, probiyotikler veya omega-3 yağ asitleri gibi biyoaktif bileşenler içeren bu ürünlerin, hastalıkların önlenmesine ve genel refaha katkıda bulunduğu bilinmektedir. Polifenoller açısından zengin zeytinyağından vitaminle zenginleştirilmiş içeceklere kadar, fonksiyonel gıdalara olan küresel talep, tüketici bilinci ve koruyucu sağlık hizmetlerine yönelimle artmaktadır. Son yıllarda teknolojik yenilikler, fonksiyonel gıda üretimini dönüştürmüştür. Mikrokapsülleme, fermentasyon ve nanoteknoloji gibi yöntemler, biyoaktif bileşenlerin stabilitesini ve biyoyararlanımını artırarak fonksiyonel gıdaları daha etkili ve pazarlanabilir hale getirmiştir. Örneğin, koruyucu kaplamalarla kapsüllenen probiyotikler sindirim sisteminin zorlu koşullarına dayanabilirken, nanoemülsiyonlar yağda çözünen vitaminlerin emilimini iyileştirmektedir. Bu yenilikler, yalnızca daha yüksek ürün kalitesini sağlamakla kalmaz, aynı zamanda raf ömrünü uzatarak hem tüketici hem de gıda endüstrisinin beklentilerini karşılar. Bunun yanı sıra, fonksiyonel gıdalar yetersiz beslenme ve kronik hastalıklar gibi toplumsal zorlukların çözümünde bir araç olarak görülmektedir. Güçlendirilmiş tahıllar ve "altın pirinç" gibi ürünler, dezavantajlı topluluklarda mikro besin eksikliklerini gidermek amacıyla geliştirilmiştir. Ekonomik açıdan ise bu sektör, yerel ve uluslararası pazarlara yenilik yapma ve ürün çeşitlendirme fırsatları sunmaktadır. Örneğin Türkiye'de keçiboynuzu ve çörek otu gibi bölgesel ürünlerden türetilen fonksiyonel gıdalar, dünya çapında tanınmaktadır. Sonuç olarak, fonksiyonel gıdalar hem sağlık iyileştirmede hem de ekonomik büyümede büyük bir potansiyele sahiptir. Ancak, düzenleyici standartlar, maliyet etkin üretim ve tüketici eğitimi gibi konular kritik öneme sahiptir. Devam eden araştırma ve yeniliklerle, fonksiyonel gıdalar modern beslenme ve tarımı yeniden tanımlamaya adaydır.

Anahtar Kelimeler: Fonksiyonel gıdalar; Güçlendirilmiş gıdalar

GİRİŞ

Fonksiyonel gıdalar, yalnızca temel beslenme ihtiyaçlarını karşılamakla kalmayıp, aynı zamanda insan sağlığına ek faydalar sunan besinlerdir. Bu ürünler, içeriklerindeki biyoaktif bileşenler sayesinde sağlık üzerinde olumlu etkiler yaratarak hem sağlık hem de ekonomi açısından giderek daha önemli bir yer edinmiştir (Haug et al., 2019).

Fonksiyonel gıda kavramı, ilk kez 1980'lerde Japonya'da tanımlanmış ve zamanla küresel ölçekte kabul görmüştür (Kaur & Kapoor, 2001). Antioksidanlar, probiyotikler, omega-3 yağ asitleri ve vitaminler gibi zenginleştirilmiş içeriklere sahip fonksiyonel gıdaların insan sağlığına sunduğu yararlar bilimsel olarak kanıtlanmıştır (Micha et al., 2017)

Amerika Beslenme ve Diyetetik Akademisi, fonksiyonel besinleri üç ana gruba ayırmaktadır:

Doğal Biyoaktif Bileşenler İçeren Geleneksel Besinler

Bu grup, doğal olarak biyoaktif bileşikler içeren gıdaları kapsar. Örneğin, portakal suyundaki antioksidan vitaminler, soya bazlı ürünlerdeki izoflavonlar ve yoğurtta bulunan probiyotikler bu kategoriye dahildir (Crowe & Francis, 2013).

Biyoaktif Bileşenlerle Zenginleştirilmiş Modifiye Besinler

İçeriklerine omega-3 gibi biyoaktif bileşiklerin eklenmesiyle modifiye edilen ürünler bu grupta yer alır. Örneğin, omega-3 ile zenginleştirilmiş margarin ya da yumurtalar buna örnek gösterilebilir.

Sentezlenmiş Fonksiyonel Gıdalar

Bu kategori, prebiyotik etkiler sağlayan oligosakkaritler ya da dirençli nişasta gibi sindirilemeyen karbonhidratlardan oluşan gıdaları içerir. Bu tür bileşenler, özellikle sindirim sistemi sağlığını desteklemek amacıyla kullanılmaktadır (Crowe & Francis, 2013). Fonksiyonel gıdalar, günümüzde popüler bir kavram olsa da kökleri geçmişe dayanır. Tarih boyunca insanlar, belirli besinlerin şifa verici özelliklere sahip olduğuna inanmıştır. Modern dünyada ise, artan sağlık bilinci, hastalıkları önleyici yaklaşımlara duyulan ilgi ve bilimsel araştırmaların bu gıdaların faydalarını desteklemesi, fonksiyonel gıdalara olan talebi büyük ölçüde artırmıştır. Bu inceleme yazısı, fonksiyonel gıdaların sağlık üzerindeki etkilerini, gelişen teknolojilerle yenilikçi üretim yöntemlerini ve bu ürünlerin ekonomik büyümeye olan katkılarını ele almayı hedeflemektedir.

FONKSİYONEL GIDALARIN SAĞLIK ÜZERİNDEKİ ETKİLERİ

Fonksiyonel gıdalar, içerdikleri biyolojik olarak aktif bileşikler sayesinde sağlık üzerinde birçok olumlu etkide bulunabilir. Bu gıdalar, vücutta çeşitli biyolojik süreçleri düzenleyerek hastalıkların önlenmesine ve sağlığın desteklenmesine katkıda bulunur (Mann 2018).Antioksidanlar, probiyotikler, omega-3 yağ asitleri ve polifenoller gibi bileşenler, bu gıdaların sağlığa fayda sağlayan en önemli unsurları arasında yer alır. Araştırmalar, özellikle kişiselleştirilmiş beslenme stratejilerinde fonksiyonel gıdaların rolünün giderek arttığını ortaya koymaktadır.

Antioksidanlar ve Sağlık Üzerindeki Rolü

Antioksidanlar, serbest radikalleri etkisiz hale getiren ve hücresel hasarı önleyen bileşiklerdir (Baghdasaryan & Martirosyan, 2024a) Oksidatif stresin yol açtığı hücresel hasar, kanser, kalp hastalıkları ve yaşlanma gibi birçok sağlık sorununun temel nedenlerinden biridir (Shahidi & Ambigaipalan, 2015). Zeytinyağı gibi antioksidan açısından zengin gıdalar, bu bileşiklerin etkinliğini artırarak kalp-damar sağlığını destekler. Antioksidanlar, bireysel sağlığı iyileştirmenin yanı sıra toplum genelindeki hastalık yükünü de azaltma potansiyeline sahiptir.

Probiyotikler, Prebiyotikler ve Sindirim Sağlığı

Probiyotikler, bağırsak mikroflorasını düzenleyen ve sindirim sistemi üzerinde olumlu etkiler gösteren canlı mikroorganizmalardır (Sanders et al., 2018). Fermente gıdalarda bulunan bu mikroorganizmalar, bağırsak sağlığını iyileştirerek sindirim problemlerini azaltır ve bağışıklık sistemini güçlendirir. Patojen mikroorganizmaların çoğalmasını engelleyen probiyotikler, aynı zamanda vücut sağlığını genel olarak destekler. Lactobacillus ve Bifidobacterium gibi probiyotik türlerinin mide asidine ve safra tuzlarına dayanıklılığı, bağırsakta faydalı etkiler göstermelerini sağlar. Ayrıca, bu bakterilerin laktik asit ve diğer antimikrobiyal bileşikler üreterek sindirime katkı sunduğu bilinmektedir (Sanders et al., 2018). Probiyotiklerin fonksiyonel gıdalara eklenmesi, sindirim sistemi sağlığını geliştiren önemli bir adım olmuştur (Gänzle, 2020). Gelişmiş mikrokapsülleme teknolojileri sayesinde probiyotiklerin bağırsakta daha uzun süre etkinliğini koruması sağlanmaktadır (Corona-Hernandez et al., 2013).

Prebiyotikler ise sindirilemeyen karbonhidratlardan oluşur ve probiyotiklerin büyümesi için uygun bir ortam sağlar. Örneğin, inulin ve fruktooligosakkaritler prebiyotik özellik taşıyan bileşiklerdir. Bu bileşenler bağırsakta fermente edilerek kısa zincirli yağ asitleri üretir ve bağırsak pH'sını düşürerek faydalı bakterilerin gelişimi için elverişli bir ortam oluşturur. Prebiyotikler ayrıca mineral emilimini artırma ve kolesterol seviyelerini düşürme gibi ek sağlık faydaları sunar.

Sinbiyotikler ise probiyotikler ile prebiyotiklerin kombinasyonundan oluşur ve bağırsak sağlığını daha etkin bir şekilde destekleyebilir. Bu sinerjik yapı, bağırsak dengesizliğiyle ilişkili sağlık problemlerinde olumlu etkiler gösterebilir (Sánchez et al., 2012).

Omega-3 Yağ Asitlerinin Sağlıktaki Önemi

Omega-3 yağ asitleri, iltihaplanmayı azaltıcı etkileriyle tanınan ve kalp hastalıklarından depresyona kadar birçok kronik rahatsızlığın önlenmesinde önemli rol oynayan temel yağ asitleridir (Li et al., 2022a). Bu yağ asitleri genellikle balık yağı gibi deniz ürünlerinden veya keten tohumu, ceviz gibi bitkisel kaynaklardan elde edilir ve fonksiyonel gıda ürünlerinde sıklıkla kullanılır (Zimmermann & Qaim, 2004) Omega-3 yağ asitleri, kalp-damar hastalıklarının riskini azaltmakla kalmaz, aynı zamanda beynin bilişsel işlevlerini destekler ve nörolojik sağlık üzerinde olumlu etkiler sağlar (McNamara & Almeida, 2019).

Omega-3 yağ asitlerinin etkisini artırmak için kullanılan biyoteknolojik yöntemler, bu besin bileşiklerinin vücutta daha iyi emilmesine ve kullanılmasına olanak tanır. Araştırmalar, omega-3 yağ asitlerinin, romatoid artrit ve sedef hastalığı gibi kronik enflamatuar rahatsızlıkların belirtilerini hafiflettiğini ve bu durumlarda sıklıkla kullanılan antienflamatuar ilaçların kullanımını azaltabileceğini göstermektedir. Alzheimer hastalığı ile ilgili yapılan çalışmalar, omega-3 tüketiminin bu hastalığın görülme sıklığını düşürdüğünü ortaya

koymaktadır. Örneğin, haftada bir porsiyon balık tüketen bireylerin, nadiren balık tüketenlere kıyasla Alzheimer riskinin %60 oranında daha düşük olduğu saptanmıştır.
Psikiyatrik rahatsızlıklar üzerinde yapılan araştırmalar da dikkat çekicidir; omega-3 yağ asitlerinin depresyon, bipolar bozukluk, şizofreni ve demans gibi zihinsel sağlık sorunlarının tedavisinde destekleyici rol oynayabileceği öne sürülmektedir. Ayrıca, gebelik ve emzirme döneminde ortaya çıkan ruhsal problemlerin yönetiminde güvenle kullanılabilecek bir seçenek olarak değerlendirilmektedir (İRKİN & BATU, 2021).

Polifenollerin Fonksiyonel Gıdalardaki Rolü

Polifenoller, bitkisel kaynaklı besinlerde bulunan ve insan sağlığına çok yönlü faydalar sağlayan doğal bileşiklerdir. Bu maddeler, serbest radikalleri etkisiz hale getirerek oksidatif stresi azaltır ve hücre hasarını önlemeye yardımcı olur. Polifenoller, flavonoidler, fenolik asitler, lignanlar ve stilbenler gibi alt gruplara ayrılır ve çay, kahve, kakao, meyve ve sebzelerde bolca bulunur. Flavonoidlerin damar sağlığı üzerinde olumlu etkileri olduğu kanıtlanmıştır; bu bileşikler, kan damarlarını genişleterek dolaşımı iyileştirir ve enflamasyonu azaltır. Örneğin, yeşil çayda ve bitter çikolatada bulunan epikateşin gibi polifenoller, kan basıncını düşürmekte ve LDL kolesterol oksidasyonunu engelleyerek kalp-damar hastalıklarına karşı koruma sağlamaktadır (SALMAN & ÖZDEMİR, 2018). Polifenollerin düzenli tüketimi, yalnızca bireysel sağlığı desteklemekle kalmaz, aynı zamanda toplum genelinde kronik hastalıkların yaygınlığını azaltmaya da katkıda bulunabilir. Bu biyolojik moleküller, fonksiyonel gıdaların içeriğinde kritik bir bileşen olarak değerlendirilmekte ve sağlık bilinci artan bireyler için tercih edilen seçenekler arasında yer almaktadır.

TEKNOLOJİK YENİLİKLER VE FONKSİYONEL GIDA ÜRETİMİ

Son yıllarda, fonksiyonel gıdaların üretiminde teknolojik gelişmeler büyük bir dönüşüm yaratmıştır. Mikrokapsülleme, fermantasyon ve nanoteknoloji gibi yenilikçi yöntemler, bu gıdaların biyoyararlanımını artırarak etkinliklerini güçlendirmiştir (Sharma et al., 2024) Bu teknolojiler, biyoaktif bileşenlerin stabilitesini korumakla kalmayıp, aynı zamanda fonksiyonel ürünlerin raf ömrünü ve pazarlanabilirliğini de önemli ölçüde geliştirmektedir.

Mikrokapsülleme ve Fermantasyon Yöntemleri

Mikrokapsülleme, biyoaktif bileşenlerin koruyucu bir tabakayla çevrelenmesi tekniği olup, özellikle probiyotik içeren gıda ürünlerinde yaygın olarak kullanılmaktadır (Feng et al., 2020) Bu yöntem, probiyotiklerin mide asidi gibi zorlu koşullardan zarar görmesini önleyerek, bağırsakta maksimum fayda sağlamalarına olanak tanır (Pattnaik et al., 2021) Fermantasyon ise, fonksiyonel gıda üretiminde sıklıkla tercih edilen bir diğer etkili yöntemdir. Fermantasyon süreci, gıdalara probiyotik ve yararlı mikroorganizmalar kazandırarak, bağırsak sağlığını destekleyen ürünler oluşturur (Yadav et al., 2012) Bununla birlikte, fermantasyon, gıda bileşenlerinin daha kolay sindirilebilir hale gelmesini sağlayarak, sağlık yararlarını artırır.

Nanoteknoloji ve Nanoemülsiyonlar

Fonksiyonel gıdalarda nanoteknolojinin kullanımı, üretim süreçlerinde devrim yaratmıştır. Nanoemülsiyonlar, yağda çözünebilen biyoaktif bileşenlerin biyoyararlanımını artırmak için tercih edilen bir yöntemdir (Singh et al., 2019) Özellikle yağda çözünebilen vitaminler, bu teknoloji sayesinde vücut tarafından daha verimli bir şekilde emilir ve böylece fonksiyonel gıdaların etkinliği artar. Nanoemülsiyonların sağladığı avantajlar, fonksiyonel gıda ürünlerinin hem güvenilirliğini hem de sağlık üzerindeki olumlu etkilerini geliştirmektedir (Delshadi et al., 2020).

Yüksek Basınçlı İşleme (HPP)

Yüksek Basınçlı İşleme (HPP), gıda teknolojisinde modern bir yaklaşım olarak öne çıkmaktadır. Bu yöntem, biyoaktif bileşenlerin stabilitesini koruyarak mikrobiyal yükü azaltmakta ve gıdaların raf ömrünü uzatmaktadır. HPP süreci, 100-600 MPa arası yüksek hidrostatik basınç kullanılarak uygulanır ve genellikle düşük sıcaklıklarda gerçekleştirilir. Bu sayede, gıdaların besin değeri, dokusu, rengi ve tadı korunurken, mikroorganizmalar ve enzimler etkisiz hale getirilir. HPP'nin ısıya duyarlı bileşenler üzerindeki minimal etkisi, özellikle vitaminler, polifenoller, flavonoidler, omega-3 yağ asitleri ve probiyotikler gibi fonksiyonel bileşenlerin korunmasında önemli bir avantaj sağlar. Bu işlem, gıdaların fonksiyonel özelliklerini artırarak tüketiciye hem besin değeri yüksek hem de güvenli ürünler sunulmasını mümkün kılmaktadır (AYDIN et al., 2021).

FONKSİYONEL GIDALARIN EKONOMİK VE SOSYAL ETKİLERİ

Fonksiyonel gıdalar, yalnızca sağlık açısından sağladıkları yararlarla değil, aynı zamanda ekonomik büyümeye olan katkılarıyla da dikkat çekmektedir. Özellikle gelişmekte olan ülkelerde, bu gıdalar, yetersiz beslenme ve mikro besin eksikliklerini gidermek için etkili bir çözüm sunmaktadır (Pang et al., 2012) Yenilikçi ürünler ve çeşitlendirilmiş gıda seçenekleri, fonksiyonel gıda sektöründe ekonomik fırsatlar yaratmakta ve yerel üreticiler için yeni pazar olanakları sunmaktadır (Baghdasaryan & Martirosyan, 2024b) Tüketicilerin bu gıdalara olan talebindeki artış, gıda üretiminde araştırma-geliştirme (Ar-Ge) yatırımlarını teşvik ederek sektörde hızlı bir büyüme sağlamaktadır. Gelişmiş teknolojiler ve modern işleme yöntemleri, bu büyümeyi daha da hızlandırmakta ve sektörü küresel düzeyde ileri taşımaktadır.

Mikro Besin Eksikliklerinin Azaltılması

Fonksiyonel gıdalar, mikro besin eksikliklerinin giderilmesinde önemli bir role sahiptir. Güçlendirilmiş tahıl ürünleri ve genetik mühendislikle geliştirilmiş altın pirinç gibi gıdalar, dezavantajlı bölgelerdeki beslenme sorunlarının çözümüne katkıda bulunur. Bu tür gıdalar, temel mikro besinleri sağlayarak yetersiz beslenmeyi azaltmak için etkili bir araç sunar (Milner, 2002). Özellikle düşük gelirli topluluklarda, bu gıdalar toplum sağlığını iyileştirmek için ekonomik ve pratik bir çözüm sunar. Mikro besin eksiklikleri, özellikle gelişmekte olan ülkelerde ciddi bir halk sağlığı sorunudur ve büyüme geriliği, bağışıklık sisteminin zayıflaması ve bilişsel gelişimin bozulması gibi sorunlara yol açar. Bu eksiklikler genellikle A vitamini, demir, iyot ve çinko gibi temel mikro besinlerin eksik olduğu diyetlerden kaynaklanmaktadır. Fonksiyonel gıdalar, bu eksikliklerin giderilmesinde önemli bir araçtır; ya mikro besinlerle zenginleştirilirler ya da doğal olarak sağlık destekleyici biyoaktif bileşikler içerirler. Örneğin, iyotlu tuz ve demirle zenginleştirilmiş tahıllar, bu mikro besin eksikliklerini önlemek için yaygın olarak kullanılmaktadır. Benzer şekilde, beta-karoten üretecek şekilde genetiği değiştirilmiş altın pirinç, A vitamini eksikliğiyle mücadelede etkili bir çözüm olarak öne çıkmaktadır (Milner, 2002).

Ekonomik Katkılar ve Yeni Pazar Olanakları

Fonksiyonel gıdalar, yerel tarımsal ürünlerin ekonomik değerini artırarak ekonomik kalkınmayı destekler. Örneğin, Türkiye'de keçiboynuzu, çörek otu gibi geleneksel ürünlerden elde edilen fonksiyonel gıdalar, uluslararası pazarda ilgi görmekte ve bu ürünlerin ihracatı ülke ekonomisine katkı sağlamaktadır. Fonksiyonel gıda sektöründeki gelişmeler, yalnızca sağlık alanında değil, aynı zamanda tarım ve gıda endüstrisinde de yeni iş fırsatları yaratmaktadır (Gok, 2023) Fonksiyonel gıdaların ekonomik potansiyeli, sadece yerel düzeyde değil, küresel ölçekte de giderek büyümektedir. Sağlık bilincine sahip tüketicilerin artan ilgisi, sektöre yenilikçi ürünlerin kazandırılmasını teşvik ederken, yerel üreticilere uluslararası pazarlarda rekabet etme şansı sunmaktadır. Bu durum, fonksiyonel gıda endüstrisini hem ekonomik kalkınma hem de sağlık için stratejik bir sektör haline getirmektedir. (Monteiro et al., 2023)

SONUÇ

Fonksiyonel gıdalar, hem sağlık alanında sundukları yararlarla hem de ekonomik kalkınmaya katkılarıyla önemli bir potansiyele sahiptir. Antioksidanlar, probiyotikler, omega-3 yağ asitleri ve polifenoller gibi biyoaktif bileşenler, bu gıdaların sağlık üzerindeki olumlu etkilerini artırmaktadır. Gelişen teknolojiler, bu bileşenlerin biyoyararlanımını optimize ederek fonksiyonel gıdaların etkinliğini daha da güçlendirmektedir. Bunun yanı sıra, fonksiyonel gıdalar, mikro besin eksikliklerinin giderilmesinde etkili bir çözüm sunarken, yerel üreticiler için ekonomik fırsatlar da yaratmaktadır. Ancak bu sektör, düzenleyici standartların karmaşıklığı, üretim süreçlerinin maliyetliliği ve tüketici bilincinin yetersizliği gibi çeşitli zorluklarla karşı karşıyadır. Tüm bu engellere rağmen, fonksiyonel gıdalar gelecekte hem modern beslenme anlayışını hem de tarım uygulamalarını yeniden tanımlayarak küresel sağlık sorunlarının çözümünde anahtar bir rol oynayacaktır (Li et al., 2022b).

KAYNAKLAR

AYDIN, M., ARSLAN DANACIOĞLU, D., & TÜRKER, S. (2021). GIDA TEKNOLOJİSİNDE YENİLİKÇİ YAKLAŞIMLAR. Helal ve Etik Araştırmalar Dergisi, 3(1), 19–36. https://doi.org/10.51973/head.925628

Baghdasaryan, A., & Martirosyan, D. (2024a). Economic implications of functional foods. Functional Food Science - Online ISSN: 2767-3146, 4(6), 216–227. https://doi.org/10.31989/ffs.v4i6.1379

Baghdasaryan, A., & Martirosyan, D. (2024b). Economic implications of functional foods. Functional Food Science - Online ISSN: 2767-3146, 4(6), 216–227. https://doi.org/10.31989/ffs.v4i6.1379

Corona-Hernandez, R. I., Álvarez-Parrilla, E., Lizardi-Mendoza, J., Islas-Rubio, A. R., de la Rosa, Laura. A., & Wall-Medrano, A. (2013). Structural Stability and Viability of Microencapsulated Probiotic Bacteria: A Review. Comprehensive Reviews in Food Science and Food Safety, 12(6), 614–628. https://doi.org/10.1111/1541-4337.12030

Crowe, K. M., & Francis, C. (2013). Position of the Academy of Nutrition and Dietetics: Functional Foods. Journal of the Academy of Nutrition and Dietetics, 113(8), 1096–1103. https://doi.org/10.1016/J.JAND.2013.06.002

Delshadi, R., Bahrami, A., Tafti, A. G., Barba, F. J., & Williams, L. L. (2020). Micro and nano-encapsulation of vegetable and essential oils to develop functional food products with improved nutritional profiles. Trends in Food Science & Technology, 104, 72–83. https://doi.org/10.1016/j.tifs.2020.07.004

Feng, K., Huang, R. meng, Wu, R. qing, Wei, Y. shan, Zong, M. hua, Linhardt, R. J., & Wu, H. (2020). A novel route for double-layered encapsulation of probiotics with improved viability under adverse conditions. Food Chemistry, 310, 125977. https://doi.org/10.1016/J.FOODCHEM.2019.125977

Gänzle, M. G. (2020). Food fermentations for improved digestibility of plant foods – an essential ex situ digestion step in agricultural societies? Current Opinion in Food Science, 32, 124–132. https://doi.org/10.1016/J.COFS.2020.04.002

Gok, I. (2023). Functional Potential of Several Turkish Fermented Traditional Foods: Biotic Properties, Bioactive Compounds, and Health Benefits. Food Reviews International, 39(5), 2568–2593. https://doi.org/10.1080/87559129.2021.1962340

Haug, W. B., Drinkwater, E. J., Cicero, N. J., Barthell, J. A., & Chapman, D. W. (2019). The Impact of Dry-Land Sprint Start Training on the Short Track Speed Skating Start. Journal of

Strength and Conditioning Research, 33(2), 544–548. https://doi.org/10.1519/JSC.0000000000001892
İRKİN, R., & BATU, Z. (2021). SAĞLIK BİLİMLERİ FAKÜLTESİ ÖĞRENCİLERİNİN FONKSİYONEL BESİNLERE YÖNELİK TUTUMLARININ VE BAZI FONKSİYONEL BESİNLERİ TÜKETİM SIKLIKLARININ BELİRLENMESİ. Sağlık Bilimleri Dergisi, 30(2), 152–158. https://doi.org/10.34108/eujhs.870320
Kaur, C., & Kapoor, H. C. (2001). Antioxidants in fruits and vegetables – the millennium's health. International Journal of Food Science & Technology, 36(7), 703–725. https://doi.org/10.1111/j.1365-2621.2001.00513.x
Li, J.-J., Dou, K.-F., Zhou, Z.-G., Zhao, D., Ye, P., Zhao, J.-J., & Guo, L.-X. (2022a). Role of omega-3 fatty acids in the prevention and treatment of cardiovascular Diseases: A consensus statement from the Experts' Committee Of National Society Of Cardiometabolic Medicine. Frontiers in Pharmacology, 13. https://doi.org/10.3389/fphar.2022.1069992
Li, J.-J., Dou, K.-F., Zhou, Z.-G., Zhao, D., Ye, P., Zhao, J.-J., & Guo, L.-X. (2022b). Role of omega-3 fatty acids in the prevention and treatment of cardiovascular Diseases: A consensus statement from the Experts' Committee Of National Society Of Cardiometabolic Medicine. Frontiers in Pharmacology, 13. https://doi.org/10.3389/fphar.2022.1069992
Mann, N. J. (2018). A brief history of meat in the human diet and current health implications. Meat Science, 144, 169–179. https://doi.org/10.1016/J.MEATSCI.2018.06.008
McNamara, R. K., & Almeida, D. M. (2019). Omega-3 Polyunsaturated Fatty Acid Deficiency and Progressive Neuropathology in Psychiatric Disorders: A Review of Translational Evidence and Candidate Mechanisms. Harvard Review of Psychiatry, 27(2), 94–107. https://doi.org/10.1097/HRP.0000000000000199
Micha, R., Shulkin, M. L., Peñalvo, J. L., Khatibzadeh, S., Singh, G. M., Rao, M., Fahimi, S., Powles, J., & Mozaffarian, D. (2017). Etiologic effects and optimal intakes of foods and nutrients for risk of cardiovascular diseases and diabetes: Systematic reviews and meta-analyses from the Nutrition and Chronic Diseases Expert Group (NutriCoDE). PLOS ONE, 12(4), e0175149. https://doi.org/10.1371/journal.pone.0175149
Milner, J. A. (2002). Functional foods and health: a US perspective. British Journal of Nutrition, 88(S2), S152–S158. https://doi.org/10.1079/BJN2002680
Monteiro, S. S., Almeida, R. L., Santos, N. C., Pereira, E. M., Silva, A. P., Oliveira, H. M. L., & Pasquali, M. A. de B. (2023). New Functional Foods with Cactus Components: Sustainable Perspectives and Future Trends. Foods, 12(13), 2494. https://doi.org/10.3390/foods12132494
Pang, G., Xie, J., Chen, Q., & Hu, Z. (2012). How functional foods play critical roles in human health. Food Science and Human Wellness, 1(1), 26–60. https://doi.org/10.1016/j.fshw.2012.10.001
Pattnaik, M., Pandey, P., Martin, G. J. O., Mishra, H. N., & Ashokkumar, M. (2021). Innovative Technologies for Extraction and Microencapsulation of Bioactives from Plant-Based Food Waste and Their Applications in Functional Food Development. Foods, 10(2), 279. https://doi.org/10.3390/foods10020279
SALMAN, S., & ÖZDEMİR, F. (2018). Beyaz Çay: Üretimi, Bileşimi ve Sağlık Üzerine Etkileri. Akademik Gıda, 16(2), 218–223. https://doi.org/10.24323/akademik-gida.449867
Sánchez, B., Ruiz, L., Gueimonde, M., Ruas-Madiedo, P., & Margolles, A. (2012). Toward improving technological and functional properties of probiotics in foods. Trends in Food Science & Technology, 26(1), 56–63. https://doi.org/10.1016/J.TIFS.2012.02.002
Sanders, M. E., Benson, A., Lebeer, S., Merenstein, D. J., & Klaenhammer, T. R. (2018). Shared mechanisms among probiotic taxa: implications for general probiotic claims. Current Opinion in Biotechnology, 49, 207–216. https://doi.org/10.1016/J.COPBIO.2017.09.007

Shahidi, F., & Ambigaipalan, P. (2015). Phenolics and polyphenolics in foods, beverages and spices: Antioxidant activity and health effects – A review. Journal of Functional Foods, 18, 820–897. https://doi.org/10.1016/J.JFF.2015.06.018

Sharma, M., Vidhya C. S., Ojha, K., Yashwanth B. S., Singh, B., Gupta, S., & Pandey, S. K. (2024). The Role of Functional Foods and Nutraceuticals in Disease Prevention and Health Promotion. European Journal of Nutrition & Food Safety, 16(2), 61–83. https://doi.org/10.9734/ejnfs/2024/v16i21388

Singh, R., Mann, B., Sharma, R., & Singh, S. (2019). Application of Nanotechnology in Functional Foods. In Nanoscience for Sustainable Agriculture (pp. 547–579). Springer International Publishing. https://doi.org/10.1007/978-3-319-97852-9_21

Yadav, H., Jain, S., & Rastamanesh, R. (2012). Fermentation Technology in the Development of Functional Foods for Human Health: Where We Should Head. Fermentation Technology, 01(01). https://doi.org/10.4172/2167-7972.1000e102

Zimmermann, R., & Qaim, M. (2004). Potential health benefits of Golden Rice: a Philippine case study. Food Policy, 29(2), 147–168. https://doi.org/10.1016/J.FOODPOL.2004.03.001

1. Özgen Özkaya, Ş. (2021). Yaşam kalitesi ve fonksiyonel besinler. Fenerbahçe University Journal of Health Sciences, 1(1), 62-68.
2. Coşkun, T. (2005). Fonksiyonel besinlerin sağlığımız üzerine etkileri. Çocuk Sağlığı ve Hastalıkları Dergisi, 48(1), 69-84. https://cshd.org.tr/article/view/509
3. Almeida, D., et al. (2017). Economic opportunities in functional food markets. Journal of Food Science and Technology
4. Bates, L., et al. (2019). Fermentation and its role in the production of functional foods. Food Research International.
5. Binks, B. P., et al. (2019). Applications of nanotechnology in functional food. Journal of Agricultural and Food Chemistry.
6. Bourne, C., et al. (2020). Antioxidants and their impact on human health. Antioxidants.
7. Chou, L., et al. (2018). Microencapsulation techniques and their applications in functional food.
8. Feng, S., et al. (2019). Microencapsulation technology for probiotics.
9. Gänzle, M. G. (2015). Fermentation in functional foods. Food Research International.
10. Gedik, M. (2019). Export potential of functional foods in Turkey. Journal of International Food and Agricultur.
11. Haug, W. (2019). The role of functional foods in human health. Food Research International.
12. Hill, C., et al. (2014). The role of probiotics in human health. Nature Reviews Gastroenterology & Hepatology.
13. Kumar, P., & Sharma, S. (2020). Functional foods for sustainable development. Journal of Sustainable Agriculture.
14. Lu, X., et al. (2020). Nanoemulsion technology in functional food development. Food Chemistry.
15. Micha, R., et al. (2017). Global dietary intakes of functional foods.
16. Mann, J. (2014). Functional foods and their role in human health.
17. McNamara, R. (2017). Omega-3 fatty acids and brain health.
18. Müller, M., et al. (2018). Improving nutrition through functional foods.
19. Patil, V., et al. (2020). Enhancing probiotic stability via microencapsulation.
20. Sanders, M. E. (2016). Probiotics and prebiotics in human health. Nature Reviews Microbiology.

21. Shahidi, F., & Ambigaipalan, P. (2015). Antioxidant properties of food bioactive compounds.Comprehensive Reviews in Food Science.
22. Thompson, H., et al. (2015). Economic impact of functional foods. Food Polic.
23. Vasilenko, N., et al. (2019). Antioxidant capacity of olive oil. Food Chemistr.
24. Zhao, L., et al. (2021). Omega-3 fatty acids in cardiovascular disease prevention. Journal of Lipid Research.
25. Zimmermann, M. B., & Qaim, M. (2012). Golden rice: A micronutrient intervention. Food Policy.
26. Patel, R., et al. (2020). Probiyotikler ve sindirim sağlığı. Nutrition and Gut Health Journal.
27. Lankaputhra, W., & Shah, N. (2019). Functional properties of probiotics. International Journal of Probiotic Researc.
28. Dave, R., & Shah, N. (2019). Prebiotic effects on gut microbiota. Gut Microbiota and Health Reports.
29. Khan, N., & Mukhtar, H. (2006). Sağlığın teşviki ve geliştirilmesi için çay polifenolleri.
30. Butz, P., & Tauscher, B. (2002). Ortaya çıkan teknolojiler: kimyasal yönler. Uluslararası Gıda Araştırmaları, 35(2-10). https://doi.org/10.1016/S0963-9969(01)00194-4
31. Van der Heijden, R., Koutsou, A., & Schou, A. (2020). Fonksiyonel gıdalar ve ekonomik fırsatlar. EU. https://europa.eu/

EFFECT OF FOLIAR CALCIUM AMPLIFIERS ON THE CHEMICAL COMPOSITION OF SWEET PEPPER

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ABSTRACT
This research aimed to determine the impact of two amplifiers of soil properties (Zeofit forte and Zeofit plus) that are completely ecological and of natural origin. They can also be successfully used for plant foliar nutrition due to the presence of a high content of calcium and magnesium. It stimulates the flowering of plants and increases immunity and yield.
In the Strumica region, North Macedonia, a field crop experiment was set in the protected spaces of 300 m^2. The material for the work was the sweet pepper variety 'Bela dolga', recognized for their high yield and fruit quality. The variants in the experiment were:
1. Control (untreated); 2. Zeofit forte (SiO_2 15%, CaO 35%, MgO 7%, P_2O_5 0.04%, K_2O 0.63%, MnO 0.043%, Fe_2O_3 4.70%) – 3 g/L; 3. Zeofit forte (SiO_2 15%, CaO 35%, MgO 7%, P_2O_5 0.04%, K_2O 0.63%, MnO 0.043%, Fe_2O_3 4.70%) – 5 g/L; 4. Zeofit plus (SiO_2 25%, CaO 21%; MgO 13%; K_2O 1.1%; Fe_2O_3 2.0%) – 3 g/L; 5. Zeofit plus (SiO_2 25%, CaO 21%; MgO 13%; K 1.1%; Fe_2O_3 2.0%) – 5 g/L.
Each variant was treated with tasted foliar fertilizer in concentrations of 3 g/L and 5 g/L solution. Foliar fertilization had a positive influence on the content of the examined parameters in pepper fruits. In all variants, the analyzed parameters gave better results compared to the untreated control variant. The highest content ($p<0.05$) of dry matter (13.50%), ash (1.15%), and vitamin C (127 mg/100g) were determined in the pepper fruits from variant 2. The highest ($p<0.05$) average content of nitrogen (1.41%), phosphorus (0.65%), potassium (2.20%), and calcium (1.53%) was determined in the pepper fruits from the variant 2, too. The highest ($p<0.05$) content of magnesium (0.49%) was determined in the pepper fruits from the variant 4.

Keywords: foliar nutrition; sweet pepper; amplifiers; organic production.

INTRODUCTION
In modern agricultural production, high and stable yields as well as the quality of garden fruits depend on the biological properties of the variety, favorable climatic and soil conditions, but also on the correct and controlled nutrition of the plants. The use of fertilizers (mineral or organic) improves the physical, chemical, and biological properties of the soil. Fertilizers contain many nutrients that have an impact on a large number of physiological-biochemical processes, the metabolism of substances, oxidation-reduction processes,

photosynthesis, as well as respiration. These processes, affect the overall growth and development of the vegetative and generative organs of the plants, as well as obtaining the larger quantity and better quality fruits (Stojanova, 2022).

With fertilizing, nutrients are introduced into the soil in order to maintain an optimal amount of the available forms of nutrition for garden plants. Nutrients can also be added and taken up through the leaf mass, ensuring faster transport to all parts of the plant. Quality and well-balanced nutrition is one of the basic prerequisites for achieving high and stable yields in garden plants, while achieving good quality and profitability in production (Stojanova, 2022).

Insufficient fertilization results in a lower yield, but also poorer quality, while excessive fertilization leads to unnecessary economic costs and represents potential environmental pollution through the luxury of providing the plant with nutrients while achieving a lower quality yield (Stojanova, 2018).

Vegetables are important sources of carbohydrates, proteins, vitamins, and minerals. Sweet pepper (Capsicum annum L.) which belongs to the Solanaceae family, is known as a vegetable and consumed both as fresh and dehydrated spices. Pepper is a good source of vitamins A, C, E, B1, and B2, potassium, phosphorus, and calcium. Moreover, it is one of the valuable medicinal plants in pharmaceutical industries because of its high amounts of antioxidants, capsaicin, and capsantinas main active substances (Aminifard and Bayat, 2018).

Generally, Solanaceous vegetables require large quantities of macronutrients such as nitrogen (N), phosphorus (P) and potassium (K), Calcium (Ca), magnesium (Mg), and sulfur (S) for better growth, fruit and seed yield. These nutrients have specialized functions and should be supplied to the plant at the right time and in the right quantity. Pepper like other crops, produces well when it is adequately supplied with the essential nutrients through fertilization (Egbe et al., 2023).

Peppers are intensive vegetable crops with a large vegetative mass and high yields with which they produce different amounts of nutrients. These crops are grown outdoors and indoors, and the fertilizing regime differs in both ways, due to significant differences in terms of yield. For successful production, the main thing in both methods is the application of organic fertilizers in combination with mineral fertilizers (Stojanova, 2022).

Sweet pepper is a warm-season crop that is grown in many parts of the world, and it is valued for its culinary and nutritional qualities. There are numerous varieties of sweet peppers, with different colors, shapes, sizes, and flavors (Stoleru et al., 2023).

It is a vegetable with low energy value and low index and glycemic load. It is one of the vegetables characterized by high health-promoting compounds, carotenoids (especially beta-carotene,-carotene, and lutein); phenolic compounds. It is also a good source of folic acid, minerals (potassium, manganese, iron, and magnesium), and dietary fiber (Ropelewska et al., 2023). Sweet peppers are rich in vitamins A and C, potassium, phosphorus and iron, folate, and fiber as well as other minerals and antioxidants. They also contain bioactive compounds that have been associated with various health benefits (Caruso et al., 2018).

Nowadays, the best-integrated fertilization management which includes inorganic, organic, and bio-fertilization; plays crucial roles in this respect. Therefore, the absence of a fertilization program for pepper production under greenhouse conditions remains a limiting factor and needs more research to develop an appropriate fertilization program that satisfies the requirements to achieve the highest yield with the best quality of pepper plants grown in plastic house environments (Omar et al., 2018).

The aim of this research was to determine the influence of soil and foliar fertilization on the chemical composition of fruit peppers grown in protected spaces in the Strumica region, North Macedonia.

MATERIALS AND METHODS

In the Strumica region, North Macedonia, the field crop experiment was set in the protected spaces of 300 m^2. The experiment was set in 18 rows. Five variants and three repetitions were included. The seedling was planted in rows with row by row distance of 60 cm, and between plants, 40 cm. The experiment was set in conditions of irrigation. During the vegetation period of peppers, basic agro-technical measures were applied. Before the planting took place, soil fertilization with mineral fertilizer NPK 6-10-30 + 2% MgO in the amount of 12 kg in the hall with an area of 300 m^2 was applied. The variants in the experiment were:

1. Control (untreated);
2. Zeofit forte (SiO_2 15%, CaO 35%, MgO 7%, P_2O_5 0.04%, K_2O 0.63%, MnO 0.043%, Fe_2O_3 4.70%) – 3 g/L;
3. Zeofit forte (SiO_2 15%, CaO 35%, MgO 7%, P_2O_5 0.04%, K_2O 0.63%, MnO 0.043%, Fe_2O_3 4.70%) – 5 g/L;
4. Zeofit plus (SiO_2 25%, CaO 21%; MgO 13%; K_2O 1.1%; Fe_2O_3 2.0%) – 3 g/L;
5. Zeofit plus (SiO_2 25%, CaO 21%; MgO 13%; K 1.1%; Fe_2O_3 2.0%) – 5 g/L.

In each variant and repetition, 50 plants were involved, and for the entire experiment, 750 plants were involved per cultivar. Each variant was treated with tasted foliar fertilizer in concentrations of 3 g/L and 5 g/L solution. The application of fertilizers was done with a hand sprayer, by spraying the leaves.

Calcium growth enhancers were applied foliarly three times during the vegetation. The first treatment was carried out immediately after fertilization and the formation of the first fruits, and then two more times at a distance of 7 days. Zeofit forte and Zeofit plus are amplifiers of soil properties that have a natural origin and are completely ecological. They can also be successfully used for plant foliar nutrition due to the presence of a high content of calcium and magnesium. It stimulates the flowering of plants and increases immunity and yield.

The material for the work was the sweet pepper variety ‘Bela dolga’ which is recognized for its high yield, and fruit quality.

‘Bela dolga’ is a medium-early variety. It is tall, compact, and with hanging fruits. The fruit is long, milky-white when technologically ripe, and red when botanically ripe. It is suitable for any type of consumption. It gives very good results when grown in favorable conditions (Lazič et al., 2001).

The harvest was done when the peppers were 18 cm long, separated into varieties, variants, and repetitions. During the vegetation, five harvests were done. Fruits were collected and measured for their size-type classification.

To determine soil fertility, soil samples were taken before setting up the experiment at a depth of 0–20 cm and 20–40 cm (Stojanova, 2019). In laboratory conditions, the soil samples were brought to an air-dry state and prepared for agrochemical analysis in which the following parameters were determined:

- pH value – determined potentiometric with pH-meter (Stojanova, 2017);
- content of easily available nitrogen – determined by the method of Tjurin and Kononova (Stojanova, 2017);
- content of easily available phosphorus – determined by AL method and reading of spectrophotometer (Stojanova, 2017);
- content of easily available potassium – determined by AL method and reading of spectrophotometer (Stojanova, 2017);
- content of humus – determined by the permanganese method of Kotzman (Stojanova, 2017);
- content of carbonates – determined with Schaiblerov Calcimeter (Stojanova, 2017);

During the last harvest, fruits were taken separately by variants The samples for chemical analysis were prepared from 10 pepper fruits from each repetition.
Some of the analyses were performed in a fresh form and some in an air-dried form. For this purpose, the fruits were finely chopped and dried to an air-dry state at a temperature of 60 °C, and then ground in an electric mill to make a powder (Stojanova, 2019).
The following parameters were performed:

- content of total moisture – by determining the content of free water (by drying the material at room temperature) and hygroscopic moisture by drying the material at a temperature of 105 °C to a constant weight (Sarić et al., 1989; Stojanova, 2017);
- total dry matter – determined by calculating when the percentage of total moisture is subtracted from 100 (Sarić et al., 1989; Stojanova, 2017);
- content of mineral substances (ash) – determined by burning the material in a muffle furnace at a temperature of 500 °C (Stojanova, 2017);
- content of organic matter – determined by calculation when the percentage of ash is subtracted from 100 (Stojanova, 2017);
- vitamin C content – determined by the Muri method (Stojanova, 2017);
- content of nitrogen (N) – determined using the Kjeldal method (Stojanova, 2017);
- content of phosphorus (P_2O_5) – determined using atomic emission spectroscopy with inductively coupled plasma (ICP - AEC) (Stojanova, 2017);
- content of potassium (K_2O) – determined by incineration of the material with concentrated H_2SO_4 and flame photometer (Stojanova, 2017);
- content of calcium (Ca), magnesium (Mg), (Sarić et al., 1989).

The obtained results were statistically processed using the software package SPSS 20. To determine the statistically significant differences of the obtained values ANOVA test post hoc Tukey's test ($p<0.05$) was performed.

RESULTS AND DISCUSSION

For the achievement of high and quality yields, the pepper requires favorable soil and climatic conditions. Pepper that is grown in protected spaces has a greater need for nutrients, and in particular requires a greater amount of potassium (Lazić et al 2001, Salama and Zake 2000). Sweet pepper (Capsicum annuum L.) is a plant with a long growing period and requires good quality soil or substrate and adequate light, temperature, and water (Sobczak et al., 2020). In a short time, the pepper creates a massive vegetative mass, but there is a less developed root system. Therefore, it is necessary to grow on good fertile soils (Shafeek et al. 2014). Light is an important environmental factor with a significant role in plant life processes. Plants use light as a source of energy for photosynthesis as well as for growth and development processes. There is a strong correlation between light availability and plant productivity. Insufficient light supplied to the plants can reduce the size and quality of the yield (Liu et al., 2011).
Deep, lighter soils, rich in organic matter, and warm structural soils with good water and air capacity are favorable for growing peppers. Good soil permeability is very important for peppers because they are not tolerant of water stagnation. Slightly acidic to neutral soil with a pH value of 6–7 is favorable for pepper (Stojanova, 2022).

Table 1. Agrochemical soil analysis

No.	Plot	Depth (cm)	pH		Available form (mg/100 g soil)			$CaCO_3$ (%)
			H_2O	KCl	N	P_2O_5	K_2O	
1	Pepper 1st part	0-20	7.35	6.65	9.55	18.30	21.20	/
2		20-40	7.40	6.64	10.20	14.20	17.00	/
Average			**7.37**	**6.64**	**9.87**	**16.25**	**19.10**	**/**
3	Pepper 2nd part	0-20	7.43	6.70	8.90	15.25	23.10	/
4		20-40	7.40	6.60	9.70	17.00	20.50	/
Average			**7.41**	**6.65**	**9.30**	**16.12**	**21.80**	**/**

From the data in Table 1, it can be concluded that the soil on which the experiment was set, has a neutral pH, good fertility with nitrogen and potassium, and medium fertility with available phosphorus. There is no presence of carbonates.
From the data in Table 2, it can be concluded that foliar fertilization had a positive influence ($p<0.05$) on the content of the examined parameters in pepper fruits. In all variants, the analyzed parameters gave better results compared to the untreated control variant.
The highest ($p<0.05$) content of dry matter (13.50%), ash (1.15%), and vitamin C (127 mg/100g) were determined in the pepper fruits in variant 2.

Table 2. Chemical content of peppers fruits of variety 'Bela dolga'

Variant	n	Total moisture (%)	Total dry matter (%)	Content of organic matter (%)	Content of mineral matter (%)	Vitamin C (mg/100g)
		$\bar{x} \pm SD$	$\bar{x} \pm SD$	$\bar{x} \pm SD$	$\bar{x} \pm SD$	$\bar{x} \pm SD$
1	30	89.75 ± 0.01^a	10.25 ± 0.10^a	99.25 ± 0.08^a	0.75 ± 0.09^a	110.40 ± 0.06^a
2	30	86.50 ± 0.09^b	13.50 ± 0.08^b	98.85 ± 0.05^b	1.15 ± 0.02^b	127.00 ± 0.06^b
3	30	88.10 ± 0.05^c	11.90 ± 0.03^c	99.05 ± 0.06^c	0.95 ± 0.02^c	119.67 ± 0.11^c
4	30	88.65 ± 0.07^c	11.35 ± 0.08^c	99.11 ± 0.05^c	0.89 ± 0.06^d	120.00 ± 0.07^d
5	30	89.70 ± 0.08^a	10.30 ± 0.10^a	99.20 ± 0.03^a	0.80 ± 0.07^e	122.25 ± 0.03^e

$^{a, b, c, d}$ – values for the same parameter of the different variants marked with different letters have statistically significant differences ($p<0.05$), ANOVA, post hoc Tukey's test.

The content of total moisture is in correlation with the dry matter content and it was the highest ($p<0.05$) in the control variant (89.75%). The content of organic matter (99.25%) was highest in the control variant.
According to the amount of vitamin C (ascorbic acid) contained in its fruits, sweet pepper surpasses all vegetables. Its fruits contain from 50 to 270 mg of vitamin C per 100 g of dry weight at technical maturity, and from 170 to 450 mg at biological maturity. Sweet pepper fruits contain 12.6 mg % of carotene (provitamin A). They accumulate a significant amount of rutin (vitamin P) and group B vitamins (thiamin, riboflavin, and folic acid) (Amanturdiev et al., 2023).
According to Gajc-Wolska et al. (2018), The quality of pepper fruits is defined mainly by the concentrations of vitamin C and carotenoids, the former being a particularly valuable nutrient due to its diverse biological activity in the human body. Kim et al. (2011) found the concentrations of capsanthin and vitamin C in pepper fruits as highly correlated with the pepper's antioxidant activity.

Table 3. Macroelements composition of peppers fruits variety ‘Bela dolga’ (% of dry matter)

Variant	n	N	P_2O_5	K_2O	CaO	MgO
		$\bar{x} \pm SD$	$\bar{x} \pm SD$	$\bar{x} \pm SD$	$\bar{x} \pm SD$	$\bar{x} \pm SD$
1	30	1.20 ± 0.08^a	0.50 ± 0.07^a	1.83 ± 0.03^a	1.35 ± 0.05^a	0.22 ± 0.07^a
2	30	1.41 ± 0.03^b	0.65 ± 0.11^b	2.20 ± 0.03^b	1.53 ± 0.08^b	0.35 ± 0.03^b
3	30	1.35 ± 0.05^c	0.59 ± 0.06^c	2.10 ± 0.09^c	1.47 ± 0.06^c	0.37 ± 0.03^c
4	30	1.30 ± 0.02^c	0.58 ± 0.08^c	2.08 ± 0.11^c	1.49 ± 0.06^c	0.49 ± 0.09^d
5	30	1.29 ± 0.02^d	0.62 ± 0.08^b	2.19 ± 0.03^b	1.50 ± 0.03^d	0.32 ± 0.01^b

$^{a,\ b,\ c,\ d}$ – values for the same parameter of the different variants marked with different letters have statistically significant differences ($p<0.05$), ANOVA, post hoc Tukey’s test.

The highest ($p<0.05$) average content of nitrogen (1.41%), phosphorus (0.65%), potassium (2.20%) and calcium (1.53%) was determined in the pepper fruits in the variant 2. The highest ($p<0.05$) content of magnesium (0.49%) was determined in the pepper fruits in the variant 4.

The positive effect of foliar fertilizers on the chemical content of peppers is the result of their chemical composition. Zeofit Forte and Zeofit Plus contain two important macrobiogenic elements (in different concentrations), calcium and magnesium, which are essential in pepper nutrition. Calcium has a role in neutralizing organic acids that are created in the metabolism of carbohydrates. It has a certain role in some enzymatic processes, in the synthesis of complex carbohydrates as well as in the synthesis of proteins. Calcium affects the structure of the cytoplasm, and thus the economic consumption of water and the activity of enzymes, especially phospholipase and D-lecinase, which hydrolyze lecithin. It has a significant role in the structure and pH value of the soil (Stojanova, 2022).

Magnesium as a biogenic element enters into the composition of chlorophyll, thereby participating in photosynthesis, biosynthesis of proteins, metabolism of nucleic acids, water regime of plants, growth and development, and quality and quantity of yields. Its presence affects greater adsorption of phosphorus and transfer of carbohydrates from the leaves to all parts of the plant (Stojanova, 2022). It has a significant role in the synthesis of proteins and the formation of the cell structure in the plant. Along with nitrogen, it has an impact on the development of the vegetative mass (Ankele et al., 2007). It prevents excessive utilization of the ammonia component in plants. It increases the mobility in utilizing the nutrient components in the plant. With an increased deficiency of magnesium in the plant, the content of calcium and zinc ions also decreases, while the concentration of manganese and iron increases (Guo et al., 2014).

In the study of Stoleru et al. (2023) three types of fertilization were tested: chemical, organic and biological. The type of fertilizer used has a significant impact on the production, proximate analysis, phytochemical composition, and mineral content of sweet peppers. Organic and biological fertilizers had a more pronounced effect on the nutritional quality of the sweet peppers than chemical fertilizers. In the variant with organic fertilizer, the content of macroelements in sweet peppers fruits were: 214.70 K ($mg \cdot 100\,g^{-1}$ f.w.), 16.22 Ca ($mg \cdot 100\,g^{-1}$ f.w.), 13.33 P ($mg \cdot 100\,g^{-1}$ f.w.) and 13.47 ($mg \cdot 100\,g^{-1}$ f.w.). Moreover, according to the results of this study, different treatments can be used to enhance the mineral content of sweet peppers, which could have essential implications for the nutritional value of these crops.

In the research of Yu et al. (2023) an orthogonal experiment $L_{16}4^5$ (5 factors, 4 levels, a total of 16 treatments) was used to design and analyze the effects of the combined action of four fertilizers and Pb^{2+}on the Pb absorption of PLI. The five factors were N, P_20_5, K_2O, sheep manure, and Pb^{2+}. The four levels are blank, low, medium, and high. The experiment is done by adding fertilizers and compounds to the soil. The five influencing factors in the experiment were added to the soil in the form of fertilizers and compounds. The effect order of fertilization on fruit weight of PLI was P_2O_5 > sheep manure > N>K_2O>Pb^{2+}; The horizontal combination of factors that promoted PLI fruit weight to reach the maximum value were N (0.15 $g \cdot kg^{-1}$), P_2O_5 (0.225 $g \cdot kg^{-1}$), K_2O (0.15 $g \cdot kg^{-1}$), sheep manure (9 $g \cdot kg^{-1}$), Pb^{2+} (100 $mg \cdot kg^{-1}$).

In the study of Ropelewska et al. (2023) the correlations between chemical properties and image textures from different color channels of red and yellow peppers untreated and treated with natural fertilizers were determined. In the case of red pepper 'Sprinter F1', statistically significant correlation coefficients were found between carotene, total carotenoids, and total sugars with selected image texture parameters. Yellow pepper 'Devito F1', as well as a combined dataset for both cultivars were characterized by the correlations between total carotenoids and total sugars with selected textures.

According to Egbe et al. (2023) pepper cultivar Capsicum frutescens contained 2.39% N, 0.42% P, 3.06% K, 0.22% Mg, and 0.17% Ca.

According Gajc-Wolska et al. (2018) with using Nano-active treatment the concentrations of macroelements in sweet peppers were 6.59 mg 100 g^{-1} N, 18.83 mg 100 g^{-1} P, 211.08 mg 100 g^{-1} K, and 12.30 mg 100 g^{-1} Ca.

CONSLUCION

Based on the obtained results for the influence of foliar fertilizing with calcium amplifiers on the chemical composition of pepper fruits 'Bela dolga' grown in protected spaces, it can be concluded that in all variants treated with foliar fertilizers, higher ($p<0.05$) content of the tested elements has been determined compared to the control variant. The highest ($p<0.05$) content of the examined parameters was achieved in the variant 2: Zeofit forte (SiO_2 15%, CaO 35%, MgO 7%, P_2O_5 0.04%, K_2O 0.63%, MnO 0.043%, Fe_2O_3 4.70%), by applying a lower concentration (3 g/L). Both amplifiers have a natural origin and are completely ecological, which is why they are recommended for successful application in horticultural production.

REFERENCES

Amanturdiev, I., Yazdonov, U., Lukova, I., Dzhurakulov, H., Shamsiev, A. (2023). The effect of fertilizer rate on the growth, development, and yield of sweet pepper in protected areas. E3S Web of Conferences 462, 02012. https://doi.org/10.1051/e3sconf/202346202012.

Aminifard, M.H., Bayat, H. (2018). Influence of different rates of nitrogen fertilizer on growth, yield, and fruit quality of sweet pepper (Capsicum annum L. var. California Wander). Journal of horticulture and postharvest research, 1(2), 105-114, doi: 10.22077/jhpr.2018.1423.1013.

Ankele, E., Kindgren, P., Pesquet, E., Strand, A. (2007). In vivo visualization of Mg ProtoporphyrinIX, a coordinator of photosynthetic gene expression in the nucleus and the chloroplast. Plant Cell., 19, 1964-1979.

Caruso, G., Stoleru, V., Munteanu, N., Sellitto V.M., Teliban, G.C., Burducea, M., et al. (2018). Quality performances of sweet pepper under farming management. Not Bot Horti Agrobo., 47, 458–64. doi:10.15835/nbha47111351.

Egbe, A.E., Soupi, M.S.N., Nkede, F. and Ndogho, A.P. (2023). Growth, Yield and Yield Characteristics of Three Pepper Cultivars to Fertilizers Application in the Mount Cameroon Region. Journal of Agricultural Chemistry and Environment, 12, 188-205. https://doi.org/10.4236/jacen.2023.122015.

Gajc-Wolska, J., Mazur, K., Niedzińska, M., Kowalczyk, K., Żołnierczyk, P. (2018). The influence of foliar fertilizers on the quality and yield of sweet pepper (Capsicum annuum L.). Folia Horticulturae, 30(2), 183-190. doi:10.2478/fhort-2018-0008.

Guo, W., Cong, Y., Hussain, N., Wang, Y., Liu, Z., Jiang, L., Liang, Z., Chen, K. (2014). The remodelling of seedling development in response to long-term magnesium toxicity and regulation by ABA-DELLA signalling in Arabidopsis. Plant Cell Physiology, 55(10), 1713-1726.

Kim, J.S., Ahn, J., Lee, S.J., Moon, B.K., Ha, T.Y., Kim, S. (2011). Phytochemicals and antioxidant activity of fruits and leaves of paprika (Capsicum annuum L., var. special) cultivated in Korea. J. Food Sci., 76, 193 198.

Lazič, B. et al. (2001). Vegetable from protected space, Belgrade.

Liu, X.Y., Chang, T.T., Guo, S.R., Xu, Z.G.; Li, J. (2011). Effect of different light quality of LED on growth and photosynthetic character in cherry tomato seedling. Acta Horticulturae, 907, 325–330.

Omar, E.S., Gabal, A.A., Alkharpotly, A., Radwan, F.I., Abido, A.I.A. (2018). Effect of Mineral, Organic and Bio-fertilization on Sweet Pepper (Capsicum annum L.) Grown Under Plastic Houses Conditions. J. Adv. Agric. Res. (Fac. Agric. Saba Basha), 23 (3).

Ropelewska, E., Szwejda-Grzybowska, J. (2023). The Estimation of Chemical Properties of Pepper Treated with Natural Fertilizers Based on Image Texture Parameters. Foods, 12, 2123. https://doi.org/10.3390/ foods12112123.

Salama, G.M., Zake, M.H. (2000). Fertilization with manures and their influence on sweet pepper of plastic-houses, Annals of Agricultural Science, Moshtohor, 38(2), 1075-1085.

Sarić, M., Stanković, Z., Krstić, B. (1989). Plant physiology, Science book, Novi Sad, Serbia.

Shafeek, M.R., Helmy, Y.I., Awatef, G. Beheiry, Fatma A. Rizk, Nadia M. Omar. (2014). Foliar Application of Some Plant Nutritive Compounds on Growth, Yield and Fruit Quality of Hot Pepper Plants (Capsicum annum, L.) Grown Under Plastic House Conditions. Current Science International, 3(1), 1-6.

Sobczak, A., Kowalczyk, K., Niedzinska, M. (2020). Growth, Yield and Quality of Sweet Pepper Fruits Fertilized with Polyphosphates in Hydroponic Cultivation with LED Lighting. Agronomy, 10, 1560. doi:10.3390/agronomy10101560.

Stojanova, T.M. (2017). Plant nutrition. Practicum, Academic Press, Skopje.

Stojanova, T.M. (2018). Plant nutrition. Academic Press, Skopje.

Stojanova, T.M. (2019). Manual for taking soil and plant samples for agrochemical analysis. Academic Press, Skopje.

Stojanova, T.M. (2022). Nutrition of horticultural plants. Academic Press, Skopje.

Stoleru, V., Mangalagiu, I., Amăriucăi-Mantu, D., Teliban, G.C., Cojocaru, A., Rusu, O.R., Burducea, M., Mihalache, G., Rosca, M., Caruso, G., Sekara, A., Jităreanu, G. (2023). Enhancing the nutritional value of sweet pepper through sustainable fertilization management. Front. Nutr. 10, 1264999. doi: 10.3389/fnut.2023.1264999.

Yu, B., Xu, D., Li, Y., Wang, W. (2023). Influence of Fertilization on Growth and Lead Content of Pepper under Lead Stress. Plants, 12, 2960. https://doi.org/10.3390/ plants12162960.

MANAGEMENT PRACTICES OF CATTLE DISEASES AND PARASITES AMONG PASTORALISTS IN NORTH-EAST, NIGERIA

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ABSTRACT

This study assessed management practices of cattle diseases and parasites among Pastoralists in North East, Nigeria. The study described the socio-economic characteristic of the pastoralists and analyzed cattle diseases and parasites management Practice. 420 respondents were selected for the study. Percentage, frequency, mean, rating scale and logit regression were used in analyzing the data. Result shows that the mean age of the pastoralists was 35 years, majority (99.5% and 88.6%) were male and acquired Koranic education. Married pastoralists constituted 52.8% with an average household size of nine persons. Vaccination ($\bar{x}$ =2.9), use of herbs ($\bar{x}$ =2.77) and deworming ($\bar{x}$ =2.72) were the pastoralists commonly used management practices in curtailing cattle diseases and parasites. Coefficient of age (0.0224), friends (0.0042), sex (0.0865), were significant in management practice of cattle diseases and parasites. The study recommends the need for extending modern management practices of cattle diseases and parasites to pastoralists so as to increase productivity and higher efficiency in the cattle industry.

Keywords: Management Practices, Cattle Diseases and Parasites, Pastoralists, North-East, Nigeria

INTRODUCTION

The important of the basic management practices of cattle diseases and parasites in the development and growth of the livestock subsector of the Nigerian economy is paramount There are limited access modern management practices of cattle diseases and parasites among the Pastoralists in North-Eastern Nigeria (Bashir,2022). Improper management of cattle diseases and parasites results in poor growth performance, lower market value and loss of animal due to death. Diseases such as Tuberculosis, Anthrax, Brucellosis, foot and mouth diseases which are zoonotic in nature have the tendency of affecting the pastoralists and their family if not properly manage.(Bashir,2022). To curtain this challenges faced by pastoralists several studied abound on the management practices employed by pastoralists. Cresswell et al. (2014), reported that vaccination is among the common management practice for prevention of BVD, with nearly 80% of surveyed cattle farmers in the British communities saying they administer BVD vaccines to some of their cattle. According to Epu(2010), on his study provide a unified approach to consumer resource modeling and reported that, the use of improved breeding stock and local concoctions were among the practices used to control pests and diseases by herdsmen. Worms in animals are treated using some herbs with specific measurement known by the farmers.

Moreover, Olaniyi, and Adewale (2013) pastoralists locally treat cases of diseases and parasites for instance to increase milk production. They also regularly make fire in the kraals to get rid of pests infestation especially ticks and lice and make the animals comfortable. Despite the efforts by researchers, it could be argued that, there was not much empirical study conducted on management practices of cattle diseases and parasites. Hence, this research assessed management practices of cattle diseases and parasites among pastoralists' in North East, Nigeria. Specifically, the study seeks to:

i. describe the socio-economic characteristics of the pastoralists in the study area; and
ii. identify cattle diseases and parasites management practices adopted by the pastoralists in the study area.

The hypothesis for the study was stated below:
H_{01}: There was no significant relationship between pastoralists' socio-economic characteristics and their management practices of cattle diseases and parasites

METHODOLOGY

The study was carried out in North East Nigeria. The region comprises of Adamawa, Bauchi, Borno, Gombe, Taraba and Yobe States. It lies between latitude $6^0 26^1$ and $13^0 45^1$N and Longitude $8^0 42^1$ and $14^0 39^1$E (Bashir, 2022). North East Nigeria was created from the Northern region on the 27th of May 1967 and covers close to one third (280,419km^2) of Nigeria's land area (909,890km^2) with a population of 18,984,299 people that is 13.5% of the country's population (NPC, 2006). The National Population Commission projected an annual growth rate of 13.6% which brought the population figure to 32,137,094 as at 2020. This area is largely located in the Sudan and Northern Guinea Savannah zones which are characterized by relatively high temperature throughout the year with an annual average temperature varying from 23.2^{o}C to 32.5^{0}C while rainfall ranges between 467 mm to 1091 mm (Bashir, 2022).

The Population of the study consists of all pastoralists in the study area. Five stage sampling procedure was employed for the study. Stage one: purposive selection of Four (4) states of Adamawa, Bauchi, Gombe and Taraba. This is due to the fact that incessant attacks and insecurity is minimal in these four states. Stage two: purposive selection of six local government areas from Adamawa (Tungo, Yola south, Jada, Ganye, Mayo-Belwa and Mubi) five from Bauchi (Alkaleri, Soro, Darazo, Katagum and Gamawa) four from Gombe (Gombe, Balanga Funakaye and Akko) and five from Taraba (Wukari, Gassol, Ardo-Kola and Gashaka) respectively. In all 20 local government areas with supportive vegetation for cattle rearing were selected for the study. Stage three: purposive selection of one community each that was mostly resided by pastoralists from the 20 local government areas selected for the study that is 20 communities were selected (Toungo ,Ngurore, kojoli, Ganye Mayo-Belwa, in Adamawa State, Alkaleri, Soro, Darazo ,Katagum ,Gamawa, in Bauch state. Gombe, Balanga Funakaye Akko in Gombe State while Wukari, Gassol, Ardo-Kola Bali and Gashaka in Taraba state respectively.

Stage four: : Snow ball technique was employed to select pastoralists for the study as the exact populations of the pastoralists in the communities were unknown. Stage five: 21 pastoralists were selected per community using a snowball technique, in all 420 pastoralists were involved in the study. However only 417 questionnaires were finally analysed as three questionnaires could not be accounted for.

Method of Data Analysis

The data obtained was analyzed using frequency, percentage, mean, and rating scale while logit regression was used to test the hypothesis of the study.

Mean

$$3 + 2 + 1 \ = \frac{6}{3} = 2$$

$$\overline{x} = \frac{\sum Fx}{n}$$

Where: $\overline{x}$ = mean rating scale
$\sum$ = Summation
F = Frequency of the Pastoralists
x = Number of pastoralists to the item

n= Total number of pastoralists

The logit regression model is explicitly specified as:

$$P = \exp\frac{(b_0 + b_1X_1 + b_2X_2 \dots\dots\dots + b_pX_p)}{1 + \exp(b_0 + b_1X_1 + b_2X_2 + \cdots + b_pX_p)}$$

The hypotheses generated for the study were tested as follow:

Hypothesis

There was no significant relationship between pastoralists 'socio-economic characteristics and management of cattle diseases and parasites.

P = management practices of cattle diseases and parasites (Dependent variable)

X_1 to X_8 = Independent variables

X_1= Age (in years)

X2 = Sex (male=1, female=0)

X3 = Marital Status (married = 1, single = 0)

X4 = Household size (Numbers of people in the household)

X5 = Educational level (number of years in formal schooling)

X6 = Management experience (number of years in cattle disease management)

X7 = Herd size (number of cattle under one's care)

X_8= Access to extension services

b_1-b_8= Regression coefficients

RESULTS AND DISCUSSION

Pastoralists' Socio-economic Characteristics

Age is an important factor in assessing pastoralists management practices of livestock diseases and parasites in North East, Nigeria. It reveals the physical strength and agility of the pastoralist. Ageing has an adverse effect on agricultural productivity in general. Moreover, Usman et al. (2017), Mohammed (2019) and Adelakun et al. (2020) are of the opinion that, age is not a factor to deny involving pastoralists' youths who were below the age of 40 years in pastoralism since young adults have to experience part of activities in the pastoralists' societies. Result in table 1 showed that majority (57.8 %) of the pastoralists were between the age of 21 – 40 years. With a mean age of 35 years, the findings implies that, pastoralist in the study area is been carried out by individuals who are active, vibrant and physically able to move around with their animals. This may be in contrast to the older pastoralists who would not possibly be able to move around with cattle due to advancement in age. This result agreed with the findings Dimelu et al. (2019) and Onah et al. (2020) both of them reported that pastoralists are often young with a lot of energy possessed to carry their animals to scavenge. This gives more advantage to the younger pastoralists knowing that nomadic life requires a lot of movement that demanded a lot of stamina.

Male and female have different roles, responsibilities, access to resources and decision making processes in the society at large. Male and female both have vital roles and contributions toward continuation and adaptation of pastoral systems. Results in table 1 showed that majority (99.5%) of the pastoralists were male. This implies that male dominated pastoralism because of their natural flexibility as it is energy demanding to move from place to place, thus limits the number of women participating. This is in agreement with the findings of Mangesho et al. (2017) and Usmanet al. (2017), who reported in their studies that majority of pastoralists were male. Therefore in packaging extension messages and technologies for the pastoralists, the fact that most of them are male should be borne in mind.

Marriage is considered a respected and revered institutions in both rural and urban societies, marriage is a respected institution. Marriage bestows on individuals social status, recognition and makes persons to be considered responsible (Ndaghu, 2011). Result in table1 shows majority (52.8%) of the pastoralists were married. This findings implies that pastoralism in the study area is seen as a means of livelihood, been carried out mostly by married individuals for households sustainability. Marriage is a crucial aspect of the Fulani culture, for a pastoralists' to get married and raise his family, is perceived to confer respect on individuals and reinforces individuals' ties.

This corroborates the findings of several scholars Mangesho et al. (2017); Hussaini, (2018) and Dimelu et al. (2019), who also reported that majority of the pastoralist are married. Therefore in packaging extension message for the pastoralists, it is important to consider the fact that marriage is a most cherished institution among them.

The size of a household underscores the rate at which pastoralism is practice in such household, especially in the Northern Nigeria where pastoralism is high. The result in table 1 below shows that majority (50.1%) of the pastoralists were from household of 7 – 13 persons, with a mean household size of 12 persons, this findings reveals that majority of the pastoralists were from large households. This implies that large household size could help the pastoralists with more members to convey the cattle for grazing and also aid easy diffusion of knowledge knowing that more individuals from a single household will participate in pastoralism. The result similar with the findings of Ismaila (2017); Mangesho et al. (2017) and Hussaini (2018); who all reported an average of household size of nine persons among pastoralist households.

Education is a variable that broadens the mental horizon, influences the totality of the mind and predisposes farmers to new ideas (Ndaghu, 2011). High level of education could enhance pastoralists understanding of cattle diseases and parasites management. Result in table 1 shows that majority (86.1%) of the pastoralists acquired no formal education. This findings implies that majority of the pastoralist had acquire no formal education yet could manage cattle, moreover, attaining some level of education could help the pastoralist in acquiring more knowledge through reading and contact with extension services regarding the management practices of cattle diseases and parasites pastoralism. Low level of education could only mean those pastoralists are limited to traditional knowledge and practices of cattle diseases and parasite management. This is in agreement with Omonona (2018); Kwagge (2018) and Yuguda et al. (2018) who reported low level of education among pastoralist in Nigeria.

Number of cattle owned elaborates the quantity and size of herds under the pastoralists care. In this regards ,most (46.1%) of the pastoralists as revealed in table 1below had a herd size of 101 – 200 cattle. The number of cattle owned by the pastoralist could hamper his desire to acquire more knowledge on the various management practices. This implies that pastoralists with small herd's size could be eager to multiply the herds size with reliable knowledge acquired. With a mean herd's size of 152 cattle, according to ICBF (2008), herds were categories into small herds (average of 37 cattle), medium (average of 54 cattle) and large herds (average of 87 cattle); the result indicates that pastoralism is practiced in a large scale within the North-East, Nigeria. This is in disagreement with Idowu (2017); Pinilla et al. (2019) and Chowdhury (2019) who all reported that pastoralists have small herds.

Pastoralists' years of experience in management of cattle disease and parasites elaborates number of years in which the pastoralist had been in cattle management and the experiences gained per duration. Result of the finding in table 1 presents that 31.4% of the pastoralists had been engaged in cattle management for 31 - 40 years. By implication, years of management experience could increase pastoralists' knowledge on management of cattle diseases as a result of its frequent occurrences among the herds. With a mean age of eight years, the finding is in line with Umoh, (2017); Usman et al. (2017); Amranet al. (2018);

Yahaya (2018) and Aliyu (2018) they all reported a mean of less than 10 years in management experience among pastoralists.

Membership of pastoralists' organization reveals whether the respondent was a member of cooperative society, or organizations that promote pastoralism. Result from table 1 below shows that almost all (97.1%) of pastoralists were members of Miyetti Allah Cattle Breeders Association (MACBAS. This finding implies that pastoralists are active in their organizations, which could be said to have benefited them in one way or the other. This is in agreement with the findings of Lawal (2017); Yahaya (2018) and Lawal-Adebowale et al. (2018) who separately reported that majority of pastoralists belongs to the Miyetti Allah cattle breeders association.

Benefits derived from MACBAS elaborately, is seen as the advantage gained by pastoralists from the immediate environment which could be social, financial, educational or psychological. Result of the finding in table 1 shows most (46.3%) of the pastoralists admitted that 'security' is the major benefits derived from the association. This implies that MACBAS benefits the pastoralists in terms of security and provision of knowledge on cattle diseases and parasites management. This finding is in agreement with Umoh (2017); Amran et al. (2018) and Buno (2018) who reported that Cattle Breeders Association provides security and information on knowledge and management of cattle diseases and parasites.

The number of visits by extension agents in the study area has to do with the number of times extension agents had direct contacts with the pastoralists in the local communities to share with them the required information and resources if possible to enable the pastoralists efficiently execute the cattle production enterprise. Results in table1 revealed that majority (65.1%) of the pastoralists admitted that they had no contact with extension agents. This finding implies that extension visits could improve the pastoralists' knowledge of cattle diseases and parasites management as they provide information that could enhance cattle production. It is evident that poor access to extension services could be a reason why majority of the pastoralists lacked modern knowledge of cattle diseases and parasites management.

Table 1: Socio-economic Characteristics of the Pastoralists

Age	Frequency	Percentage	Mean ($\bar{X}$)
≤ 20	48	11.5	35
21 – 30	108	25.9	
31 – 40	133	31.9	
41 – 50	86	20.7	
51 and above	42	10.0	
Sex			
Male	415	99.5	
Female	2	0.5	
Marital Status			
Single	177	42.4	
Married	220	52.8	
Widow/Widower	2	0.5	
Divorce	18	4.3	
Household size			
<6	58	13.8	12
7 – 13	209	50.1	
14 – 20	123	29.4	
21 and above	28	6.7	
Educational Attainment			
No formal education	359	86.1	
Primary education	29	7.0	
Secondary education	10	2.3	
Tertiary education	19	4.6	
Number of cattle			
<100	167	40	152
101 – 200	192	46.1	
201 – 300	47	11.3	
Years of management experience			
<20	80	19.2	8
21 – 30	131	31.4	
31 – 40	113	27.1	
Membership of pastoralist organization			
Yes	405	97.1	
No	12	2.9	
Benefits from pastoralist organization			
Cattle diseases and parasite information	101	24.0	
Loan	81	19.4	
Security	193	46.3	
Others	42	10.0	
Frequency of visit by extension agents			
Daily	0	0.0	
Weekly	4	0.9	
Monthly	5	1.3	
Once in a management year	136	32.7	
Not at all	271	65.1	
Total	**417**	**100**	

Source: Field Survey, 2021.

Cattle Diseases and Parasites Management Practices Adopted by the Pastoralists

Modern Practices

The result in Table 2 showed the various management practices in cattle diseases and parasites. The results based on the sub-ranking showed that vaccination with a mean score of 2.0 was ranked 1st as the modern practices of management of cattle disease, followed by deworming with a mean score of 1.97, while dipping and spraying was sub-ranked 3rd with a mean score of 1.96 respectively. This implies that the pastoralists have a good knowledge on vaccination and deworming which is seen as a modern practice of cattle diseases and parasites management in the study area. This is in line with the findings of Singh et al.(2016) and Abiola et al.(2016) who reported vaccination and deworming as a measure in management of cattle diseases and parasites.

Traditional Methods

The result in table 2 based on sub-ranking reveals that use of herbs was ranked as 1stwith a mean score of 1.86 as the cultural practices of cattle diseases and parasite management, while smoked and manual ticks removal were ranked 2nd and 3rd with a mean score of 1.78 and 1.75 as the traditional practices involved in management of cattle diseases and parasites. This implies that the pastoralists also engaged in traditional methods and could be evident that they have traditional knowledge of cattle diseases and parasites management in the study area. This is in agreement with the findings of Usman et al.(2017) who reported that manual ticks removal is a basic parasite management practice by pastoralist in the study area.

Modern/Traditional Practices

Based on the general ranking of the results in Table 2, among both modern and traditional methods adopted by pastoralist in cattle diseases and parasite management, vaccination was ranked 1st with a mean score of 2.0, followed by deworming with a mean score of 1.97, dipping and spraying and dusting with a mean score of 1.96 and 1.95 which were rank 3rd and 4th respectively. The traditional method commonly practiced by the Pastoralists were use of herbs, smoked and manual ticks removal with a mean score of 1.86, 1.78, and 1.75 were ranked in 7th, 9th and 10th respectively. This is implies that Pastoralists in the study still hold on to some traditional practices of cattle diseases and parasite management which they found it effective despite the availability and ease in the use of modern management practices. It could be deduced that pastoralist in the study area highly uses modern practices of cattle diseases and parasites management such as vaccination, deworming, quarantine, dipping and dusting more than the traditional methods like the use of herbs, use of smoke and manual ticks removal.

Table 2: Distribution of Pastoralists based on management practices of cattle diseases and parasites

S/No.	Practices	Yes Freq/%	Effective Freq/$\bar{X}$)	Not Effective Freq/$\bar{X}$)	Mean $\overline{(X)}$	Sub-Rank	General Rank
Modern practices							
i.	Dipping and spraying	321(76.9)	308 (1.92)	13(0.04)	1.96	3rd	3rd
i.	Dietary supplementation	395(94.7)	344(1.74)	51(0.13)	1.87	6th	6th
i.	Vaccination	413(99.0)	398(1.96)	15(0.04)	2.0	1st	1st
v.	Docking/tailing	362(86.8)	290(1.60)	70(0.19)	1.79	7th	8th
v.	Dusting	395(94.7)	373(1.89)	22(0.06)	1.95	4th	4th
i.	Deworming	409(98.0)	399(1.95)	10(0.02)	1.97	2nd	2nd
i.	Quarantine	310(74.3)	288(1.86)	22(0.07)	1.93	5th	5th
Traditional practices							
i.	Bush Burning	312(74.8)	174(1.12)	138(0.44)	1.56	6th	13th
x.	Use of Holy Books	398(95.4)	211(1.06)	187(0.47)	1.53	7th	14th
x.	Movement away	346(82.9)	157(0.91)	189(0.55)	1.46	8th	15th
i.	Manual ticks removal	319(76.5)	241(1.51)	78(0.24)	1.75	3rd	10th
i.	Use of herbs	415(99.5)	359(1.73)	56(0.13)	1.86	1st	7th
i.	Smoked	402(96.4)	311(1.55)	91(0.23)	1.78	2nd	9th
v.	Incantation (Spiritual)	402(96.4)	242(1.20)	160(0.39)	1.59	5th	12th
v.	Breeding	412(98.8)	270(1.31)	142(0.34)	1.65	4th	11th

Source: Field Survey, 2021.

Testing of Hypotheses of the Study

The result of the analysis in Table 3 showed that, age (0.0224), household size (0.0311) and access to extension service (0.0440) were found to be negatively and statistically significant at 5%. This implies that an increase in these socio-economic variables will definitely increase their use of management practice of cattle diseases and parasites in the study area. Therefore the null hypothesis (H_0) of this study which stated that there was no significant relationship between Pastoralists' socio-economic characteristics and use of management practices was rejected and the alternative hypotheses (H_1) accepted which states that there is statistical and significant relationship between Pastoralists' socio-economic characteristics and use of management practices of cattle diseases and parasites.

This result implies that as the pastoralists gets older, years of management practices increases with more knowledge and experienced gained likewise household increases overtime, which also play a significant role in the management of cattle diseases and parasites. The higher the number of pastoralists in a household the more the tendency to acquire and get acquainted with different management practice of cattle diseases and parasite, access to agricultural extension services could also increase, and could result to adequate increase in management practices of cattle diseases and parasites such as vaccination, deworming, manual ticks removal among others. This findings is similar to Usman et al. (2017) who reported that age had a positive relationship with the pastoralists' knowledge of cattle parasite and disease management.

Table 3: Logit regression analysis of relationship between socio-economic characteristics and management practices of cattle diseases and parasites

Variables	Regression Coefficient	Standard error	Z-statistics	Prob.
X_1(Age)	0.893326	0.02739	1.544584	0.0224*
X_2(Sex)	0.878446	.955044	-1.714365	0.0865^{NS}
X_3 (Marital status)	0.884474	0.499834	0.116330	0.9074^{NS}
X_4 (Household size)	0.893659	0.046209	-2.156024	0.0311*
X_5(Educational Level)	0.894574	0.387962	-0.794731	0.4268^{NS}
X_6 (Experience)	0.895439	0.027424	-1.312767	0.0893^{NS}
X_7 (Herd size)	0.893261	0.001064	0.895454	0.3705^{NS}
X_8 (Access to Extension services)	0.879783	0.204410	-2.014239	0.0440*
C	5.686781	2.008176	2.831815	0.0046
R-square	0.140059			
Adjusted R-square	0.930456			
5% level of significance *				
NS - Not significant				

Source: Field Survey, 2021.

CONCLUSION

Based on findings of the study, the following conclusions were drawn. The pastoralists were mostly young male adults who were married with a large household size, with less or no formal education; they practiced small scale cattle production with the years of management experiences only. This has contributed to limited or no access to modern sources of information on cattle diseases and parasite management with the majority of the pastoralist in North-East Nigeria belonging to Miyetti Allah Cattle Breeders Association.

It could be noted the mobility engulfing pastoralism in general limits or even disconnects the pastoralist from extension services entirely for a longer duration resulting to haphazardly accessing information on cattle management as well. This has deprived pastoralists from benefiting from other extension services such as access to cattle management equipments and tools provided by the government on low and affordable prices for cattle production.

RECOMMENDATIONS

Based on the findings of the study, the following recommendations were made.

i. Majority of the pastoralists have low level of education and majorly speak only their native languages (Fulfulde), for effective extension service delivery messages meant for the pastoralists should be packaged, using both audio-visuals translated to local languages, as it is evidenced that most of the pastoralist rarely communicate effectively in Hausa the perceived common language of the people.

ii. Pastoralism a gesture of instability with both the cattle and herder, which ensures that the cattle breeders moves from one place to another in search of quality grazing field, various mobility measures and devices as applicable to extension services should be provided to ensure that majority of pastoralists get access to various extension services provided at different places and time.

iii. It is clearly indicated that majority if not all of the pastoralists belongs to the Miyyeti Allah Cattle Breeders Association, by this, the organization should solely be the target audience for dissemination of extension services instead of face to face or individual contact methods, also a need to promote and support the organization in all round knowing that diffusion of extension services will be at ease thereby securing the cattle industry in Nigeria at large.

iv. With the finding that pastoralists acquires more experiences on management practices of cattle diseases and parasite as they grow older, extension services as well should target the teenage pastoralist so as to aid them grow and practice modern pastoralism with a higher level of knowledge on the cattle diseases and parasites management overtime.

v. Pastoralists should try to embark on other forms of cattle diseases and parasites management other than the default vaccination, deworming and the traditional measures of smoked and manual ticks' removals so as to aid them curtail the dangers attached to the prevalence of these diseases and parasites.

REFERENCES

Abiola, O.J, Olaogun SC, Emedoh, O.M. and Olalekan, T.J. (2016). A retrospective study of ruminant cases presented between 1996 and 2005 at the Veterinary Teaching Hospital, University of Ibadan, Ibadan Nigeria. International Journal of Livestock Research, **6**(7): 16-23.

Adelakun, O., Akande, F., Olumoyegun, F., Awosanya, E., Ishola, O. and Cadmus, S. (2020). Prevalence and Predictors of Gastrointestinal Parasitic infection among Agro-Pastoral Cattle Herds in Ibarapa, Oyo State, southwestern Nigeria.Retrieved from https://doi.org/10.22541/au.158636179.91818198.

Adelakun, O.D., and Akande, F.A.(2018). Assessment of gastrointestinal parasites in extensively grazed cattle in southwestern Nigeria.Journal of Animal Health and Production, Africa, 66 (4), 741-749.

liyu, O.A.L. (2018). Dynamics of ruminant livestock management in the context of the Nigerian Agricultural System. In: Livestock Production (K Javed, editor). InTech. USA. Pp 61.

Amran, MA, Yadav SK, Akter F, Sarkar S, Hossain MA, Joy SM,andSamrat AAK (2018). Prevalence of gastrointestinal parasitic infections in different existing goat breeds in different districts of bangladesh. J. Adv. Parasitol. 5(1): 11-21.

Andrew, C. A. (2017), The state and the management of conflict between nomadic herdsmen and crop farmers in North Central Nigeria: Implications for sustainable development, International Journal of Liberal Arts and Social Science, 3(7),:20-28.

Bashir (2022) Pastoralists Knowledge on Management Practices of Cattle Diseases and Parasites in North east, Nigeria Unpublished PhD Thesis Submitted to the School of Post graduate Studies, Taraba State University, Jalingo

Brhane, G., Mammo, Y. and Negusse, G. (2017). Sources of Information and Information Seeking Behavior of Smallholder Farmers of TanqaAbergelleWereda, Central Zone of Tigray, Ethiopia. Journal of Agricultural Extension and Rural Development, l.9(4): 47-52.

Buno, P.H. (2018). Helminthiasis: Control and Factors Militating Against its Control in Northern Nigeria. Journal of Tropical Health and Diseases, 8(3): 1-5..

Chowdhury, S.M.Z.H, (2019) Prevalence of helminthic infections in Zebu cattle (Bosindicus) at Savar Bangladesh. Australian Journal of Animal Science 6: 427-431.

Cresswell E, Brennan ML, Barkema HW, and Wapenaar W (2014).A Questionnaire-Based Survey on the Uptake and use of Cattle Vaccines in the UK. Veterinary Record Open 1: e000042.

Dimelu, M., Salifu, D., and Enwelu, A. (2019). Challenges of herdsmen-farmers conflict in livestock production in Nigeria: Experience of pastoralists in Kogi State, Nigeria. African Journal of Agricultural Research 12(8) 642-650.

Ducrotoy, J.M., Ayodele, O. M., Alexandra, P.M.S., Husein, B., Usman, B.M., Wilson, J.B., Amahyel, M. G., Reuben, A. O., Ward, B.and Susan, C. W. (2018). Patterns of passage into protected areas: drivers and outcomes of Fulani immigration into the Kachia Grazing Reserve, northwest Nigeria, Pastoralism. Pastoralism: Research, Policy and Practice. 8(1). 1 – 16.

Epu, W. M. (2010). "Biomass transformation webs provide a unified approach to consumer-resource modelling". Ecology Letters. 14 (2): 113–124.

Hussaini, S. (2018).The Causes and Consequences of Fulani Pastoralist Farmers Conflict in Nigeria.International Journal of Innovation and Research in Educational Sciences 5(3):32-37.

Idowu, L.D. (2017). Causes, Consequences, an resolutions of environmental conflicts in Nigeria. International Journal of social sciences nd economic research 2(1). 2063-3076.

Ismailla, U. (2017): Cereals Production in Nigeria: Problems, Constraints, and Opportunities for betterment. AfricanJournal of Agricultural Research 5(12), 1341-1350.

Kwagge, W.J. (2018). Prevalence of gastrointestinal parasites of goats in Ibadan, Southwest, Nigeria.World Journal of Agricultural Research, 3(2): 49-51.

Lawal, U., (2017).Economic Analysis of Small-Scale Cow Fattening Enterprise in Bama Local Government Area of Borno State, Nigeria.Production Agriculture and Technology (PAT), 4(1):1-10.

Lawal-Adebowale, O.A., Ayinde, I.A., Olanite, J.A., Ojo, V.O.A., Onifade, O.S., Jolaoso, A.O. and Arigbede, O.M. (2018). Pastoralists' grazing systems and eco-related outcomes in Yewa Division of Ogun State, Nigeria.Tropical Grasslands-ForrajesTropicales 6(1):93–103

Makun, H.J. (2018). Dairy Production Systems in Nigeria. Presentation Delivered at the Technical Meeting of Africa Sustainable Livestock 2050, April, Abuja.

Mangesho, M. Neselle, E.D. Karimuribo, J.E. Mlangwa, K. Queenan, L.E.G.,and Mboera, J. (2017) RweyemamuExploring Local Knowledge and Perceptions on Zoonoses among Pastoralists in Northern and Eastern TanzaniaPLoSNegl. Trop. Dis., 11 (2): (2017), Article e0005345

Mohammed, B.T. (2019). Conflicts between Transhumant Pastoralist and Farmers in Nigeria-The Way out.Journal of sustainable development in Africa. 30(1), 1-13.

Mohammed, I., Ismaila, A. B. and Bibi, U. M. (2015).An assessment of farmer-pastoralist conflict in Nigeria using GIS.International Journal of Engineering Science Invention, 4(7).23-33.

Mosha, G.,L., Obedy, M.U., Nyakwaka, D. and Onyango, M.U. (2018). "Information Needs and Sources of Maasai Pastoralists at Orkesumet in Simanjiro District Manyara Region - Tanzania.Library Philosophy and Practice (e-journal).1882. http://digitalcommons.unl.edu/libphilprac/1882.

Ndaghu, A.A. (2011) Use of information and Communication Technologies (ICTS) among Women Farmers in North Eastern Nigeria. PhD Thesis Department of Agricultural Extension and Rural Development University of Ibadan,Nigeria.

NPC (2006).National Population Commission 2006 Figure.Taraba State Government (2006, Ministry of Information, Taraba Annual Report.

Olaniyi, O. A. and Adewale, J. O. (2013).Women farmer's perception utilization of market information on cassava in Osun State, Nigeria.Journal of Agricultural Extension, 17 (2): 23 – 32.

Omonona, A., Ikhimioya I. and Akintayo A. (2018).Seasonal distribution of major diseases among sheep and goats in selected sub humid areas in Nigeria.Journal of Agriculture, Science and Technology, 16(2): 86-94.

Onah, O., Akarugwo, A. E., Okeke, N.A. and Nwakile, T.C. (2020).Climate Change and Transhumance Pastoralism in North-Central Nigeria.International Journal of Multidisciplinary and Current Research, 8(1)**,** 98-108.

Pinilla León JC, Delgado, N.U. and Florez, A.A. (2019) Prevalence of gastrointestinal parasites in cattle and sheep in three municipalities in the Colombian Northeastern Mountain, Veterinary World, 12(1): 48-54.

Singh R, Bal MS, Singla LD and Kaur P (2016). Detection of anthelmintic resistance in sheep and goat against fenbendazole by faecal egg count reduction test. Journal of Parasitic Diseases, doi:10.1007/s12639-016-0828-8.
Umoh, N. R. (2017), The ecology of Nigeria's public administration and employee motivation in the Plateau State Civil Service (2004-2014), Unpublished PhD thesis in Policy and Development Studies, University of KwaZulu-Natal, South Africa.
Usman, I. S., Bzugu, P. M. and Pur. J. T (2017). Indigenous Control Methods for Parasites among Pastoralists Communities in Adamawa State, Nigeria. Journal of Agricultural Extension, 21 (1):109-121.
Yahaya, A. (2018). A Survey of Gastrointestinal Parasitic Helminths of Bovine Slaughtered in Abattoir, Wudil Local Government Area, Kano\ State, Nigeria. Greener Journal of Biological Sciences. 4 (4): 128 -134
Yuguda AU, Samaila AB and Panda SM. (2018).Gastrointestinal helminths of slaughtered cattle in Bauchi Central Abattoir, Bauchi State, Nigeria. GSC Biological and Pharmaceutical Sciences, 4(2), 58-65.
Yuguda, A. U., Babayo, S. A. and Mao, P. S. (2018).Gastrointestinal helminths of slaughtered cattle in Bauchi Central Abattoir, Bauchi State, Nigeria. GSC Biological and Pharmaceutical Sciences Journal 04(02), 058–065.

DYNAMIC NITROGEN BALANCE IN THE EARTH'S PEDOSPHERE AND ATMOSPHERE

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ABSTRACT

This review paper looks at the dynamic balance between the pedosphere and the Earth's atmosphere regarding the intensity of the emission of nitrogen oxides and molecular nitrogen and their uptake by the biosphere. Maintaining this balance is important for minimizing the consequences of excessive N_2O emission (desertification, greenhouse effect), on the one hand, and encouraging nitrogen fixation processes, on the other hand, which protects the soil from degradation.
Keywords: nitrogen, nitrogen fixation, balance, balance, cycle.

INTRODUCTION

According to modern data, microorganisms play a leading role in circling all biogenic macro and microelements and the transformation and geochemical migration of many other chemical elements in the biosphere (Đukić et al., 2007).
The soil microbial community's participation in the global cycle of elements is well known only when it comes to carbon, while their role in the transformation of other biogenic elements, especially nitrogen, is still not well known. Therefore, this review paper aims to stimulate thinking and practical activities in that direction.
Bacteria are present in almost all ecosystems, both terrestrial and aquatic, and play crucial ecological roles. For example, bacteria mediate the mineralization of labile carbon (C). Moreover, anammox bacteria play a vital role in the nitrogen cycle, and rhizobia is involved

in nitrogen fixation. Bacteria affect local and global biogeochemical cycles by absorbing organic carbon and nutrients, and therefore, the study of these microorganisms is key to understanding ecosystem dynamics (Meng et al., 2022).
Throughout the history of scientific research, nitrogen (N) has continuously emerged as the most important component in promoting increased productivity in plant development. Within the soil matrix, N manifests in various guises – as inorganic entities like ammonium and nitrate, and in organic incarnations such as amino acids (Pruthviraj et al., 2024).
Among the chemical elements, nitrogen is one of the most abundant elements on Earth, making up approximately 78.1% of the atmosphere. It is also an essential nutrient for life, and it can take many chemical forms in soil. The reactions making possible the transformations among these forms are mainly driven by soil microorganisms. Several nitrogen-containing compounds are also toxic. Soil microbial reactions involving nitrogen, therefore, have the potential to affect human and environmental health, sometimes spatially and temporally far from the microorganisms that originally performed the transformation. During the last decades, anthropogenic activities have also seriously impacted the global biogeochemical nitrogen cycle (Martínez-Espinosa et al., 2023).
Nitrogen (N) is an essential element in biological systems and one that often limits production in both aquatic and terrestrial systems. Due to its requirement in biological macromolecules, its acquisition and cycling have the potential to structure microbial communities, as well as to control productivity on the ecosystem scale. In addition, its versatile redox chemistry is the basis of complex biogeochemical transformations that control the inventory of fixed (biologically available) N in local environments, on a global scale, and over geological time. Although many of the pathways in the microbial nitrogen cycle were described more than a century ago, additional fundamental pathways have been discovered only recently. These findings imply that we still have much to learn about the microbial nitrogen cycle, the organisms responsible for it, and their interactions in natural and human environments. Progress in N-cycle research has been facilitated by recent rapid technological advances, especially in genomics and isotopic approaches (Ward and Jensen, 2014).

CHEMISTRY AND BIOGEOCHEMISTRY OF NITROGEN

Nitrogen is the primary macrobiogenic element. It belongs to the group of macroelements because its total forms in the soil are represented on average above 0.10%, and biogenic because it participates in a series of important physiological-biochemical processes in plants. In the soil, nitrogen mainly comes from proteins and other nitrogenous substances that are synthesized by plants and soil microorganisms. Rocks and minerals do not contain nitrogen, but they may contain NH_4^+ ions originating from precipitation or organic matter (Stojanova, 2018).
Nitrogen (N) belongs to the V subgroup of the periodic system of elements and has five electrons in its outer shell, due to which it has a clearly expressed tendency to fill that shell up to an octet. Valence states with the values -3, 0, +3, +5 are most suitable for nitrogen. In the ground state, nitrogen has an outer electron shell structure of $2s^2$ $2p^3$ and is threevalent. Successive nitrogen ionization energies have the following values (eb): 14.53; 29.59; 47.43; 77.45; 97.86. The affinity of a nitrogen atom for one electron is +12 kCal/g-atom and for three – 500 kCal/g-atom.
The melting point of nitrogen is at -200˚C and the boiling point is at -195˚C.
In the composition of natural compounds on Earth, nitrogen is represented by two stable isotopes - ^{14}N and ^{15}N, whose participation is 99.635% and 0.365%, respectively. Radioactive isotopes (^{12}N, ^{13}N, ^{16}N, ^{17}N) can be obtained artificially, and are characterized by a short life span; one of them with the longest lifetime (^{13}N) has a half-life of 10.8 minutes, which makes

it impossible to use highly sensitive radioisotope methods in the study of nitrogen metabolism in living cells and the specificity of its transformation in nature.

The total nitrogen content in the soil crust is estimated at 0.03%. Its largest part (about $4x10^{15}$ t) is in the Earth's atmosphere in the form of free (molecular) nitrogen (N_2), where it constitutes the main part (79%) of the air. Molecular nitrogen (N_2) is chemically very inert and under normal conditions practically does not react with metals or metalloids. Heating increases its chemical activity, above all concerning metals. With some of them, it binds, forming nitrides (for example Mg_3N_2). In the upper layers of the earth's atmosphere, the photochemical dissociation of the N_2 molecule is continuously taking place, as a result of which the N^+ ion is present in a small amount over 500 km.

Nitrogen traverses various classifications, each tethered to distinct criteria. Anchored in the quantum demanded by plants, it claims the designation of a macronutrient, necessitating a quantity of 1000 μg g−1 dry matter for optimal growth. This nutrient dynamic is reflected differently across soil and plant domains: nitrogen’s nitrate form assumes a mobile disposition within the soil, while its ammonical form exhibits reduced mobility (Pruthviraj et al., 2024).

The N_2 molecule contains three bonds and is characterized by the nuclear distance d (NN)=1.095A, wave number = 2331 cm^{-1}, power constant k=22.4, and dissociation energy 226 kCal/mol. The breaking energy of the first of the three bonds in the N_2 molecule is 130 kCal/mol. 941 kJ/mol is required to break all three bonds. The solubility of N_2 in water is low – about 2 Vol%.

In the earth's crust, nitrogen creates three basic types of minerals that contain CN, NO_3^-, and NH_4^+. They are rare in nature, and sodium (Chilean) saltpeter ($NaNO_3$) and potassium (Indian) saltpeter (KNO_3) have limited industrial importance. Small amounts of nitrogen are found in coal (1.0-2.5%) and oil (0.2-1.7%).

In the biosphere of the Earth, bound nitrogen is concentrated mainly in the composition of soil organic matter (1.5×10^{11} t) and in the biomass of prokaryotes (1.3×10^{11} t), which is significantly more than in the biomass of plants (1×10^9 t) and animals (6.1×10^7 t) (Orlov and Bezuglova, 2000).

Nitrogen present in the air finds its conversion through diverse pathways. Blue-green algae facilitate the process through electrochemical fixation while nitrifying bacteria also play a role. This atmospheric nitrogen, once harnessed, contributes to the pool of nitrate nitrogen within the soil. The nitrate nitrogen, ensconced within the soil, embarks on its transformation journey. Denitrifying bacteria orchestrate the conversion of nitrate nitrogen back into nitrogen gas, releasing it into the atmosphere once more. Throughout the storage phase, nitrogen losses are a reality, often manifesting as ammonia volatilization, with the majority of losses from manure stacks occurring in this gaseous form. Environmental elements, such as ambient temperature, wind velocity, and solar radiation, wield their influence on the pace of loss from open storage setups. As manure makes its way into the soil, nitrogen losses continue to shape the narrative. The spectrum of these losses encompasses ammonia volatilization (ranging from 5% to 35%), denitrification (exceeding 10%), nitrogen leaching (ranging between 2% and 50%), immobilization, as well as soil erosion or runoff losses. The complicated connection between these changes and losses emphasizes how dynamic nitrogen is in the larger ecological framework (Figure 1) (Pruthviraj et al., 2024).

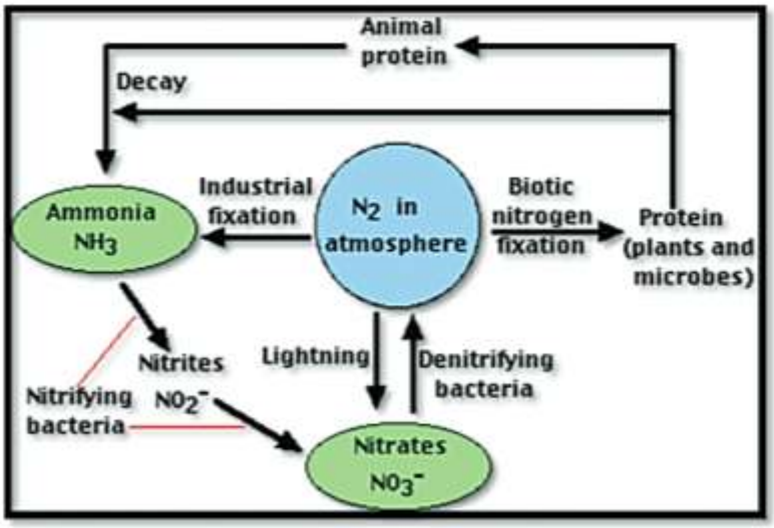

Figure 1. Nitrogen dynamics in the atmosphere (Sardar et al., 2023).

Considering that nitrogen transformations in soils are dynamic and highly dependent on the microbial biodiversity inhabiting those environments apart from climates, cropping systems, and management practices, it is important to obtain information from experiments in which all these parameters are considered to monitor nitrogen chemical transformations, not only in natural soils (not affected by anthropogenic activities) but also in soils for agricultural practices (Martínez-Espinosa et al., 2023).

PARTICIPATION OF MICROORGANISMS IN THE BIOGEOCHEMICAL CYCLE OF NITROGEN

Biogeochemical cycles are critical components of ecosystem dynamics and contribute to the degradation of refractory organic materials as well as the recycling of nutrients, toxic elements, carbon, nitrogen, sulfur, and phosphorus. Biogeochemical cycles can be either directly or indirectly altered by human activities. Direct effects include changes in the biological, chemical, and physical properties and processes of the environment. However, global warming and climate change may threaten the balance of biogeochemical cycles. Moreover, several studies have indicated that bacteria play an important role in biogeochemical cycles. For example, particle-associated bacteria seem to play a much more important role in biogeochemical cycles than free-living bacteria (Meng et al., 2022).

The biophilicity (average content of the element in living systems concerning its content in the earth's crust) of nitrogen is similar to the biophilicity of carbon. The index of biogenic enrichment of soil with nitrogen about the earth's crust is 1000, and that of plants concerning soil is 10000 (Kovda, 1985).

Summarizing the characteristics of the participation of microorganisms in the biogeochemical cycle of nitrogen, the following can be highlighted (Đukić et al., 2007):

- nitrogen cycling in nature is carried out by microorganisms, primarily prokaryotes;
- the high mobility of all natural nitrogen compounds and the high rate of metabolism are the main causes of the absence of its visible accumulations in nature (in the form of minerals and agronomic ores) and in the composition of reserve substances of living cells;
- nitrogen, the only one of all biophilic elements, is initially absent in the parent rocks and decomposes in the soil as a result of the activity of diazotrophic bacteria, which completes the formation of its most important property – fertility;

- only soils, due to their unique properties, can accumulate and retain nitrogen in the composition of humus, which is why they play the role of the main natural reservoir and source of accessible forms of nitrogen;
- to the greatest extent, nitrogen cycling is carried out in the soil, because (and as a consequence of that) in terms of total biomass, biological diversity, and productivity, land ecosystems exceed ocean ecosystems almost 1000 times;
- the biogeochemical cycle of nitrogen in the biosphere is closely connected with the biogeochemical cycle of carbon;
- the existing global soil degradation is manifested by disturbing the biogeochemical cycle of nitrogen – by changing the existing dynamic balance between its content in the soil and the atmosphere.

If nitrogen enters the biosphere during nitrogen fixation, it is lost during other processes of its biogeochemical cycle, primarily in the form of gases (Jemcev and Đukić, 2000; LaSarre et al., 2024). In the nitrogen cycle, two links (nitrification and denitrification) are responsible for the creation of gaseous compounds, as end products - nitrogen suboxide (N_2O) and molecular nitrogen (N_2).

Nitrogen suboxide (hemioxide, dinitrogen oxide, "happy gas") is one of the most important biogenic microgases of the Earth's atmosphere, which is responsible not only for the creation of the greenhouse effect but also for the breakdown of the planet's ozone layer (the so-called stratospheric outflow of N_2O occurs). Compared to other microgases of the greenhouse (CO_2 and CH_4), nitrogen suboxide is characterized by a significantly greater (approximately 150 times, than carbon dioxide, and 40 times, than methane) shielding ability, and significantly exceeds them in terms of residence time in the atmosphere (about 130 years), which predetermines the importance of studying the soil as its basic source in nature (Table 1).

Table 1. Some properties of the most important greenhouse gases (Bauwman, 1990)

Properties/gases	CO_2	CH_4	N_2O
Protective effect	1	39	150
Role of living beings, %	30	80	90
Residence time in the atmosphere, year	100	10	130

The total content of nitrous oxide in the atmosphere is estimated at 1500 Tr $N\text{-}NO_3^-$, and the concentration increases up to 320 ppb (Bowman, 1990). Annually, the concentration increases by 0.2-0.3%, and lately, the pace of this process has been increasing. Data on the content of nitrous oxide in frozen air bubbles in the glaciers of Antarctica and Greenland are usually used as a control initial concentration. According to those estimates, even 200 to 300 years ago it was at the level of 200-280 ppb, therefore, there is a shift in the dynamic balance of the content of nitrogen oxides in the atmosphere towards its constant increase, and the average annual intake of nitrogen oxides has increased by almost 50 %.

In addition to the formation of nitrogen suboxide in the biosphere, primarily in the soil, its absorption (reduction to N_2) is constantly taking place, and this poorly studied process can serve as another drain for N_2O (the so-called tropospheric drain).

Although the reduction of nitrous oxide can take place with the participation of four enzyme systems: Cu-dependent nitrous oxide reductase (rusticyanin), Mo-dependent nitrogenase, Ni–Fe-dependent dehydrogenase and Co-dependent synthase (Berks et al., 1995), in nature, this process is carried out, basically, with two groups of bacteria - denitrifiers and nitrogen fixers (Umarov, 1990; Cabello et al., 2004).

According to the results of research in the last two decades, there are significant differences between different types of soil in terms of the rate of formation and absorption of N_2O. Zonal soils are characterized by a balanced process of nitrogen suboxide formation and absorption, and the result is a relatively low emission of this gas. On the contrary, saline soils, as well as soils with a disturbed structure (arable eroded soils) are characterized by a low ability to absorb nitrogen-suboxide and therefore can have the property of its active "generator". These data indicate a special (possibly, leading) role of saline and eroded soils in the creation of nitrogen suboxide in global relations. Bearing in mind that more than 35% of land in the world is in a state of desertification and salinization, that it is subjected to aeolian and water erosion, and in the previous 50 years the speed of such degradation has increased by 30 times compared to the previous period (Jemcev and Đukić, 2000; Dobrovoljskij 2003; Đukić et al., 2018), the huge role of soil in changing the nitrogen-suboxide balance in the Earth's atmosphere is quite clear (Table 2).

Table 2. Area of degraded lands in the world (Dobrovoljskij, 2003)

The cause	Surface area	
	10^9 ha	%
Water erosion	1.09	55.6
Aeolian erosion	0.55	27.9
Chemical degradation (salination, pollution, etc.)	0.23	12.2

The nitrogen status of most terrestrial ecosystems has not yet been determined, because the extent of their participation in nitrogen transformation processes and its redistribution between the land and the atmosphere is unknown (Figure 2).

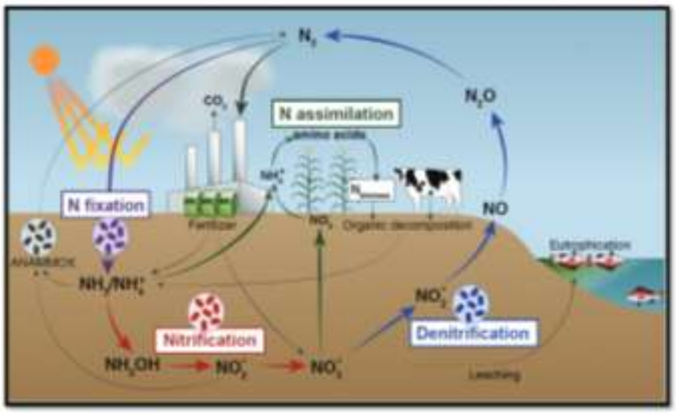

Figure 2. Nitrogen cycle (Martinz-Espinosa et al., 2023).

CONCLUSION

Looking at the dynamic balance of the earth's pedosphere and atmosphere, it can be concluded that the total nitrogen content in the earth's crust is about 0.03%, while the largest part of it is in the earth's atmosphere (about 4 x 10^{15}t) in the form of free (N_2) nitrogen, making up the main part (79%) air. Atmospheric nitrogen and its mineral forms (containing ions CN^-, NO_3^-, and NH_4^+) from the soil are concentrated in the composition of soil organic matter and the biomass of pro- and eukaryotes (some microorganisms, plants, and animals). Microorganisms play the greatest role in maintaining the dynamic balance of nitrogen in the earth's soil and atmosphere, including it in the biogeochemical cycle. Due to the disruption of that cycle, and thus the disruption of the dynamic balance between the nitrogen content in the soil and the atmosphere, global soil degradation occurs.

During the nitrogen fixation process, nitrogen reaches the biosphere, while during other processes (nitrification and denitrification) it is lost, conditionally, in the form of gases (N_2O) and molecular nitrogen (N_2). N_2 is responsible for the formation of the greenhouse effect and the depletion of the planet's ozone layer. It is significantly more aggressive than CO_2 and CH_4. The concentration of N_2O in the atmosphere is constantly increasing.
On the one hand, the process of creating N_2O is constantly taking place, and on the other hand, the process of its reduction to N_2, so this poorly studied process can serve as another drain of N_2O. Although N_2O reduction can be performed with the participation of four different enzyme systems, in nature this process is mainly performed by two groups of bacteria – nitrogen-fixing and denitrifying.
Different soils differ in the rate of formation and absorption of N_2O. While the ratio is balanced in zonal soils, it is not in saline and degraded soils.
The nitrogen status of most terrestrial ecosystems has not been determined, so the levels of their participation in nitrogen transformation processes and their redistribution between the land and the atmosphere are not known.

REFERENCES

Berks, B.C., Fergusson, S.J., Morr, J.W. (1995). Biochim. Biophys Acta, 1232(3), p. 97-173.
Bouwman, A.F. (1990). Soils and the Greenhouse Effect. J. Willey&Sons, p. 501.
Cabello, P., Roldán, M. D., Moreno-Vivián, C. (2004). Nitrate reduction and the nitrogen cycle in archaea. Microbiology, 150, 3527–3546.
Dobrovolskij, G.V. (2003). Strukturno-funkcionalnnaja rolj počv i počvennoj bioti v biosfere. M.: Nauka, p. 364.
Đukić, A.D., Jemcev, V.T., Kuzmanova, J. (2007). Soil Biotechnology, Budućnost, Novi Sad.
Đukić, A.D., Jemcev, V.T., Semenov, A.M., Iutinskaja, G.A., Selickaja, O.V. (2018). Ecological Biotechnology, Faculty of Agriculture, Čačak and the Balkan Scientific Center of the Russian Academy of Natural Sciences, Belgrade, book 1.
Jevmcev, V.T., Đukić, A.D. (2000). Microbiology, Military Publishing House, Belgrade.
Kovda, V.A. (1985). Biogeohimija počvennogo pokrova. M: Nauka.
LaSarre, B., Morlen, R., Neumann, G.C., Harwood, C.S., McKinlay, J.B. (2024). Nitrous oxide reduction by two partial denitrifying bacteria requires denitrification intermediates that cannot be respired. Appl. Environ. Microbiol., https://doi.org/10.1128/aem.01741-23.
Martinz-Espinosa, R.M., Ryusuke, H., Yupeng, W., Muhammad, S. (2023). Nitrogen dynamics and loads in soils. Frontiers in Environmental Science 11:1197902. doi:10.3389/fenvs.2023.1197902.
Meng, S., Peng, T., Liu, X., Wang, H., Huang, T., Gu, J.D., Hu, Z. (2022). Ecological Role of Bacteria Involved in the Biogeochemical Cycles of Mangroves Based on Functional Genes Detected through GeoChip 5.0. mSphere. 23,7(1): e0093621. doi: 10.1128/msphere.00936-21.
Orlov, D.S., Bezuglova, O.S. (2000). Biogeochemistry, Feniks.
Pruthviraj, N., Murali, K., Chaitanya, A., Harish, M.C., Karthik, A.N. (2024). Exploring the Dynamics of Nitrogen from Conventional Manures in the Soil Plant Atmosphere Continuum: A Comprehensive Review. Communications in Soil Science and Plant Analysis. doi:10.1080/00103624.2024.2323080.
Sardar, M.F., Youna, F., Zia, U.R.F., Yanli, L. (2023). Soil nitrogen dynamics in natural forest ecosystem: A review. Frontiers in Forest and Global Change 6:1144930. doi:10.3389/ffgc.2023.1144930.
Stojanova, T.M. (2018). Plant nutrition. Academic Press, Skopje.
Umarov, M.M. (1990). Soils and the Greenhouse Effect. J. Willey & Sons, p. 141-150.
Ward, B.B., Jensen, M.M. (2014). The microbial nitrogen cycle. Frontiers in Microbiology. doi: 10.3389/fmicb 00553.

THE IMPORTANCE OF KNOWING A FOREIGN LANGUAGE FOR SPECIFIC PURPOSES IN THE AGRICULTURAL SECTOR

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ABSTRACT

In the process of globalization, knowledge of a foreign language, and especially the language for specific purposes, is of great importance. A foreign language for specific purposes is primarily in the function of a profession and can be considered a communication upgrade of a general foreign language. Companies that operate outside the borders of the domestic market need to employ people who understand various social, cultural and communication aspects of business along with knowledge of professional terminology in order to be able to adapt to target markets. The basic goal of this paper is to determine the importance of knowing a foreign language for specific purposes in agricultural sector. The paper will analyze attitudes of employees in the agricultural sector about the importance of the language of a profession in a business environment. The intention is to determine how important knowledge of a foreign language for specific purposes is to employees that work in agricultural businesses, how often they use it and how important it is to them in their career advancement. The results of the research will give employers an idea of the level of knowledge of foreign languages of employees and of the possible needs for improvement of the foreign language for specific purposes, and educational institutions can gain insight into which part of the language competences in the context of knowledge of a foreign language for specific purposes is most needed by employers.

Keywords: agricultural business environment, foreign language for specific purposes, career advancement, foreign language competences

INTRODUCTION

In the process of globalization, or interaction and integration of people, knowledge of a foreign language, and especially the language for specific purposes, is of great importance. A foreign language for specific purposes is primarily in the function of a profession and can be considered a communication upgrade of general foreign language knowledge. In order to make the effectiveness of the use of a foreign language for specific purposes in everyday business communication as good as possible, a high level of both professional and linguistic and communication competences is required. In order to use a foreign language for specific purposes well, it is not enough to know a general-purpose language, but it is necessary to understand various social, cultural and communication patterns, to adopt professional terminology and terminology specific to a particular profession. Companies that operate outside the borders of the domestic market need to employ people who understand various social, cultural and communication aspects of business along with knowledge of professional terminology in order to be able to adapt to target markets.

The basic goal of this paper is primarily to determine, and then to raise awareness of the importance of knowing a foreign language for specific purposes in a business environment. The paper will present and analyze the attitudes of employees in the agricultural sector about the importance of the language for specific purposes in a business environment. The intention is to determine how important knowledge of a foreign language for specific purposes is to

employees employed in agricultural businesses, how much they know it, how often they use it, and how important it is to them in their career advancement. In this context, it is useful to conduct research to find out to what extent a foreign language is used, whether employees have sufficient knowledge of a foreign language, and how to enable the best possible improvement of knowledge of foreign language for specific purposes. This is important information for companies in the agricultural sector, but also for educational institutions. Based on the results of the research, in the final part, knowledge of a foreign language for specific purposes will be analyzed and guidelines will be provided for the possible improvement and improvement of language competences in the foreign language for specific purposes. The results of the research will give employers an idea of the level of knowledge of foreign languages of employees and of the possible needs for improvement of the foreign language for specific purposes, and educational institutions can gain insight into which part of the language competences in the context of knowledge of a foreign language for specific purposes is most needed by employers. This also gives employees the opportunity to consider how and to what extent it is necessary (or not) to improve the language for specific purposes
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CONCEPTUAL FRAMEWORK

The aim and purpose of this paper is to determine the importance of knowing a foreign language for specific purposes in the business environment of the agricultural sector. Also, the research conducted as part of the paper aims to raise awareness among employees in the agricultural sector of how important it is to know the language for specific purposes and the need for its improvement. The respondents will express their views on how important it is for them to know a foreign language for specific purposes, how much they know it, how often they use it, how important the language for specific purposes is for their career advancement, how important it is for them to improve it and how best they can improve it. Furthermore, it will be determined which foreign language for specific purposes is most often used and whether it is necessary to know more foreign languages for specific purposes. Based on the specific results obtained on a representative sample, a final conclusion will be made. Thus, the research will result in data on how much the language for specific purposes is known, which is the most important or most frequently used language in business communication and why. The research will also find out whether the knowledge of foreign languages for specific purposes of employees is sufficient to perform their business tasks and how important it is to know the language for specific purposes in the agricultural sector and how often a foreign language for specific purposes is used. The answers obtained from the respondents will reveal whether knowledge of a foreign language can enable a quick finding of a better job in the profession abroad, but also in the domestic labor market, whether knowledge of foreign languages affects the level of income and status within the company, and whether there is a need and desire to improve knowledge of the language for specific purposes and how knowledge of the language can best be improved. In short, the conclusions drawn will mainly talk about the use of foreign languages of the agricultural profession in the business environment of employees from the agricultural sector and how they assess the importance of their knowledge and improvement. In today's time of global warming, major droughts, weather disasters and climate disasters, food in general, and in particular the cultivation of healthy food as well as sources of clean water and food security in general, form the backbone of human existence and life. Therefore, agriculture is considered one of the most important economic sectors in the world. Any exchange of information, joint production, joint projects, discussions about challenges and crop cultivation, exchange of students, lecturers, academic mobility – all this requires experts who are not only competent in the field of agriculture, but also competent in linguistic expression and the transfer and exchange of knowledge and experiences. Berger et al. (2015) talk about the fact that communication at work is becoming increasingly important in the service sector and address the issues of the importance of a foreign language for the development of professional competences in an increasingly globalized working world. At the same time, companies are increasingly complaining about the lack of language and communication skills among job candidates. Language and communication skills play an important role in successful professional functioning (Sander, 2021), where the focus should certainly be on the area of oral communication skills with a mandatory professional vocabulary and listening and understanding (Brecht, W. 2000). The authors Tichy and Tesch (2021) present the thesis that the constantly growing international labor market requires more than ever language and professional knowledge related to work. The content of professional and technical language education is increasing in the curricula of philological and German studies at home and abroad. They are now an integral part of most study programmes. Hughes and Wallis (2010) selected the development of personal and professional competences including cultural awareness and intellectual competence, communication competence as well as personal autonomy and problem solving as a priority for improving learning outcomes and obtaining better employment opportunities abroad.

In its 2005 strategy for multilingualism, the European Commission stressed that encouraging EU citizens to learn foreign languages is very important for achieving the goals of European policies. This thesis was clarified in the ELAN study[1] in which around 2,000 medium-sized and small enterprises participated and answered questions related to determining the current situation. For example, it was found that companies that export are more productive than those that do not export their products and that such companies have advantages that they draw from contact with technical innovations, better knowledge of the market, cost savings and their own efficiency. It is an indisputable fact that foreign languages allow you to obtain better information about the business environment and new ideas about production, raw materials, commercialization and distribution channels. In practice, a distinction is often made between learning a general foreign language and a foreign language of a profession, while in entrepreneurship education we speak of learning a business foreign language. When we talk about learning a business foreign language, we must keep in mind that this process does not only include acquiring language knowledge in the sense of adopting appropriate business vocabulary, but is a much more complex process. Being linguistically competent in a business environment means knowing business etiquette, having appropriate social and presentation skills, knowing how to participate in a business meeting, knowing how to lead a meeting, being able to conduct a telephone conversation in a foreign language, being able to communicate in writing, knowing how to compose a memo, email, business letter, etc. All of these are skills and competencies that must be an integral part of learning a foreign language as part of entrepreneurship education (Šimunović et al., 2011). Based on the results of the research conducted, Cook et al. (2021) make a recommendation to the Government of Great Britain, that is, inform them about the problems that would improve the learning and employment outcomes of young people who speak languages other than English.

Knowledge of foreign languages in the context of the agricultural profession is particularly important today. Cooperation between countries is developing in the economy, culture, education, science, politics and agriculture. Therefore, the importance of knowledge of foreign languages stems from globalization and world trends in international cooperation and integration. Today, there is almost no job advertisement that does not list knowledge of a foreign language as a desired skill. Many companies today operate globally. Connectivity and the globalization trend have strengthened even more during the COVID-19 pandemic, and employees who speak more than one language have become a great advantage for employers. Employees who speak a foreign language are generally better paid than their colleagues.

[1] ELAN: Effects on the European Economy of Shortages of Foreign Language Skills in Enterprise. http://www.commercetalen.nl/media/11%20taalvaardigheden.pdf

Studies have shown that knowledge of a second foreign language increases wages by 11-35%. This percentage depends on the language you speak, the country in which you are employed and the demand for knowledge of a particular foreign language on the labor market (Liwiński, 2019). Employability skills emerged as a concept in the 1980s and are often referred to as generic skills, transferable skills, basic skills, essential skills, soft skills, foundational skills, core competencies, enabler skills or key skills. Many countries have developed national frameworks based on employability skills that serve as a guide for graduates and their potential employers. The dynamic environment in the world of work requires that these frameworks be updated frequently. In order for graduates to be successful in the labour market, they need to have the desired employability skills. These skills play an important role for diplomats in securing employment and succeeding in the workplace (Zaharim, 2009). A linguistically competent entrepreneur prevents potential cultural barriers, as well as those of a business nature. It is important to emphasize that language competences are acquired exclusively through continuous work and that this process must be well structured in order to achieve its purpose in entrepreneurship – business free from communication difficulties and cultural prejudices (Šimunović et al., 2011). Business communication is one of the most important segments of business and is an extremely important skill and activity for both managers and employees (Gibson, 2002). It takes place daily, and is reflected in the transfer, exchange and processing of information in all forms and methods of correspondence within the company as well as with the business environment, where in principle everyone is responsible, given the assigned tasks and authorities, for the effectiveness of their own communication (Ashley, 2003). Rouse M.J. and Rouse S. (2005) believe that communication that provides better quality, relevant, true, valid and timely information will be easier to understand, which means that managers of companies or business organizations, together with employees, will have better quality, valid and reliable information and data. Based on the above stated facts, it is clearly evident that the ability to apply knowledge of a foreign language in a professional context is a skill that is imperative today when it comes to employment and often becomes a decisive factor in employment or promotion.

METHODOLOGY

Research topic

The subject of this paper and research are the attitudes of employees on the importance of knowing a foreign language for specific purposes in a business environment. This paper will define which key language competencies an employee must have and how these competencies can be acquired. In addition, it will be shown that learning a business foreign language does not only mean acquiring business vocabulary and necessary terminology, but is a much more complex process that encompasses a wide range of knowledge. Business success is closely linked to language competencies and therefore education for successful operation in a business environment must include systematic learning of business foreign languages and communication skills. The data were collected in the form of a survey questionnaire that was conducted among employees in the following institutions: Ministry of Agriculture, Administrative Department for Agriculture, Rural Development and Forestry of Zagreb County, Payment Agency for Agriculture, Fisheries and Rural Development.

Ministry of Agriculture2 performs administrative and other tasks in the field of agriculture, fisheries, forestry, rural development, management and disposal of state-owned agricultural land, agricultural policy, market and structural support in agriculture, food and tobacco industry and veterinary medicine, namely: plant production and agroecology, protection of plant varieties and recognition of varieties of agricultural plants, trade and application of

[2] https://poljoprivreda.gov.hr/o-ministarstvu/9

fertilizers and soil improvers, plant health, trade and application of plant protection products, breeding of breeding animals, prescribes conditions for the production and trade of grapes, wine and other grape and wine products. The Administrative Department for Agriculture, Rural Development and Forestry operates within the Zagreb County and is organized with two internal organizational units, and related tasks and tasks are functionally classified according to groups of activities into the Department of Agriculture and the Department of Rural Development and Forestry.3 The Paying Agency for Agriculture, Fisheries and Rural Development4 is a public body responsible for the operational implementation of direct support measures, rural development measures, maritime and fisheries measures (in part of delegated functions) and common market organisation measures, as well as keeping registers and registers and maintaining and using the Integrated Administrative and Control System (IACS) through which direct payments to farmers are received, processed and controlled. Respondents were informed of the purpose of conducting the survey and the fact that the questionnaire was anonymous and voluntary. It was conducted in the state sector due to the greater availability of respondents, therefore the private sector was not included in the research.

Research method

In order to reveal the importance of knowing a foreign language for specific purposes in the business environment, research through a questionnaire and reference literature was used. Therefore, the knowledge necessary to understand the importance of knowing a foreign language in the business environment has its sources in domestic and foreign literature - books, scientific and professional magazines and articles, relevant pages on the Internet and in research through questionnaires.

The questionnaire has a total of 26 questions, of which the first three questions in the introductory part serve to collect demographic data. In the continuation of the questionnaire, questions were asked about how important knowledge of a foreign professional language is to employees, how well they know it, how often they use it, how important it is to them in career advancement, how important it is to them to improve it and how they can improve it best. The final part of the questionnaire refers to the assessment of what is most important in communication in a foreign language in a business environment, which is the most common foreign language for specific purposes and whether knowledge of several foreign languages for specific purposes is necessary. For the purposes of creating the paper, data was collected using a survey questionnaire. The Google Forms tool was used to create the survey questionnaire.

After obtaining the results through automatic data processing, percentages and average values were analyzed and the results were presented using graphs.

Analysis of the research problem

For the purpose of conducting this research, which was conducted in the Administrative Department for Agriculture, Rural Development and Forestry of Zagreb County, the Ministry of Agriculture and the Agency for Payments in Agriculture, Fisheries and Rural Development, the questionnaire was completed by 51 respondents. , of whom 51% were women and 49% were men. The survey was most frequently completed by respondents in the age group 51+ (43.1%), followed by the 41-50 age group (31.4%). 13.7% of respondents were in the 31-40 age group, while the rest of the respondents were in the 20-30 age group (11.8%). When asked about their level of education, the majority of respondents stated that they had a

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[3] https://www.zagrebacka-zupanija.hr/ustrojstvo/upravni-odjel-za-poljoprivredu-ruralni-razvitak-i-sumarstvo/o-odjelu/

[4] https://www.apprrr.hr/o-nama/

master's degree (62.7%), 17.6% stated a master's or doctorate, 11.8% had a higher education degree, and 7.8% had completed secondary school. Most respondents are employees with a university degree who have been learning a foreign language for many years, to be exact around 14 years. Analysis of the data on the question of how long respondents have been learning a foreign language indicates that most respondents have been learning and improving their knowledge of foreign languages for a period of 12 to 14 years (31.4%). A high percentage of respondents stated that they had been learning a foreign language for a period of 9 to 11 years (29.4%), while the number of respondents who had been learning a foreign language for 8 years or less, or more than 14 years , is equal (19.6%). Considering the age group of the respondents, i.e. that the largest number of respondents falls into the age group of 50+ and the group of 41 to 50 years when foreign languages were not yet learned from the first grade of primary school but only from the fifth grade, it can be concluded that most respondents learned and improved their knowledge of a foreign language for several more years after primary and secondary education and university. When asked how satisfied the respondents are with their knowledge of the foreign language(s) of their profession, it is clear that the majority of respondents (72.5%) are not completely satisfied with their knowledge of the foreign language of their profession. This indicates that the respondents, although they already have sufficient work experience in their profession and are largely highly educated, still need to improve their knowledge of the foreign language of their profession. Only 23.5% are satisfied with their knowledge of the foreign language of their profession, and a very small percentage (4%) are those who are not at all satisfied with their knowledge of the foreign language of their profession. The data indicate that the vast majority have sufficient knowledge of the foreign language of their profession, but given that the foreign language of their profession is taught at universities, it can be determined that those respondents who have not graduated from university are not satisfied with their knowledge of the foreign language.
The respondents assessed how important the knowledge of a foreign language for specific purposes is within the agricultural sector and the majority of respondents assessed the importance of knowing a foreign language for specific purposes as very important (31.4%) important (31.4%), which indicates that the knowledge of a foreign language for specific purposes in the agricultural sector is truly relevant. When we talk about how well the respondents know a certain foreign language in speech and writing and which language it is, the vast majority of respondents (68.6%) know English excellently in speech and writing, followed by German with 15.7%, and 27.5% of respondents do not know any foreign language excellently in speech and writing. A total of 6% of respondents know Italian, Slovenian and Hindi excellently in speech and writing. The results obtained are satisfactory and positive because the vast majority of respondents know at least one foreign language excellently in speech and writing, which significantly contributes to the value of the employee, but also to the institution in which he is employed. When asked whether respondents believed that they also had excellent oral and written knowledge of the language for specific purposes or whether they needed further training and development, 62.7% of the total number of respondents responded that they knew the foreign language for specific purposes excellently in oral and written form, 29.4% of the respondents responded that they did not know the language for specific purposes excellently in oral and written form, and 7.9% responded that they needed to improve their language competences in the area of knowledge of the foreign language for specific purposes. This question can be compared with the previous one and it can be established that those respondents who know the foreign language excellently in oral and written form also know the language for specific purposes excellently in oral and written form. When it comes to writing skills, it is clear that 31.4% of the respondents are more skilled in writing. The same number (31.4%) of the respondents have equal knowledge of the language in oral and written form, 29.4% of the respondents are

more skilled only in oral form, and 7.8% are not skilled in knowledge of the language for specific purposes either in oral or written form. Namely, most respondents state that they are more skilled in either speaking or writing or equally so, which means that they have largely mastered language skills, and they give a certain advantage to either speaking or writing skills only. In the context of the frequency of using a foreign language for specific purposes in a business environment, the results of the survey indicate that 35.3% of respondents use the foreign language for specific purposes very rarely, 23.5% of respondents use the language for specific purposes very often, 21.6% often, 11.8% of respondents use the foreign language for specific purposes every day, while 7.8% of respondents do not use the foreign language for specific purposes at all. From the above, it follows that employees in the agricultural sector use the language for specific purposes occasionally, and less often every day. The results of the survey also indicate that 84.3% of employees have sufficient knowledge of the foreign language for specific purposes to perform their business tasks, while 11.8% of respondents do not have sufficient knowledge that they need to function in a business environment. 3.9% of respondents believe that, depending on the situation, they sometimes have satisfactory knowledge of foreign languages for their profession to perform their work tasks, and sometimes not.

When asked about the need to use the Google Translate tool, 70.6% of respondents said they use the tool sometimes, which indicates that this tool is very useful regardless of their knowledge of a foreign language for specific purposes. 17.6% of respondents answered that they use the tool often, while 11.8% of respondents almost never use it. When it comes to the impact of knowing a foreign language for specific purposes on career advancement, in the institutions where the research was conducted, 45.1% of employees stated that based on knowing a foreign language for specific purposes, they may be able to advance, while 33.3% believe that they certainly can, while as many as 21.6% of respondents believe that knowing a foreign language for specific purposes is not a relevant factor for career advancement. According to the answers to the question whether knowledge of a foreign language for specific purposes can ensure a quick finding of a better job in the profession, it is evident that half of the respondents (58.8%) believe that knowledge of a foreign language for specific purposes may have an impact on quickly finding a new job or a better job, while 27.5% of the respondents believe that knowledge of a foreign language for specific purposes can have an impact on quickly finding a better job in the profession. 13.7% of the respondents believe that knowledge of a foreign language for specific purposes cannot have an impact on quickly finding a better job in the profession. The data indicate that knowledge of a foreign language for specific purposes in any case provides an additional advantage and the opportunity for employment in a better job. As part of the questionnaire, the respondents were required to state whether and in what way their lack of knowledge of a foreign language limits them in performing their work. The results show that lack of knowledge of a foreign language is a limiting factor when communicating with foreign partners and representatives of the European Union and the European Commission. Furthermore, the possibility of presenting and participating in international projects, consulting professional literature, etc. is made more difficult.

In the context of proposals for improving knowledge of a foreign language for specific purposes, the analysis of the research results shows that 64.7% of respondents believe that knowledge of a foreign language for specific purposes can be improved by communicating in a foreign language several times a week, while 54.9% of respondents believe that going abroad for a few months would be the right solution for improving knowledge of a foreign language for specific purposes. 6% of respondents responded that knowledge of a foreign language for specific purposes can be improved through courses, lifelong learning programs, and the creation of a professional dictionary or glossary. 68.6% of respondents responded that the best way to improve a foreign language is everyday communication in a business environment, 17.6% believe that these are individual courses, 9.8% group courses, and 4% online learning and learning through various applications. The most frequently asked question about which foreign language is considered the most important in business communication is, as expected, English, with respondents stating that they need English because it is the main, global and most widespread language used in the business environment. Respondents further state that communication in a foreign language is important to them because of communication with the European Commission, the large number of international projects and cooperation with EU countries, the use of IT terms and abbreviations, European legislation and seminars, and because the most literature, professional texts and computer programs are in English.

CONCLUSION AND DISCUSSION

Analyzing the results of the questionnaire, some answers were predictable, while some gave surprising results. Thus, the answers indicated very good, and in some respondents, excellent knowledge of a foreign language for specific purposes. However, self-criticism towards one's own knowledge was not absent, nor was the need for improvement. The vast majority of respondents know one language for specific purposes excellently in speech and writing, especially English, and it is the language most often used in business communication. German and Italian are also used to a lesser extent. It was concluded that English is the most necessary language in business communication and is most often used because it is a global language, the language in which professional literature is written, the language of information and communication technologies, etc. Also, in most cases, respondents declare that they have sufficient knowledge of foreign languages for specific purposes to perform their business tasks. However, the majority of employees use a foreign language only occasionally, and less often daily or often. Regardless of the frequency of use of a foreign language for specific purposes, the research shows that knowledge of a foreign language for specific purposes is of great importance in the agricultural sector, as indicated by the scores of 4 and 5 on the importance scale given by the majority of respondents (62.8%). Furthermore, the research found that knowledge of a foreign language for specific purposes does not affect the possibility of advancement to such an extent, but if a job in the profession were to be sought abroad or in another company involved in agriculture, the respondents believe that knowledge of a foreign language can enable a quick finding of a better job in the profession abroad, but also in the domestic labor market. When it comes to the level of personal income, the vast majority of respondents responded that knowledge of foreign languages does not affect the level of income, nor does it significantly affect the status within the company. The result is not surprising given that the respondents are public and civil servants and the level of their income is determined based on the Law on Salaries in the Civil Service and Public Services. For this reason, there is no possibility of additional remuneration or increase in personal income based on special knowledge and skills such as knowledge of a foreign language for specific purposes. It would certainly be interesting to investigate the situation in this regard in the private sector. Since there is always room for improvement, a significant number of respondents have a desire to improve, and they believe that the best way to improve a language is through everyday communication in a business environment, in addition to various courses, and going abroad for a few months would certainly be an advantage.

In the actual communication in a foreign language in a business environment, the majority of respondents give priority to the knowledge of the language for specific purposes and professional terminology, as well as sufficiently clear communication in order to be able to understand a certain topic related to a certain profession, over grammatically correct expression. For employees and employers, the importance of knowing a foreign language in a business environment is not only reflected in the execution and performance of a task, but also in the presentation of the overall picture of the company/institution and its employees, i.e. their ability to independently and confidently participate in various business activities in an international business environment. From the data obtained as part of the research, it can be concluded that employees within the agricultural sector know the foreign language for specific purposes very well and excellently. They are competent to represent their institution abroad or before a delegation of EU representatives in Croatia if necessary. They therefore have sufficient knowledge of the foreign language for specific purposes to perform their business tasks, as well as the ability to independently and confidently appear at various business events abroad. The research shows that the majority of respondents consider knowledge of a foreign language for specific purposes important, as evidenced by high scores in response to the question, regardless of the fact that further data indicate that the use of a foreign language for specific purposes is not that common. The importance of knowledge of a foreign language for specific purposes is supported by data indicating that knowledge of a foreign language for specific purposes has an impact on advancement as well as on quickly finding a better job in the profession. Communication skills in a foreign language for specific purposes and good knowledge of the language and professional terminology are important determinants in determining the level of personal income. This was not confirmed in this research due to the fact that the respondents are employees in public institutions where personal income is regulated by the Law on Salaries in the Civil Service and Public Services. Furthermore, based on the survey questionnaire, the results of which are presented and analyzed in the paper, it can be concluded that the need to improve a foreign language for specific purposes, primarily English, is one of the very important items that should be paid attention to when educating employees. It is important to emphasize that language competences are acquired exclusively through quality and continuous work. In order to improve the knowledge of a foreign language for specific purposes as much as possible and for employees to be as competent and successful as possible in business activities that require the use of a foreign language for specific purposes, it is necessary to develop language skills through everyday communication in the business environment and the organization of various courses. Further upgrading of knowledge should take place by sending employees to improve their language competences abroad with an evaluation that would measure the success and effectiveness of such a program or project.

Namely, by investing in human resources, institutions invest in the development of their business, and thus in success and international reputation. The questions in the survey questionnaire are largely focused on self-assessment of knowledge of a foreign language for specific purposes in order to somehow encourage the respondents themselves to question their own knowledge of the language for specific purposes and thereby become even more aware of how important it is to know a foreign language for specific purposes. The purpose of conducting the research was, among other things, to raise awareness among employees in the agricultural sector of the importance of the need to improve their foreign language for specific purposes, and the research confirmed that the importance of knowing a foreign language for specific purposes is of great importance.

REFERENCES

1. Agencija za plaćanja u poljoprivredi, ribarstvu i ruralnom razvoju, https://www.apprrr.hr/o-nama/ (accessed 12 May 2024)

2. Ashley, A. (2003): Commercial Correspondence, Oxford: Oxford University Press.
3. Janich, N. (2015): Fachsprache, Fachidentität und Verständigungs-
4. kompetenz – zu einem spannungsreichen Verhältnis Sprache und Beruf, Zeitschrift des Bundesinstituts für Berufsbildung, W. Bertelsmann Verlag 41. Jahrgang H 2015. https://www.bwp-zeitschrift.de/dienst/publikationen/de/6861 (accessed 22 November 2023).
5. Brecht, W. (2000): Bedeutung von Fremdsprachen für die Unternehmen. https://www.hueber.de/sixcms/media.php/36/Unternehmen.pdf (accessed 22 November 2023).
6. Cook, L., Hutchinson, V., Cara, O., Mallows, D., Tereshchenko, A. (2021). Policy Briefing: Education and employment outcomes of young people who use English as a second or additional language. https://www.bell-foundation.org.uk/app/uploads/2021/10/ESOL-policy-briefing-report-FV.pdf (preuzeto, 20. studenog 2023.).
7. ELAN: Effects on the European Economy of Shortages of Foreign Language Skills in Enterprise.
http://www.commercetalen.nl/media/11%20taalvaardigheden.pdf (accessed 02 November 2023).
8. Gibson, R. (2002): Intercultural business communication, Oxford: Oxford University Press.
9. Hughes, A., Wallis, S. (2010): Internationalisation at the University of Kent: Meeting the challenge of enhancing student mobility, International Focus, No. 62, pp 3.
10. Liwiński J. (2019): The wage premium from foreign language skills. https://link.springer.com/article/10.1007/s10663-019-09459-0 (accessed 20 November 2023).

11. Ministry of Agriculture of the Republic of Croatia, https://poljoprivreda.gov.hr/o-ministarstvu/9, (accessed 12 May 2024)
12. Rouse, M.J., Rouse, S. (2005). Poslovne komunikacije, Zagreb: Masmedia.
13. Sander, I.L. (2021): Berufssprach. https://bibliotekanauki.pl/articles/2056875.pdf (accessed 20 November 2023).
14. Šimunović, A., Letica, I. i Halter, K. (2011). Znanje stranih jezika kao jedna od ključnih poduzetničkih kompetencija. Učenje za poduzetništvo, 1 (1), 271-https://hrcak.srce.hr/130159 (accessed 02November 2023).
15. Tichy, E., Tesch, F. (2021): Deutsch in Fach und Beruf, Aktuelle Fragen und neue Ansätze der Fremdsprachenvermittlung, Peter Lang Verlag, https://www.peterlang.com/document/1058376#BigPicturePanel (accessed 04 January 2024).
16. Zaharim, A; Yuzainee, Y; Zaidi, O.M.; Azah, M; Norhamidi, M. (2009): Engineering employability skills required by employers in Asia. Proceedings of te 6th WSEAS conference on engineering education.
17. Administrative Department for Agriculture, Rural Development and Forestry, https://www.zagrebacka-zupanija.hr/ustrojstvo/upravni-odjel-za-poljoprivredu-ruralni-razvitak-i-sumarstvo/o-odjelu/, (accessed 12 May 2024)
18. Law on salaries in public service in the Republic of Croatia, O.G. 155/2023 https://narodne-novine.nn.hr/clanci/sluzbeni/2023_12_155_2359.html (accessed 08 May 2024).

DETERMINATION OF SOME MORPHOLOGICAL, PHYSIOLOGICAL AND COLOR VALUES OF NATURALLY GROWNING DANDELION (Taraxacum montanum (C.A. MEYER) DC.) PLANT COLLECTED FROM VAN LAKE AROUND

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ÖZET
Dağ hindibası (Taraxacum montanum), Asteraceae familyasına ait olan, Nisan ve Mayıs aylarında tarla kenarlarında, çayırlarda ve yol kenarlarında doğal olarak yetişen, sarı çiçekli, çok yıllık otsu bir bitkidir. Anadolu'da “acıgunek, guneyik, çıtlık ve arslandisi” olarak bilinse de en yaygın kullanılan adı “radika” dır. Bu çalışmanın materyalini oluşturan Taraxacum montanum bitki materyali, 2023 yılında Doğu Anadolu Bölgesi'nde Van Gölü çevresindeki doğal ortamından toplanmıştır. Bu çalışmada Van ilinde doğal yayılış gösteren Taraxacum montanum türünde bitki boyu, gövde genişliği, yaprak uzunluğu ve genişliği, azot denge indeksi, klorofil, flavonol ve antosiyanin içerikleri ile L*, a*, b*, Chroma ve Hue olarak yaprak renk değerleri belirlenmiştir. Bitki boyu 23.00±2.65 cm, gövde genişliği 0.43±0.15 cm, yaprak boyu 18.33±3.79 cm, yaprak genişliği 5.17±2.75 cm, azot balans indeksi (NBI) 55.33±15.73 dual indeks, klorofil 21.70±2.07 dual indeks, flavonol 0. 48±0.12 dual indeks, antosiyanin içeriği 0.04±0.02 dual indeks, renk değerleri ise yaprakta L*39.91±1.58, a*-12.37±0.65, b* 20.78±1.45, Chroma 24.19±1.58 ve Hue 120.79±0.43 olarak belirlenmiştir. Türle ilgili yeterli literatür bulunmamaktadır, bu nedenle yaygın kullanıma sahip türün detaylı araştırmalarının yürütülmesi gerekmektedir.
Anahtar Kelimeler: Azot Balans İndeksi, Renk değerleri, Taraxacum montanum

ABSTRACT
Dandelion (Taraxacum montanum) is a perennial herbaceous plant with yellow flowers, belonging to the Asteraceae family, which grows naturally in April and May on field edges, meadows and roadsides. Although the flower petals are yellow, the plant is called "dandelion". Although it is known as "acıgunek", "guneyik", "çıtlık" and "arslandisi" in Anatolia, the most commonly used name is "radika". Taraxacum montanum plant material, which constitutes the material of this study, was collected from its natural environment around Lake Van in the Eastern Anatolia Region in 2023. In this study, plant height, stem width, leaf length and width, nitrogen balance index, chlorophyll, flavonol and anthocyanin contents and leaf color values as L*, a*, b*, Chroma and Hue were determined in Taraxacum

montanum species which is naturally distributed in Van province. Plant height 23.00±2.65 cm, stem width 0.43±0.15 cm, leaf height 18.33±3.79 cm, leaf width 5.17±2.75 cm, nitrogen balance index (NBI) 55.33±15.73 dual index, chlorophyll 21.70±2.07 dual index, flavonol 0.48±0.12 dual index, anthocyanin content 0.04±0.02 dual index, color values were determined as L*39.91±1.58, a*-12.37±0.65, b* 20.78±1.45, Chroma 24.19±1.58 and Hue 120.79±0.43 leaves. There is insufficient literature on the species, so detailed research on this widely used species needs to be carried out.
Keywords: Colour value, Nitrogen Balance index, Taraxacum montanum

GİRİŞ

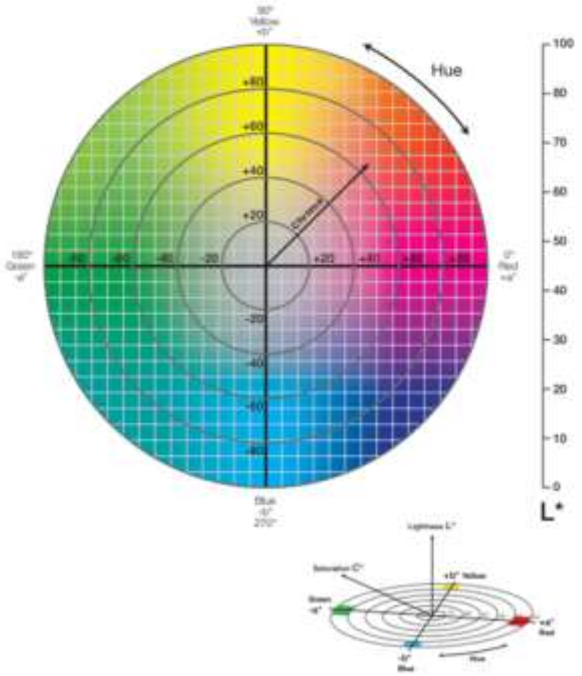
Asteraceae familyası 1000'e yakın cins ve 20.000 kadar tür içeren çiçekli bitkilerin en zengin familyalarından biridir (Tanker ve ark., 1993). Taraxacum cinsi de yaklaşık 2000 türden oluşur ve Asteraceae familyasının bir üyesidir. Yapılan bir çalışmada, bu cinsin dokuz kısma bölünen pek çok alttür ile yaklaşık 30-57 varyete içerdiği bulunmuştur (Schütz ve ark., 2006). Taraxacum cinsi ülkemizde toplam 55 tür sayısı ve 2 alt tür ile 57 taksona sahiptir. Bu türlerden biri olan Taraxacum montanum Türkçe'de Dağ hindibası olarak adlandırılmaktadır. Çok yıllık olan tür, otsu forma sahip genellikle kayalık yamaçlarda ve nemli alanlarda yayılış göstermektedir. Anadolu'nun hemen hemen her yerinde yayılışı bulunan türün (B7, B8, B9, C4, C5, C6, C9, C10) dünyada ise Kafkasya, Kuzey Irak, Kuzey İran ve Transhazar bölgesinde yayılışının olduğu bilinmektedir. Taraxacum sonchoides türün yaygın bir sinonimi olarak karşımıza çıkmaktadır.

Bu çok yıllık yabani bitki türü, eski tarihlerden beri tedavi edici özellikleri ile mide ekşimesi ve bulantısı, dalak ve karaciğer şikayetleri, hepatit ve anoraksi gibi türlü hastalıkların tedavisinde kullanılmaktadır (Schütz ve ark., 2006). Tarihte bitkinin kullanılışına ilişkin ilk kayıt, bu cinsin Grekçeden köken alan ve inflamasyon (yangı) anlamına gelen "taraxis" ve tedavi edici anlamına gelen "akeomai" kelimelerinden oluşan isminde belirtilmiştir. Tedavi amaçlı kullanımına ait ilk bulgular, 10. ve 11. yüzyıl Arap fizikçileri tarafından özellikle karaciğer ve dalak rahatsızlıklarında kullanıldığı yolundadır. 16. yüzyıldan bu yana Almanya, Batı dünyasında Taraxacum'un kullanımına ait en geniş kayıtları elde etmiştir. Alman fizikçi ve botanikçi Leonhard Fuchs, gut hastalığı, diyare, su toplanması, dalak ve karaciğer şikayetlerinde bu bitkinin kullanımını tanımlamıştır. Kuzey Amerikan aborijin tıbbında, bitkinin kökünden ve kendinden yapılan infüzyonlar ve dekoksiyonlar; böbrek rahatsızlıkları, disepsi ve mide ekşimesi tedavisinde kullanılmıştır (Sweeney ve ark., 2005). Ayrıca bu drog, kan temizleyici olarak düşünülmüş, geleneksel tıpta egzama ve cilt rahatsızlıklarının yanında eklem ve romatizmal hastalıkların tedavisinde de uygulanmıştır (Bisset ve ark., 1994). Tüm bitkiden hazırlanan dekoksiyon, Meksika'da geleneksel olarak Diabetes mellitus hastalığının kontrolünde kullanılmaktadır (Hernandez-Galicia ve ark., 2002). Geleneksel Türk tıbbında bu bitki, laksatif, diüretik ve kuvvetli anti diabetik olarak uygulanmaktadır (Ertaş ve ark., 2005).

Bu çalışmada Van ilinde doğal yayılış gösteren Taraxacum montanum türünün bitki boyu, gövde genişliği, yaprak uzunluğu ve genişliği, azot denge indeksi, klorofil, flavonol ve antosiyanin içerikleri ile L*, a*, b*, Chroma ve Hue olarak yaprak renk değerleri belirlenmesi amaçlanmıştır.

MATERYAL VE YÖNTEM

Çalışma materyalini Van yöresinde doğal yayılış gösteren Taraxacum montanum (C.A. MEYER) DC. türü oluşturmaktadır. Bitkilerden alınan çiçek ve yaprak örnekleri analizler için Van YYÜ Ziraat Fakültesi Tarla bitkileri bölümüne ait Fizyoloji ve Sitoloji laboratuvarlarına taşınmıştır. Yapılan flora çalışmasından elde edilen örneklerin morfolojik, fizyolojik ve renk özellikleri belirlenmiştir. Morfolojik ölçümlerden bitki boyu, gövde eni ve yaprak boyu dijital kumpas yardımıyla cm olarak tespit edilmiştir. Azot balans indeksi, klorofil, flavonol ve anthosiyanin içeriğinin ölçümü taşınabilir özellikte olan Dualex Scientific+™ cihazı ile gerçek zamanlı ve tahribatsız olarak yapılmıştır. Renk değerleri Minolta CR-400 (Osaka, Japan) marka renk ölçer ile L*, a*, b* C ve Hue° açı değeri olarak ifade edilmiştir. L* açıklık (L*=0 siyah ve L*=100 beyaz), a* kırmızı/yeşil (+a* kırmızı, – a* ise yeşil), b* sarı/mavi (+b* sarı, -b* mavi), Chroma canlılık veya matlık, Hue ise algılanan renk ve rengin ismini belirleyen değerlerdir (Anonim, 2024).



Şekil 1. L*, a*, b*, Chroma ve Hue değerinin renk aralığı (Anonim, 2024).

BULGULAR VE TARTIŞMA

Yürütülen çalışmada T. montanum türüne ait morfolojik ölçümler ve Dualeks ölçüm değerleri Çizelge 1'de verilmiştir. Elde edilen sonuçlara göre bitki boyu 23.0 cm, gövde genişliği 0.43 cm, yaprak boyu 18.33 cm ve yaprak eni 5.16 cm olarak tespit edilmiştir. Daha önce yürütülen çalışmalarda Taraxacum turcicum türünün bitki boyu 11,5-26.5 arasında değişiklik gösterdiği, yaprak boyunun 6.5-16 cm, yaprak eninin ise 1.8-5.3 cm arasında değişiklik gösterdiği bildirilmiştir (Abdullayeva, 2018). Taraxacum serotinum türünde ise bitki boyunun 16.0-36.5 cm arasında, yaprak boyunun 6.3-28 cm ve yaprak genişliğinin ise 1.5-7.2 cm arasında değişiklik gösterdiği bildirilmiştir (Abdullayeva, 2018).

Çizelge 1. T. montanum türüne ait morfolojik ölçümler ve Dualeks değerleri

Bitki Boyu (cm)	Gövde Genişliği (cm)	Yaprak Boyu (cm)	Yaprak eni (cm)	NBI (Dualeks index)	Klorofil (Dualeks index)	Flavonoid (Dualeks index)	Anthosiyanin (Dualeks index)
23,00 ± 2,65	0,43 ± 0,15	18,33 ±3,79	5,16 ± 2,75	55,33 ± 15,73	21,70 ±2,07	0,48 ± 0,12	0,04 ± 0,02

Bitki yapraklarında yapılan dualeks ölçümlerinde NBI 55,33 dualeks index, klorofil miktarı 21,70 dualeks index, flavonol miktarı 0,48 dualeks index ve anthosiyanin miktarı 0.04 dualeks index olarak tespit edilmiştir (Çizelge1.). Bir bitkinin bitki nitrojen durumunun klorofil ve flavonoid içerikleri aracılığıyla tahmin edilebileceği genel bir kabul olarak kabul edilmektedir (Agati vd., 2016). Nitrojen klorofil içine dahil edildiğinden (Evans ve ark, 2001) ve flavonoid içerikleri bitkideki N içeriğine zıt etki gösterdiğinden, klorofilin flavonollere oranının bitki nitrojen durumunun daha hassas bir göstergesi olduğu belirlenmiştir (Longchamps ve Khosla, 2014; Padilla ve ark, 2014).

Çizelge 2. T. montanum türüne ait yaprak renk değerleri

L	a	b	Chroma	Hue
39,91±1,58	-12,37 ±0,65	20,78±1,45	24,19±1,58	120,79±0,43

T. montanum türünün yaprak renk değerleri L*, a*, b*, chroma ve Hue cinsinden belirlenmiştir. L* değeri 39,91, a* değeri -12,37, b* değeri 20,78 olarak belirlenirken chroma değeri 24,19 ve Hue değeri ise 120,79 olarak tespit edilmiştir.

SONUÇ

Taraxacum cinsinin hem ülkemizde hemde Dünya genelinde doğal bir yayılış sergilediği ve eski tarihlerden beri tamamlayıcı geleneksel tıpta çeşitli hastalıkların iyileştirilmesinde kullanıldığı görülmektedir. Fakat literatür taraması yapıldığında hem cins bazında hemde T. montanum türü için yeterli araştırma, bilgi ve değerlendirme yapımadığı görülmektedir. Türün içerdiği biyoaktif bileşenlerinin ve etki mekanizmalarının araştırılması türün kıymetinin ortaya çıkarılması için gereklidir. Aynı zamanda bitkinin yetiştiricilik şartlarının verim ve kalite değerlerininde belirlenmesi gereklidir. Yaygın bir şekilde doğada bulunan bu ve buna benzer türlerin araştırma konusu olması, hem ticari ve kültür yetiştiriciliğine konu olabilecek yeni türlerin keşfedilmesini sağlayacak hemde ekonomik olarak bu türlerden getiri elde edilmesini sağlayacaktır.

REFERENCES

Abdullayeva N. (2018). Bursa ve Çevresinde Yayılışı Olan Taraxacum F.H. Wıgg. (Asteraceae) Türleri Üzerinde Taksonomik Araştırmalar. Bursa Uludağ Üniversitesi Fen Bilimleri Enstitüsü, Yüksek Lisans Tezi, Bursa.

Agati, G., Tuccio, L., Kusznierewicz, B., Chmiel, T., Bartoszek, A., Kowalski, A., Grzegorzewska, M., Kosson, R., Kaniszewski, S. (2016). Nondestructive Optical Sensing of Flavonols and Chlorophyll in White Head Cabbage Grown under Different Nitrogen Regimens. Journal of Agricultural and Food Chemistry 64: 85-94.

Anonim, 2024. https://leventkirca.com.tr/hue-acisi-nedir-excelde-hue-acisi-nasil-hesaplanir Erişim Tarihi:15.11.2024

Bisset, N. G., Phillipson, J. D., Czygan, F. C., Frohne, D. Höltzel, D., Nagell, A., Pfander, H. J., Willuhn, G., Buff, W. (Eds.) (1994). Herbal drugs and phytopharmaceuticals: A handbook for practice on a scientific basis, CRC Press, Boca-Raton, Ann-Arbor, London, Tokyo, pp. 486–489.

Ertaş, Ö. S., Aktaş, H. F., Haznedaroğlu, M. Z. (2005). Analysis of sodium and potassium levels in Taraxacum officinale by flame emission photometry, Acta Pharmaceutica Turcica, 47, 127–130.

Evans, C.A., Miller, E.K., Friedland, A.J., (2001). Effect of Nitrogen and Light on Nutrient Concentrations and Associated Physiological Responses in Birch and Fir Seedlings. Plant Soil 236: 197-207.

Hernandez-Galicia, E., Aguilar-Contreras, A., Aguilar-Santamaria, L., Roman-Ramos, R., Chavez-Miranda, A. A., Garcia-Vega, L. M., Flores-Saenz, J. L., AlarconAguilar, F. J., 2002, Studies on hyperglycemic activity of Mexican medicinal plants, In: Proceedings of theWestern Pharmacology Society, 45, 118–124.

Longchamps, L., Khosla, R. (2014). Early Detection of Nitrogen Variability in Maize Using Fluorescence. Agronomy Journal 106: 511-518.

Padilla, F.M., Peña-Fleitas, M.T., Gallardo, M., Thompson, R.B. (2014). Evaluation of Optical Sensor Measurements of Canopy Reflectance and of Leaf Flavonols and Chlorophyll Contents to Assess Crop Nitrogen Status of Muskmelon. European Journal of Agronomy 58: 39-52.

Schütz K, Carle R, Schieber A. (2006). Taraxacum--a review on its phytochemical and pharmacological profile. Journal of Ethnopharmacology,107(3), 313-323.

Sweeney, B.,Vora, M., Ulbricht, C., Basch, E., 2005, Evidence-based systematic review of dandelion (Taraxacum officinale) by natural standard research collaboration. Journal of Herbal Pharmacotherapy, 5, 79–93.

Tanker N, Koyuncu M, Coşkun M. (1993). Farmasötik Botanik. Ankara Üniversitesi Eczacılık Fakültesi Yayınları, No.70.

MORPHOLOGICAL CHARACTERISTICS AND COLOR VALUES OF Colchicum szovitsii FISCH. ET MEY. AND Colchicum kurdicum (BORNM.) STEF. SPECIES GROWING NATURALLY IN VAN REGION

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ÖZET
Geniş yayılış gösteren ve endemik olmak üzere çok sayıda bitki türüne sahip olan Türkiye, doğal bitkiler açısından en zengin ülkelerden biridir. Geofitler bu zenginliğin önemli bir parçasıdır. Bu floral zenginliğin bir parçası olarak geofitler, büyüleyici çiçekleriyle Türkiye florasının %15'ini oluşturmaktadır. Colchicum spp. türlerinin 3000 yılı aşkın süredir tıbbi bitki olarak kullanıldığı bilinmektedir. Colchicum türleri modern tıpta kolşisin gibi toksik ilaçlar için kullanılır. alkaloidlerin kaynağı olan kolinosinoid adı verilen terapötik olarak aktif bir alkaloiddir. Bunlar Gut, FMF (Ailevi Akdeniz Ateşi) ve Behçet hastalıklarının tedavisinde ilaç olarak kullanılmaktadır. Geofitler sadece tıpta değil aynı zamanda süs bitkisi endüstrisinde de kullanılmakta ve birçoğu güzel çiçekleri park ve bahçelerde süs bitkisi olarak kullanılmaktadır. Bu çalışmada Colchicum szovitsii Fisch. Et Mey. ve Colchicum kurdicum (Bornm.) Stef. türlerinin morfolojik ölçüm ve renk değerleri belirlenmiştir. C. kurdicum ve C. szovitsii türlerinin bitki boyu, bitki eni ve çiçek uzunluğu sırasıyla 11.33±1.15-10.83±0.76 cm, 2.17±0.76-0.53±0.15 cm ve 5.33±1.53-2.73±0.25 cm olarak belirlenmiştir. Türlerin yaprak, gövde ve çiçek salkımı gibi farklı organlarının renk değerleri her iki tür için de belirlenmiştir.
Anahtar Kelimeler: Azot Balans İndeksi, Colchicum sp., Renk değerleri,

ABSTRACT
Turkey, which has many plant species, both widespread and endemic, is one of the richest countries for natural plants. As a part of this floral richness, geophytes, with their charming flowers, comprise 15% of the Turkish flora. Colchicum spp. have been used as medicinal plants for more than 3000 years are known. Colchicum species are used in modern medicine for toxic drugs such as colchicine. a therapeutically active alkaloid called colchinosinoid which are the source of alkaloids. These are the cause of Gout, FMF (Familial Mediterranean Fever) and Behçet's are used as medicines in the treatment of diseases. Geophytes are not only are used not only in medicine but also in the ornamental plant industry, and many of them are beautiful flowers are used as ornamental plants in parks and gardens. In this study Colchicum

szovitsii Fisch. Et Mey. and Colchicum kurdicum (Bornm.) Stef. morphological measurement and color values were determined. The plant height, plant width and flower length of C. kurdicum and C. szovitsii species were 11.33±1.15-10.83±0.76 cm, 2.17±0.76-0.53±0.15 cm and 5.33±1.53-2.73±0.25 cm, respectively. Color values of different organs such as leaves, stems and inflorescence of the species were determined for both species and expressed as L, a, b, Chroma and Hue values.
Keywords: Colchicum sp., Colour value, Nitrogen Balance index

GİRİŞ

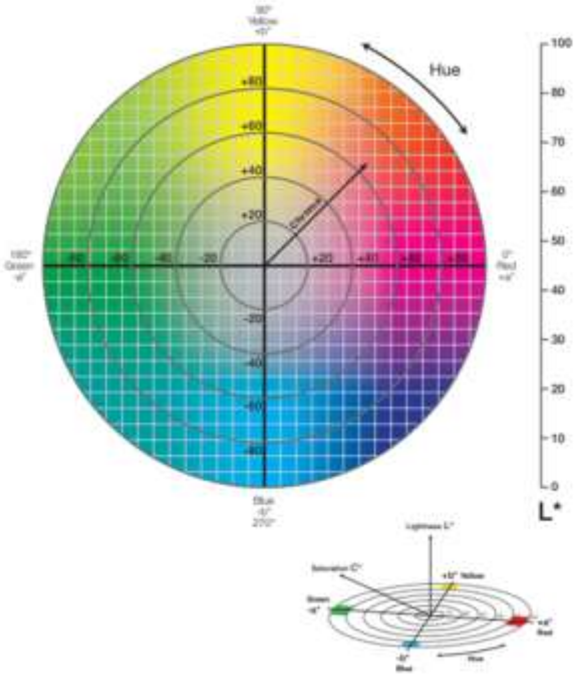
Acı çiğdem, Zambakgiller (Liliaceae) familyasına ait otsu ve kormlu yapıda olan çok yıllık bitkilerdir. Son yıllarda yapılan çalışmalarda tüm dünyada 99 civarında türün doğal yayılış gösterdiği ve bununla birlikte 49 tür ile Türkiye florasının ana gen merkezi olduğu kabul edilmektedir (Kaya, 2011). Türkiye'de doğal olarak yayılış gösteren yaklaşık 50 adet acı çiğdem türünün 22 tanesi endemiktir (Güner ve ark., 2002). Cinse ait türlerin bir kısmı ilkbaharda çiçek açarken bir kısmı da son baharda çiçek açmaktadır. Çalışma materyalini oluşturan türlerin ilkbaharda çiçek açtığı bilinmektedir (Kulaksız-Pişkin, 2022).

Liliaceae familyasındaki Colchicum cinsine ait bitkilerin tedavi edici etkileri yüzyıllar öncesine dayanmakta olup Dioscorides, Galen ve Tralesli İskender gibi birçok Yunan hekiminin tedavide kullandıkları kaydedilmiştir (Suhail ve ark. 2017). Colchicum türleri zehirli alkaloidler içermelerinden dolayı insan ve hayvan sağlığı açısından çok tehlikeli bitkilerdir (Yaldız ve ark., 2010). Bu alkoloitlerden biri olan Kolşisin ilk kez 1820'de Colchicum autumnale L. türünden Pelletier ve Caventou tarafından izole edilmiştir (Pandey ve Banik 2012). Saf kristalize formu Fransız eczacı Alfred Houde tarafından elde edilmiştir (Karamanou ve ark. 2018; Toader ve ark. 2021). Kolşisin, bitki ve hayvanlarda hücre bölünmesi üzerine güçlü inhibitör etki göstermektedir. Metafaz evresinin durdurulmasıyla hücre bölünmesi tamamlanamamakta ve antikanser etki ortaya çıkmaktadır (Akhtar ve ark. 2018). Kolşisin'in antimitotik ve antiinflamatuvar aktivite göstermesinden dolayı, kolşisin terapötik olarak gut artriti, ailevi Akdeniz ateşi, Behçet hastalığı, osteoartrit, çeşitli kardiyovasküler hastalıklar ve farklı kanser türlerinde kullanılmaktadır Türkiye'de preparatları olarak kolşisin ve türevlerinden hazırlanan ColchicumDispert®, Kolsin®, MuscoRil®, Muscoflex®, Adeleks®, Thiospa® bulunmaktadır (Kayaalp 2002; Kavalalı 2014; Ergül ve Bakar-Ateş 2021).

Bu çalışmada Van ilinde doğal yayılış gösteren Colchicum szovitsii Fisch. Et Mey. ve Colchicum kurdicum (Bornm.) Stef. türlerinin bitki boyu, gövde genişliği, yaprak uzunluğu ve genişliği ile yaprak, gövde ve çiçek olmak üzere farklı organların L*, a*, b*, Chroma ve Hue olarak renk değerleri belirlenmesi amaçlanmıştır.

MATERYAL VE YÖNTEM

Çalışma materyalini Van yöresinde doğal yayılış gösteren Colchicum szovitsii Fisch. Et Mey. ve Colchicum kurdicum (Bornm.) Stef. türleri oluşturmaktadır. Bitkilerden alınan çiçek ve yaprak örnekleri analizler için Van YYÜ Ziraat Fakültesi Tarla bitkileri bölümüne ait Fizyoloji ve Sitoloji laboratuvarlarına taşınmıştır. Yapılan flora çalışmasından elde edilen örneklerin morfolojik, fizyolojik ve renk özellikleri belirlenmiştir. Morfolojik ölçümlerden bitki boyu, bitki eni ve çiçek boyu dijital kumpas yardımıyla cm olarak tespit edilmiştir. Renk değerleri yaprak, gövde ve çiçek olmak üzere Minolta CR-400 (Osaka, Japan) marka renk ölçer ile L*, a*, b* C ve Hue° açı değeri olarak ifade edilmiştir (Şekil 1.). L* açıklık (L*=0 siyah ve L*=100 beyaz), a* kırmızı/yeşil (+a* kırmızı, – a* ise yeşil), b* sarı/mavi (+b* sarı, -b* mavi), Chroma canlılık veya matlık, Hue ise algılanan renk ve rengin ismini belirleyen değerlerdir (Anonim, 2024).



Şekil 1. L*, a*, b*, Chroma ve Hue değerinin renk aralığı (Anonim, 2024).

BULGULAR VE TARTIŞMA

Yürütülen çalışmada Colchicum szovitsii Fisch. Et Mey. ve Colchicum kurdicum (Bornm.) Stef.türüne ait morfolojik ölçüm değerleri Çizelge 1'de verilmiştir. Elde edilen sonuçlara göre C. kurdicum ve C. szovitsii türleri için sırasıyla bitki boyu 11,33 ve 10,83 cm, bitki eni 2,17 ve 0.53 cm, çiçek boyu 5.33 ve 2,73 cm olarak tespit edilmiştir. Daha önce yürütülen çalışmalarda C. szovitsii türü için olgunlaşma döneminde çiçek boyunun 1,5 cm ile 3,5 cm arasında değişiklik gösterdiği (Düşen ve Sümbül, 2007), C. kurdicum türünün ise çiçek alanının 10 santimetre kareden az olduğu bildirilmiştir (Şahin ve ark., 2021).

Çizelge 1. Colchicum kurdicum ve Colchicum szovitsii türlerine ait morfolojik ölçümler ve Dualeks değerleri(±Std)

Tür	Bitki boyu (cm)	Bitki eni (cm)	Çiçek boyu (cm)
C. kurdicum	11,33±1,15	2,17±0,76	5,33±1,53
C. szowitsii	10,83±076	0,53±0,15	2,73±0,25

C. kurdicum türü için L*, a*, b*, Chroma ve Hue olmak üzere sırasıyla yaprak renk değerleri 39,70, -9,79, 13,03, 16,21 ve 126,97, gövde renk değerleri 68,90, -5,12, 36,28, 36,65 ve 97,42 olarak belirlenirken çiçek renk değerleri 63,42, 5,23, 1,17, 6,82 ve 132,31 olarak belirlenmiştir. C. szowitsii türü için ise aynı şekilde sırasıyla yaprak renk değerleri 34,11, -3,54, 9,47, 9,12 ve 106,95, gövde için 69,90, -4,36, 23,94, 24,86 ve 101,92, çiçek için ise 65,09, 12,09, -5,22, 13,42 ve 340,40 olarak tespit edilmiştir. Birçok araştırmacı çilek (Tekin ve Çavuşoğlu, 2018), nohut (Aydoğan ve ark.,2014), ıspanak (Dadali ve ark., 2007) ve patlıcan (Taşova, 2018) gibi farklı bitkilerde renk değişimlerini L*, a*, b* Chroma ve Hue açı değeri cinsinden belirtmiştir. Çağındı ve Ötleş (2008), ıhlamur, siyah çay, adaçayı, kuşburnu, kekik, ısırgan, papatya, yeşil çay, nane ve biberiye bitkilerinin L*, a*, b* renk değişimlerini incelemiş ve renk değerleri ile toplam antioksidan aktivitesi ve toplam fenolik madde miktarı arasında korelasyon olduğunu saptamıştır.

Çizelge 2. Colchicum kurdicum ve Colchicum szovitsii türlerine ait yaprak, gövde ve çiçek renk değerleri(±Std)

Tür	Kısım	L	a	b	C	H
C.kurdicum	Yaprak	39,70±3,19	-9,79±1,77	13,03±2,66	16,21±3,07	126,97±1,88
	Gövde	68,90±3,31	-5,12±3,51	36,28±21,06	36,65±21,34	97,42±1,24
	Çiçek	63,42±11,0	5,23±2,015	1,17±0,68	6,82±4,05	132,31±21,02
C. szovitsii	Yaprak	34,11±4,83	-3,54±4,50	9,47±5,05	9,12±4,13	106,95±10,76
	Gövde	69,90±5,61	-4,36±3,39	23,94±3,97	24,86±4,80	101,92±9,37
	Çiçek	65,09±1,97	12,09±3,20	-5,22±4,17	13,42±4,42	340,40±13,60

SONUÇ

Colchicum cinsi halihazırda yaygın olarak çeşitli hastalıkların tedavisinde hem modern tıpta hem de alternatif (tamamlayıcı) tıpta yaygın olarak kullanılan bir cinstir. Fakat cinse ait türlerin morfolojilerinin, biyoaktif bileşenlerinin ve etki mekanizmalarının tür bazında aydınlatılması gerekmektedir. Bu sayede hem çeşitli doğal kökenli etken maddeler elde edilmiş hem de bu etken maddeler farklı alanlarda değerlendirilme imkanı bulmuş olacaktır. Aynı zamanda bitkinin yetiştiricilik şartlarının verim ve kalite değerlerininde belirlenmesi gereklidir. Yaygın bir şekilde doğada bulunan ve doğadan toplanarak piyasaya arz edilen bu ve buna benzer türlerin araştırma konusu olması, hem ticari ve kültür yetiştiriciliğine konu olabilecek yeni türlerin keşfedilmesini sağlayacak hemde doğal floranın korunmasını sağlayacaktır.

REFERENCES

Akhtar, S. ve Siddiqui, M. Z. 2018. Suranjan shirin (Colchicum autumnale): A review of an anti-arthritic Unani drug. The Pharma Innovation, 7(12), 09-12.

Anonim, 2024. https://leventkirca.com.tr/hue-acisi-nedir-excelde-hue-acisi-nasil-hesaplanir Erişim Tarihi:15.11.2024

Çağındı, Ö., Ötleş, S., & Bornova, İ. (2008). Farklı demleme sürelerinde hazırlanan bitki çaylarının antioksidan aktiviteleri ile renkleri arasındaki korelasyonun belirlenmesi. Türkiye, 10, 21-23.

Düşen, O. D., & Sümbül, H. (2007). A morphological investigation of Colchicum L.(Liliaceae) species in the Mediterranean region in Turkey. Turkish Journal of Botany, 31(5), 373-419.

Ergül, M. ve Bakar-Ates, F. 2021. Investigation of molecular mechanisms underlying the antiproliferative effects of colchicine against PC3 prostate cancer cells. Toxicology in Vitro, 73, 105138.

Güner, A., Özhatay, N., Ekim, T. and Başer, K., 2002. Flora of turkey and east Aegean islands. XI volumes, ISBN:1–55297–673–4. USA. 224.

Kavalalı, G. 2014. Bitkisel Aktif Madde Olan Kolşisin'in Etnofarmakolojik Yönden Değerlendirilmesi. Mersin Üniversitesi Tıp Fakültesi Lokman Hekim Tıp Tarihi ve Folklorik Tıp Dergisi, 4(1) 16-18.

Karamanou, M., Tsoucalas, G., Pantos, K. ve Androutsos, G. (2018). Isolating colchicine in 19th century: an old drug revisited. Current Pharmaceutical Design, 24(6), 654-658.

Kaya, E., 2011. Türkiye'nin doğal süs bitkileri kataloğu. Atatürk Bahçe Kültürleri Merkez Araştırma Enstitüsü Yayınları, Yayın No:91, s:272.

Kayaalp, O.S. 2002. Farmakolojiye Giriş, Rasyonel Tedavi Yönünden Tıbbi Farmakoloji. 10th ed. Ankara: Hacettepe-Taş Kitapçılık

Kulaksız Pişkin, B. 2022. Colchicum variegatum L. Üzerinde Farmakognozik Araştırmalar. İstanbul Üniversitesi Sağlık Bilimleri Enstitüsü

Pandey, D. K. ve Banik, R. M. 2012. Optimization of extraction conditions for colchicine from Gloriosa superba tubers using response surface methodology. Journal of Agricultural Technology, 8(4), 1301-1315.

Sahin, E. C., Kaya, E., Tuyel, U., Aydin, Y., Ozhatay, N., & Uncuoglu, A. A. (2021). An assessment on the floristic variety of Colchicum genus of Turkey in terms of morphological characteristics. Scientia Horticulturae, 287, 110251.

Suhail, S., Shakir Jamil, S. ve Jilani, S. 2017. Phytochemical and Pharmacological Review of Suranjan Shireen (Colchicum autumnale). Indo American Journal of Pharmaceutical Res, 7(4), 8492-6.

Toader, M. P., Esanu, I. M., Taranu, T., Mocanu, M. ve Toader, S. (2021). Colchicine in the treatment of refractory aphthous ulcerations: Review of the literature and two case reports. Experimental and Therapeutic Medicine, 21(3), 1-1.

Yaldız, G., Yüksek, T. ve Şekeroğlu, N., 2010. Rize ili florasında bulunan tıbbi ve aromatik bitkiler ve kullanım alanları. 3. Ulusal Karadeniz Ormancılık Kongresi 20– 22 Mayıs 2010, Artvin, s:1100–1114.

gelişim süreci geçmişten günümüze ekim makinaları alanında da önemli avantajlar sağlamıştır. Bu çalışmada, ekim makinalarında kullanılan güncel teknolojilerin derlenmesi amaçlanmıştır.

Gereç ve Yöntem: çalışma amacı doğrultusunda ekim makinaları ile ilgili gelişmeleri belirlemek amacıyla bilimsel çalışmalardan ve imalatçı firmaların güncel verilerinden yararlanılmıştır.

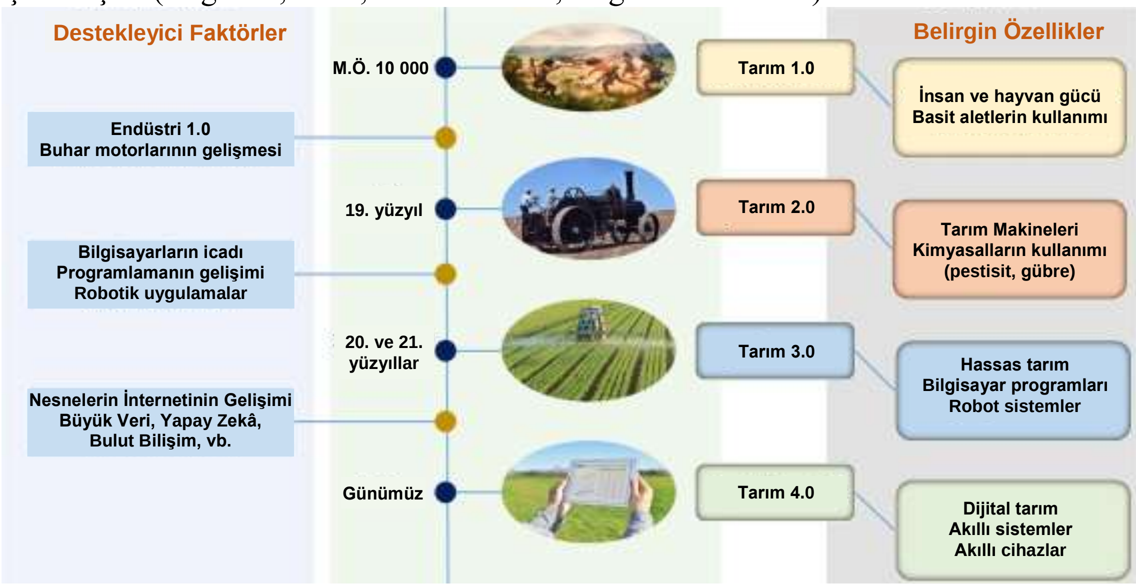
Bulgular ve Tartışma: Ekim makinaları alanındaki evrimsel süreç, Tarım 1.0 ile ekim-dikim işlerinin insan gücü ve hayvan kuvvetine dayanan basit aletlerin kullanılmasıyla başlayıp, Tarım 4.0'ın çerçevesini oluşturan akıllı tarım sistemleriyle devam etmektedir. Yapılan çalışmalara göre, ekim makinalarındaki gelişmelere en büyük katkıyı sağlayan teknolojiler; bir tarım makinasını akıllı bir sisteme dönüştüren algılayıcılar ve değişken oranlı uygulama teknolojileri olduğu anlaşılmaktadır. Bu ve benzeri teknolojileri ve katkılarını; ekim homojenliğinin gerçek zamanlı kontrolü, tarladaki değişkenliğe göre bastırma kuvvetini ayarlayan akıllı baskı sistemleri, sensörlü tohum tekleme düzenleri, otomatik bölüm ve oran kontrolünün sağlandığı değişken oranlı ekim sistemi, farklı nem koşullarında hızlı ve kolay ekim derinliği sağlayan nem sensörleri, ekim işleminde makinanın performansını düşürmeden ekim hızının artırılabildiği sensörlü tohum borusu sistemi, arazinin eğimli hatlarına göre ekim işleminin yapılabildiği otomatik dümenleme sistemi vb. şeklinde sıralamak mümkündür.

Sonuç: Bu teknolojiler sayesinde, ekim işleminde yatay ve dikey tohum dağılım düzgünlüğünün iyileşmesinin yanı sıra, hem tohumdan tasarruf hem de daha kaliteli bir ekim işlemiyle üreticiye yüksek kar sağlanabilir.
Anahtar Kelimeler: Ekim Makinaları, Akıllı Sistemler, Ekim Tekniği, Yeni Teknolojiler.

GİRİŞ

Geçmişten günümüze teknolojinin ulaştığı düzey insanlık tarihi boyunca yığışımlı bir birikimin sonucudur. Binlerce yıl öncesinden başlayan teknolojik evrim, 18. ve 19. yüzyıllarda hızlı bir gelişme ve yenilenme sürecine girmiş, insan ve hayvan gücü kullanımının çok ötesinde bir güç olan buhar makineleri ve bu makinelerle özdeşleşen sanayi devrimiyle ivme kazanmış, 21. yüzyıla gelindiğinde ise bilgi çağıyla devam eden bir süreklilik kazanmıştır (TMMOB, 2004). Bu süreç, inovasyon ve araştırma yoluyla doğal kaynakların kullanımını rasyonalize edebilen kalkınma modellerini pekiştirerek sürekli bir gelişim içerisinde olmuştur. Aynı süreç, tarım mekaniğinin agronomik tekniklere paralel gelişmesine, iş gücünün daha verimli kullanılmasına ve ekipmandan rasyonel olarak yarar sağlayabilmek için teknolojik çözümler sunmuştur. Tarımdaki bu teknolojik gelişim, geleneksel tarım uygulamalarından başlayarak Tarım 4.0'a doğru gelişen kademeli ve uzun vadeli bir süreci kapsamaktadır.

Tarım tekniğindeki evrimsel sürecin ilk ve en uzun aşaması olan Tarım 1.0, insan gücüne ve hayvan kuvvetlerine dayanan basit aletlerin kullanıldığı ve ürün verimliliğinin düşük olduğu geleneksel tarımı ifade etmektedir (Zhai vd. 2020; Gagliardi vd. 2022). Tarımsal üretim gerçekleştirilirken, 17. yüzyılın ortalarına kadar tarım makinalarından söz etmek çok mümkün değildi. Adı geçen yüzyılda Joseph Locatelli tarafından geliştirilen ekim makinasının tasarımı ve bu ekim makinasının 18. yüzyılda Jehtro Tull tarafından geliştirilmesi, yine aynı yüzyılın sonunda da James Cook (1785) tarafından bugünkü ekim makinalarının ilk modelinin geliştirilmesi, tarımsal üretimde makine kullanımının ayak sesleri olarak gösterilebilir (Önal, 2011; Fagnani, 2023). 19. yüzyılda geliştirilen buhar motorlarının endüstride olduğu gibi tarımda da yaygın olarak kullanılmaya başlanması, Tarım 2.0 olarak adlandırılan sürecin başlamasına öncülük etmiştir. Bu aşama, çiftçilerin etkinliğini ve üretkenliğini önemli ölçüde artırırken, kimyasal kirlenme, aşırı güç tüketimi ve doğal kaynakların zarar görmesi gibi birçok zararlı soruna neden olmuştur. Yirminci yüzyılda bilgi işlem ve elektroniğin hızlı gelişmesiyle Tarım 3.0 ortaya çıkmıştır. Otomasyon ve robotiklerin kullanıldığı Tarım 3.0'da tarım makineleri arasında verimli iş dağılımları sağlanarak Tarım 2.0'da sebep olunan çevre sorunlarının üstesinden gelme, kimyasal kullanımını azaltma, sulama hassasiyetini artırma gibi gelişmeler sağlanmış ve bu süreç "hassas tarım" kavramını ortaya çıkarmıştır (Zhai vd. 2020; Gagliardi vd. 2022). Tarım 4.0 ise güçlü bir ekonomi, çevresel ve sosyal etki ile sektöre önemli katkılar sağlamaktadır (Şekil 1). Son devrimin çerçevesini, nesnelerin interneti, büyük veri, derin öğrenme, yapay zekâ, modelleme ve simülasyon uygulamaları, bulut bilişim, uzaktan algılama, kablosuz sensör ağı, otonom traktörler, robotik uygulamalar vb. kaynaklar oluşturmuştur (Özgüven, 2018; Zhai vd. 2020; Gagliardi vd. 2022).

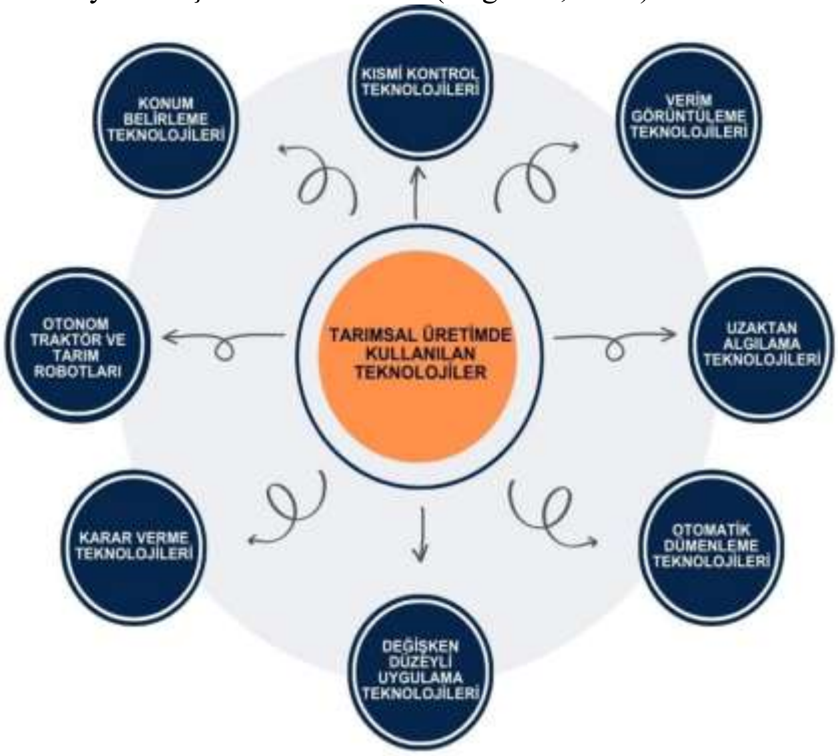


Şekil 1. Tarımda teknolojik evrim süreci (Zhai vd. 2020'den uyarlanmıştır)

Tarımsal üretimde mekanizasyon aşamaları; toprak işlemeyle başlayıp, ekim-dikim, bakım, gübreleme, sulama, zararlılarla mücadele ve hasat-harman süreciyle tamamlanmaktadır. Tarımsal üretim geleneksel çiftçilik yöntemleriyle gerçekleştirildiğinde, elde edilen ürünün önemli bir bölümü hasat işleminden önce kaybolmaktadır. Bu kayıplar, çiftçiyi zarara uğratmakla beraber önemli bir de karbon ayak izi bırakmaktadır. Bu durumu kontrol altına almanın yolu üretimin bütün aşamalarında günümüz teknolojilerinden optimum düzeyde yararlanmaktır. Tohum yatağı hazırlığını takiben yapılan ekim işleminde, tohumun toprakla teması sağlandıktan sonra geriye dönüş olamamaktadır. Bu aşamada gerekli önlemler alınmadığında veya alınamadığında ileride meydana gelecek ürün kayıplarına da zemin hazırlanmış olmaktadır. Oysaki tohumun bırakıldığı derinlik, her bir bitki için ayrılan alan, tohumun çizi içerisinde bastırılma miktarı ve çizinin kapatıldığı toprağın sıkıştırılma derecesi vb. hususları günümüz teknolojileriyle tespit etmek mümkündür. Bu nedenle, mevcut derleme kapsamında, bitkisel üretimin ekim aşamasında ekim işlemini kolaylaştıran, daha güvenli ve kaliteli bir ekim yapılmasını temin eden; ekim makinalarının ekim sürecinde ön plana çıkan bazı ünitelerinin gelişimini veya iyileştirilmesini sağlayan yeni teknolojiler hakkında bilgiler verilmiştir.

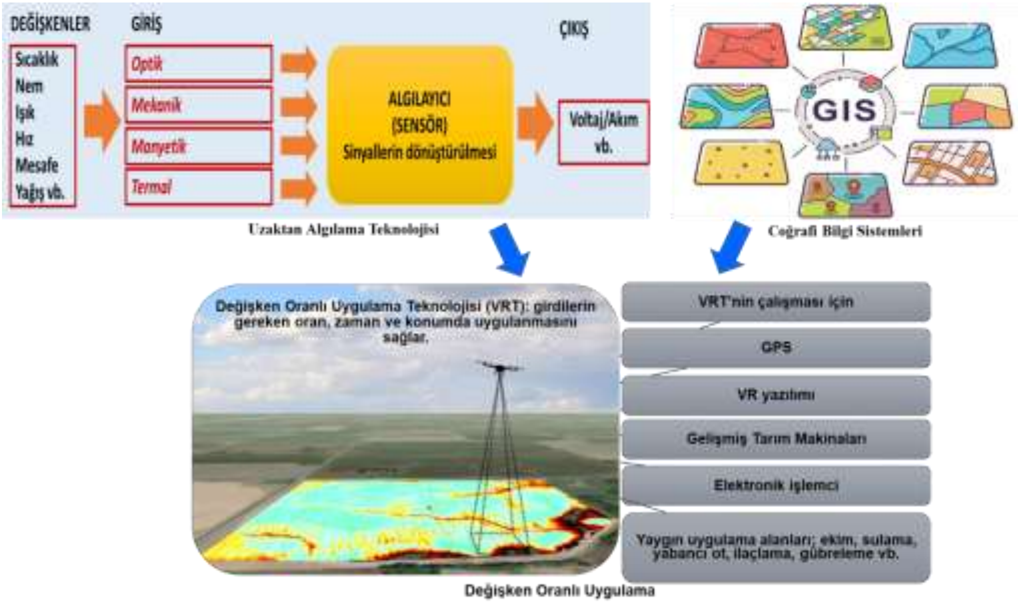
TARIM MAKİNALARINDA KULLANILAN GÜNCEL TEKNOLOJİLER

Dünya nüfusundaki hızlı artış ve buna bağlı olarak kaynaklardaki hızlı tükeniş, gıda talebini daha yüksek ve daha akıllı çiftçilik sistemlerine itmektedir. Bu karmaşıklık, çevreyi korurken minimum kaynakla maksimum çıktıyı hedefleyen hassas tarım tekniklerinin entegre edilmesini içeren bütünsel bir yaklaşımı ortaya çıkarmıştır. Bu yeni tarım tekniğinin uygulanmasında çok sayıda teknolojiden yararlanılmaktadır (Şekil 2). Bu teknolojilerin en çok kullanıldığı ve bir kontrol merkezi olarak yararlanılan tarım makinası traktörlerdir. Bir işletmeye satın alınacak tarım traktörünün akıllı sistemlerle donatılmış olması toprak işlemeden başlayıp hasat işlemiyle sonlanan üretim sistemini olumlu yönde etkileyecektir. Bununla birlikte, üretim aşamasında akıllı sistemlerle donatılmamış olsa bile sorun teşkil etmeyecektir. Çünkü bir tarım makinası, üretim aşamasında akıllı sistemlerle donatılmamışsa bile, akıllı bir makineye dönüştürülebilmektedir (Özgüven, 2022).



Şekil 2. Tarım makinalarının akıllı sistemlere dönüştürülmesinde kullanılan teknolojiler

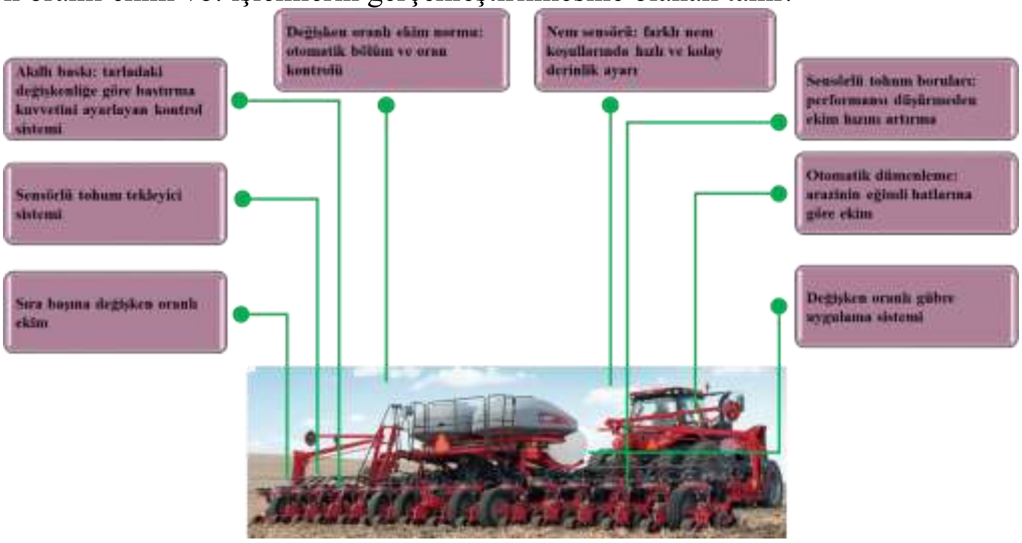
Bir tarım makinasının akıllı bir sisteme dönüştürülmesindeki önemli teknolojilerden birisi uzaktan algılama sistemidir. Uzaktan algılama, herhangi bir fiziksel temas olmaksızın veri toplanmasıdır. Bu sistemin en önemli elemanlarından birisi sensörler/algılayıcılardır (Grisso et al., 2011). Sensör, bir sistemde, sistem dışından gelen uyarılara tepki vererek algılayan ve önceden belirlenmiş değişkenleri ölçen cihazlardır. Bu teknoloji, günümüz tarım makinalarında yaygın olarak kullanılan ve kullanıldığı makinalara önemli özellikler kazandıran yeni nesil teknolojiler arasında yer almaktadır (Şekil 3). Uzaktan algılama sisteminin coğrafi bilgi sistemleri gibi diğer günümüz teknolojileriyle kullanımı sonucunda harita veya sensör bazlı değişken oranlı uygulama teknolojilerine olanak verir.



Şekil 3. Yeni teknolojilerin kullanımına temsili bir örnek

EKİM MAKİNALARINDA TEKNOLOJİK GELİŞMELER

Teknolojik evrim, uydu alıcılarıyla birlikte, hem traktörün hem de çalışılan makinelerin izlenmesini veya otomasyonunu desteklemek için bilgisayarlar aracılığıyla yönetilen birçok sensörün varlığına yol açmıştır (Özgüven, 2022). Bu teknolojiler, ekim makinalarında, tohum dağılımının gerçek zamanlı kontrolü, sensörlü tohum tekleyiciler, sensörlü tohum boruları, akıllı baskı sistemleri, ekim işleminde tohumun bırakıldığı derinlik, toprağın tuzluluk, nem, organik madde, besin içeriği değerleri; yine ekim işleminde otomatik sıra ve bölüm kontrolü, değişken oranlı ekim vb. işlemlerin gerçekleştirilmesine olanak tanır.

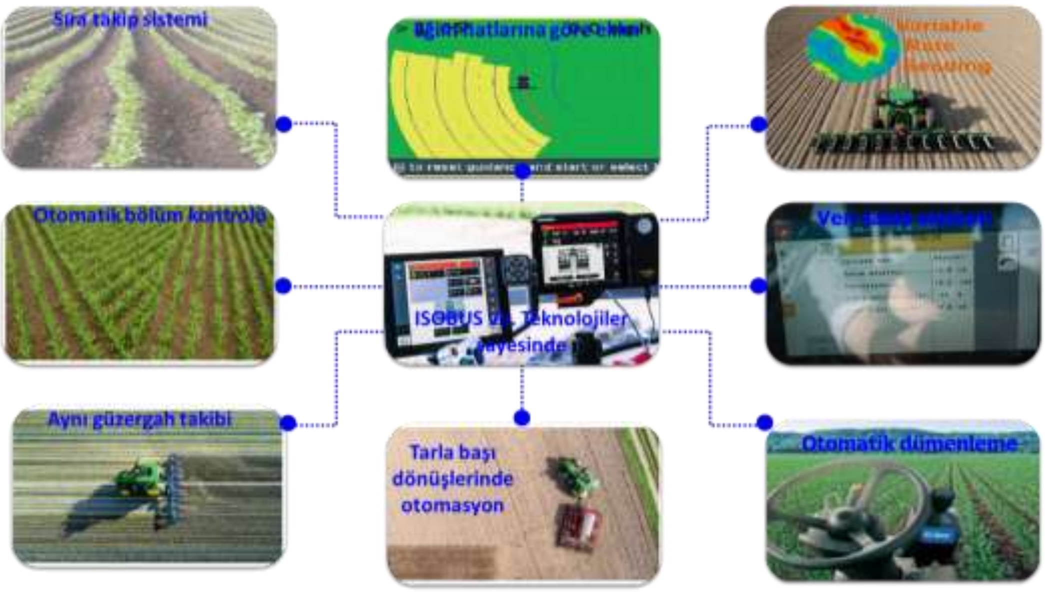


Şekil 4. Ekim makinalarında kullanılan bazı yeni teknolojiler (Anonymous, 2015; Görsel)

Veri Kontrol ve Takip Sistemi

Veri takip ve kontrol sistemi sadece ekim makinalarının değil, diğer bütün tarım makinalarının traktöre entegre edilmesini sağlayan ve buna bağlı olarak değişken oranlı uygulamanın ayar, kontrol ve takibinin yapıldığı ISO-BUS vb. teknolojilerden oluşmaktadır. Bu sistem, ekim, ilaçlama, gübreleme vb. tarım makinalarında araziye yapılacak uygulama bilgilerinin manuel veya yazılım yöntemleriyle traktör kabinindeki terminale iletilmesini;

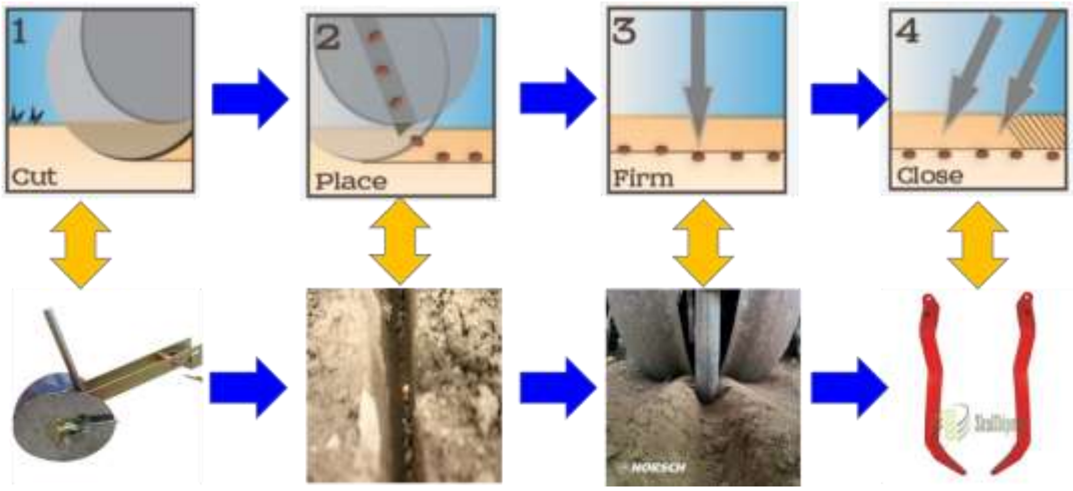
toplam işlem yapılan alan, kullanılan tarımsal üretim materyalinin miktarı, gerçek iş zamanı, GPS (global positioning system) verileri vb. bilgilerin kayıt altına alınmasını ve çiftlik yönetim yazılımlarına aktarılması sağlamaktadır. Bu sistem sayesinde, traktör direksiyonuna entegre edilen bir elektrik motoru aracılığıyla otomatik dümenleme, tarla başı dönüşlerinde kolaylık, farklı tarla işlemleri için aynı güzergah takibi, tarlanın eğim hatlarına göre ekim, sıra takip ve otomatik bölüm kontrolü vb. işlemlerin yapılmasında da önemli avantajlar sağlamaktadır. Ayrıca, traktörün ilerleme hızına göre ekim makinasının ayarlanmasını ve tohum ekiminin eşit aralıklarla yapılmasına olanak tanımaktadır. Bunların yanı sıra, RTK (real-time kinematic) GPS kullanılarak ekim makinasının yüksek hassasiyette konumlandırılması ve ekim işleminin düz-stabil hatlar şeklinde yapılması sağlanır. Tohum borusu kullanılan ekim makinalarında ise tohum boruları üzerinde yerleştirilebilen optik okuyucular sayesinde tohum sayımı yapılabilmekte, ekim ünitesi ve depo içerisine yerleştirilen sensörler vasıtasıyla da tıkanma, arıza ve tohum deposu doluluk bilgileri terminale iletilebilmektedir. Bunların yanı sıra, ekim makinalarında kolaylık sağlanan diğer bir husus sıra arası mesafelerin ayarlanmasıdır. Özellikle çapa bitkileri için kullanılan bir hassas ekim makinası sıra arası farklı olan bitkilerin ekimi için kullanılmak istendiğinde ekim ünitelerini ana kiriş üzerine bağlayan kelepçelerin gevşetilerek yapılması gerekmektedir. Belli bir iş gücü gerektiren bu işlemde bir mekanizma sayesinde kabinden kolaylıkla yapılabilmektedir.



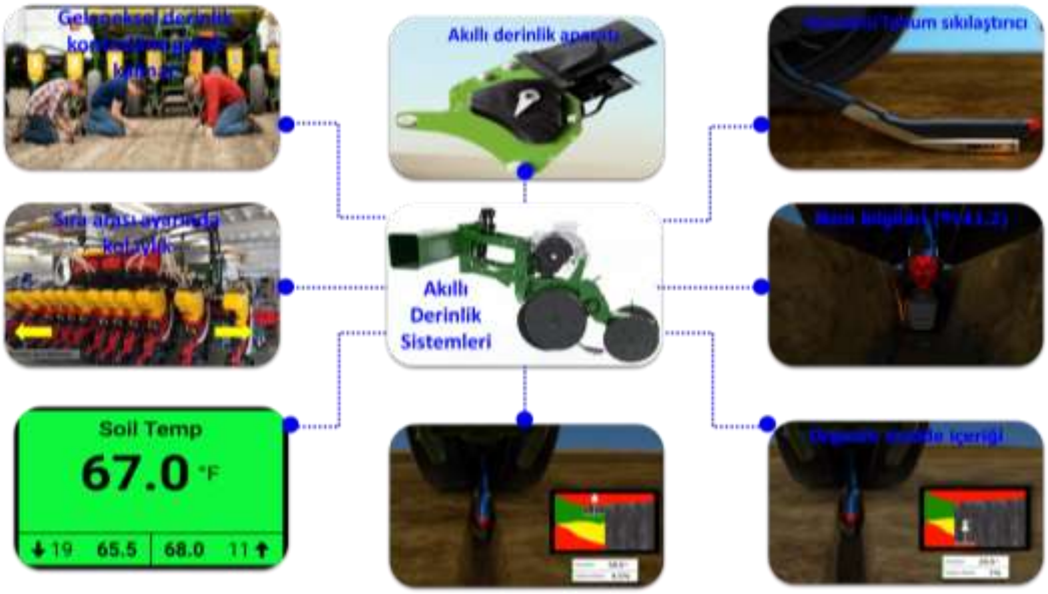
Şekil 5. Traktörlerde kullanılan ISOBUS vb. teknolojiler sayesinde ekim makinalarında sağlanan gelişme ve iyileştirmeler (Brodsky, 2023)

Ekim Makinalarında Akıllı Derinlik Ayarı ve Kontrol Sistemleri

Ekim işlemi esnasında tohumun toprağa yerleştirilme süreci dört aşamada gerçekleşir (Şekil 6). Bu aşamalar, tohumun gömüleceği uygun derinliği ayarlayabilmek için tarla yüzeyindeki anız ve toprağın kesilerek çizinin açılması, açılan çizinin tabanına tohumun uygun bir şekilde yerleştirilmesi, belirli oranda basınç uygulanarak tohumun toprakla temasının sağlanması ve çizinin gevşek bir toprak tabakasıyla kapatılarak çimlenmeye ve çıkışa ortam oluşturulması olarak ifade edilebilir (Önal, 2011).



Şekil 6. Ekim makinalarında ekim derinliği ve kapatma düzeni sistemi

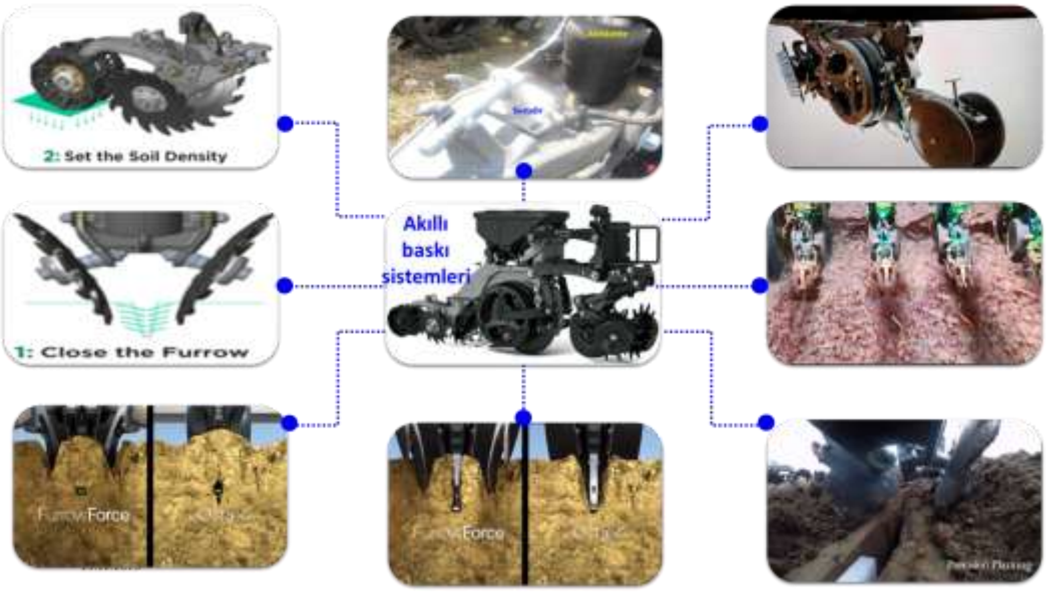


Şekil 7. Sensör teknolojileri sayesinde ekim işleminde sağlanan kolaylıklar (Precision planting, 2024)

Ekim derinliğindeki düzgünlük, ekim işleminin başarıya ulaşmasındaki en önemli hususlardan birisidir. Çünkü ekim derinliği, bitkinin sadece toprak altındaki bölümünü değil, aynı zamanda tarla yüzeyinde ki tohum dağılımını da etkilemektedir. Herhangi bir tohum çeşidi ekildiğinde ekim derinliğindeki hedef, tohumun açılan çizinin tabanına bırakılmasıdır. Çizi tabanına bırakılmayan bir tohum çizinin sağına veya soluna bırakılmış olacak ki, bu durum hem ekim derinliğinin hem de sıra arası bitki aralığının bozulmasıyla sonuçlanacaktır (Günal ve Kuş, 2021; Kuş, 2021a; Kuş, 2021b; Kuş, 2021c). Ekim makinalarında geleneksel olarak yapılan ekim derinliği ayarından sonra, bir miktar ekim yapılır ve tohumun düştüğü derinlik; çizide tohumun üzerindeki toprağın alınıp tohum ile toprak yüzeyi arasındaki mesafenin ölçülmesiyle belirlenmeye çalışılır. Bu işlem zahmetli ve zaman alıcı olmakla beraber, küçük tohumların çizi içerisinde yerini değiştirmeden uygulayabilmek oldukça zordur. Ayrıca bu ayar ve kontrol yöntemiyle yapılan ekim işleminde, aynı derinlik ayarı, aynı derinlik anlamına gelmemektedir. Çünkü ekim sıralarının tamamı aynı derinlik ayarına ayarlanmış olsa bile, tohumlar farklı derinliğe bırakılabilmektedir. Bununla birlikte, derinlik sistemlerindeki gelişmeler bu ayar ve kontrol sisteminin traktör kabinindeki veri takip ve kontrol sisteminden kolaylıkla yapılabilmesine olanak tanımaktadır. Çiziye bırakılan tohumun toprakla temasını sağlayan tohum sıkılaştırma aparatının üzerine yerleştirilen sensörler aracılığıyla sadece tohumun bırakıldığı derinlik değil aynı zamanda bırakıldığı derinlikteki, sıcaklık, nem, organik madde, besin maddeleri vb. hakkındaki bilgiler de veri kontrol merkezine gönderilmektedir. Bu sistem sayesinde herhangi bir iş gücüne mahal vermeden terminalden ayar ve kontroller yapılabilmektedir.

Ekim Makinalarında Akıllı Baskı Sistemleri

Bir tarlada yapılan ekim işleminde toprağa binlerce tohum ekilmekte ve bu tohumları toprağa gömerken tek bir şansınız bulunmaktadır. Homojen bir derinliğe bırakılmayan ve uygun bir baskı kuvveti uygulanmayan tohumların çıkışı ve gelişimi de aynı oranda farklı olacaktır. Bu nedenle, ekim işleminde optimum bitki çıkışı ve gelişimi, çizi içerisine bırakılan tohumun etrafının muntazam bir toprak yoğunluğuyla kapatılması, tohumun eşit ısı ve nem ortamına bırakılması ve her bir tohumun etrafında hava cebinin kalmamasıyla sağlanabilir.

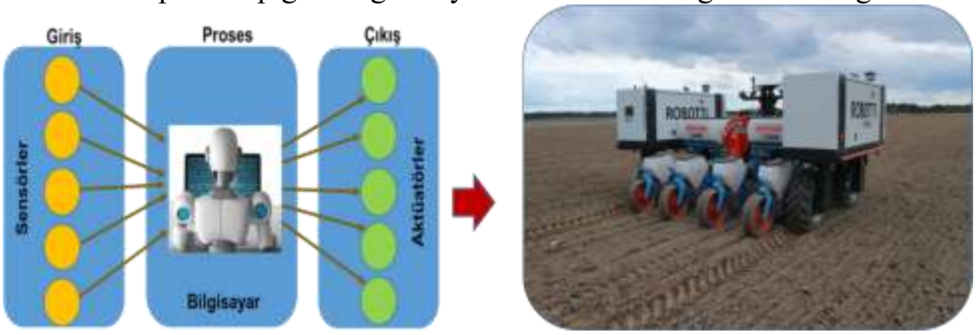


Şekil 8. Ekim makinalarının tohum kapatma ve baskı sistemlerinde gelişmeler.

Ekim makinaları baskı sistemleri yüzeyden bastırma ve ekim derinliğinden bastırma olmak üzere iki şekilde yapılabilmektedir. Baskı şeklini belirleyen ise baskı sisteminin veya baskı tekerleğinin tasarım şeklidir. Araştırmalar, ekim derinliği düzeyinden yapılan baskının daha uygun olduğunu göstermektedir (Önal, 2011). Her ne kadar baskı işleminin ekim derinliği düzeyinden uygulanması daha uygun bir ekim sağlasa da, baskı sisteminin yapısı ve uygulanan baskı oranı da (basınç değeri) önemlidir. Yeni teknolojiler hem baskı sisteminin yapısında iyileştirmeler hem de sensörler sayesinde akıllı baskı oranlarına olanak sağlamaktadır. Sıkışık çizi duvarlarının oluştuğu normal bir ekim işleminde (veya doğrudan ekim makinalarıyla yapılan ekim işleminde) tohum doğru bir şekilde kapatılsa bile, çizi duvarlarındaki sıkışma ve bilinmeyen baskı oranından dolayı çıkış işlemi gecikebilir. Bunun üstesinden gelmek ekim makinalarında iki aşamalı bir sistem kullanılmaktadır. İlk aşamada belirli bir açıyla birbirlerine doğru yerleştirilen parçalı bir aparat vasıtasıyla sıkışmış çizi duvarları gevşetilmektedir. Sonraki aşamada ise bu aparatın ardından gelen ve yine belirli bir açıyla yerleştirilen baskı tekerlekleri sayesinde tohumun üstü, etrafında hava cebi kalmayacak şekilde kapatılmakta ve belirli bir baskı uygulanmaktadır. Bu sistemde, baskı tekerlekleri yerle temas ettiğinde üst tarafına yerleştirilmiş olan bir sensör sayesinde tekerleklerin ağırlığı ve yere uyguladığı basınç ölçülebilmektedir. Sensör, bir aktöatör ve hava yastığıyla kontrol edilmekte ve elde edilen veri kabinden takip edilebilmektedir.

Ekim robotu ve insansız hava araçları

Günümüzde ekim işlemi yeni teknolojilerle donatılmış ekim makinalarının yanı sıra otonom robotlarla da (ekim robotu) yapılabilmektedir (Anonim, 2023). Ekim robotuyla yapılan ekim işleminde herhangi bir insan müdahalesine gerek duyulmadan tamamıyla otomatik kontrollü yapılmaktadır (Şekil 9). Ekim işlemindeki diğer bir gelişme ise insansız hava araçlarının (İHA) kullanılmasıdır. İnsansız hava araçları tarlalara yakın uçabildiğinden, bulut örtüsü, zayıf ışık koşullarından daha az etkilenir. Uydu görüntüleme, daha iyi ölçüm hassasiyeti sunabilir, ancak İHA'larla görüntüleme, milimetreye kadar doğru görüntü konumu üretme yeteneğine sahiptir. Bu özellik, ekim - dikimden sonra tarlada ekilemeyen ve boş olarak kalan alanların tespit edilip gerektiğinde yeniden ekilebileceği anlamına gelmektedir.



Şekil 9. Bir robotun çalışma prensibi ve ekim robotu (www.futurefarming.com)

İnsansız hava araçlarının yeni uygulamalarından bir tanesi ekim işlemidir. Otomatik insansız hava mibzerleri çoğunlukla ormancılık endüstrisinde kullanılmaktadır. Özellikle ulaşılması zor olan alanların işçileri tehlikeye atmadan ekilmesi mümkün hale gelmektedir.

Şekil 10. İnsansız hava araçlarıyla ekim işlemi (Anonymous, 2024)

KAYNAKLAR

Agerris, (2020). Agerris. Chippendale, Australia. Erişim adresi https://agerris.com/ Son Erişim 6 Aralık 2024.

Anonim, (2023). Tarım Robotları. Erişim adresi https://www.tarimbilgisi.com/haber/tarim-ve-ciftci/tarim-robotlari/, Son Erişim Tarihi: 30.11.2024.

Anonymous, (2015). Case IH launches 2000-series planters. Erişim adresi https://www.farmprogress.com/farming-equipment/case-ih-launches-2000-series-planters, Son Erişim Tarihi: 28.11.2024.

Anonymous, (2024). Drone technology in agriculture. Erişim adresi https://www.croptracker.com/blog/drone-technology-in-agriculture.html, Son Erişim Tarihi: 05.11.2024.

Brodsky, S. (2023). How Autonomous tractors and smart farm tech could help improve self-driving cars. Erişim adresi https://www.lifewire.com/how-autonomous-tractors-and-smart-farm-tech-could-help-improve-self-driving-cars-7375339, Son Erişim Tarihi: 01.11.2024.

Fagnani, M.L. (2023). The Development of Agricultural Science in Northern Italy in the Late Eighteenth and Early Nineteenth Century. Italian and Italian American Studies ISBN 978-3-031-20656-6, ISBN 978-3-031-20657-3 (eBook). Palgrave Macmillan by Springer Nature Switzerland AG The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland. 297 s. https://doi.org/10.1007/978-3-031-20657-3

Gagliardi, G., Cosma, A.I.M., Marasco, F. (2022). A decision support system for sustainable agriculture: the case study of coconut oil extraction process. Agronomy, 12, 177. https://doi.org/10.3390/agronomy12010177

BIOLOGICALLY ACTIVE PLANT COMPOUNDS AND THEIR MECHANISMS OF ACTION: REWIEV

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ABSTRACT

Introduction and Purpose: Numerous studies conducted over the past few decades have confirmed that active compounds isolated from plants have multiple biological effects, including antioxidant, antimicrobial, anticancer, antiallergic, and anti-inflammatory properties. The primary focus of phytochemical research has been on phenolic compounds and their potential applications in medicine, cosmetics, pharmacy and agriculture.
The aim of this work is to highlight the significance of biologically active components isolated from plants and to clarify their mechanisms of action at the cellular level, with the goal of contributing to the development of plant-based antimicrobial and antioxidant agents.

Materials and Methods: In this scientific paper, we present the research results on biologically active compounds from plants and their mechanisms of action at the cellular level to summarize this field of study and, in part, contribute to the development of biologically active plant-derived compounds. During the database search, we used the following keywords: "biologically active plant compounds," "antimicrobial activity," and "antioxidant properties of plants."

Results: Plants are characterized by a mixture of various active mechanisms with different pharmacological profiles, allowing them to affect multiple diseases, unlike synthetic drugs, which are designed to inhibit or stimulate a single pharmacological pathway. The antimicrobial potential of essential oils and plant extracts is due to the presence of many pharmacologically active compounds, and their mode of action on bacterial cells depends on the concentration of the active substance, the type of microorganism, and the structure of their cell wall. Biologically active compounds isolated from plants are associated with antioxidant activity in biological systems, as they play an important role in the absorption and neutralization of free radicals.

Discussion and Conclusion: In recent years, significant efforts have been made to isolate and examine biologically active compounds from plants and their antioxidant and antimicrobial properties. Special attention has been given to the mechanisms of action of these compounds on microbial cells. Biologically active compounds affect the transmembrane pH gradient and membrane integrity of microbial cells, causing leakage of intracellular contents, disruption of transport and energy production processes, as well as the respiratory chain, and play an important role in the absorption and neutralization of free radicals. A review of the literature concludes that the plant world represents an inexhaustible source of biologically active compounds with antimicrobial and antioxidant properties, which should continue to be studied to contribute to the development of plant-based antimicrobial and antioxidant agents.
Keywords: Biologically Active Compounds, Antimicrobial Properties, Antioxidant Activity.

INTRODUCTION

The use of medicinal plants in the prevention and treatment of various health issues dates back to ancient civilizations. Knowledge about the beneficial effects of numerous medicinal plant species and their proper usage has been passed down from generation to generation. Today, in many developing regions, between 70 and 95% of the population still relies on plants as a primary form of medicine, and many countries have integrated traditional plant-based remedies into their main healthcare systems through regulatory frameworks (RBG Willis, 2017). However, the use of plants in treatment is not limited to underdeveloped countries; plants are increasingly used in developed countries where modern medicine is readily available (Bošković, 2017).

According to the World Health Organization (WHO, 1997), plants represent an inexhaustible natural resource for the production of various medicines. The WHO has developed a strategy for the application of traditional herbal medicines, including a set of technical guidelines and documents related to the safety, efficacy, and quality assurance of medicinal plants and herbal materials (WHO, 2007). With advancements in scientific instrumental methods, it has become possible to achieve detailed characterization of biologically active compounds from medicinal plant species.

Numerous studies conducted over the past few decades have confirmed that active compounds isolated from plants exhibit multiple biological effects, including antioxidant, antimicrobial, anticancer, antiallergic, and anti-inflammatory properties. Scientists are in search of new natural sources of antioxidants that could replace synthetic ones in cosmetics, pharmaceuticals, and the food industry.

Phenolic compounds are highly prevalent in the plant kingdom. Major dietary sources of polyphenols include legumes (pulses and beans), cereals (corn, barley, oats, sorghum, rice, and wheat), nuts, oilseeds (rapeseed, flaxseed, olive seeds, and canola), beverages (fruit juices, tea, coffee, beer, wine, and cocoa), as well as fruits and vegetables (Khatoon et al., 2018). Phenolic compounds and flavonoids are associated with antioxidant activity in biological systems, mainly due to their redox properties, which play an important role in the absorption and neutralization of free radicals, mitigate the effects of singlet and triplet oxygen, or decompose peroxides (Saha et al., 2008). Besides their pronounced antioxidant activity, phenolic compounds contribute to the prevention of carcinogenesis and mutagenesis.

The antimicrobial potential of plant extracts is attributed to the presence of various pharmacologically active substances, and the mode of their action on bacterial cells depends

on the concentration of the active substance, the type of microorganism, and the structure of their cell wall.
The aim of this work is to highlight the significance of biologically active components isolated from plants and to clarify their mechanisms of action on cells, with the objective of contributing to the development of plant-based antimicrobial and antioxidant agents.

METHODOLOGY

In this scientific paper, we presented the results of research on biologically active compounds from plants and their mechanisms of action on cells in order to summarize this area of research and partially contribute to the development of biologically active compounds from plants. During the database search, we used the following keywords: "biologically active plant compounds," "antimicrobial activity," and "antioxidant properties of plants."

RESULTS AND DISCUSSION

In the process of photosynthesis, plants synthesize a large number of organic compounds, secondary metabolites, which were not given much importance until a few decades ago. However, recent research has shown that these compounds play an essential role in plant development, particularly in surviving adverse conditions (Kliebenstein, Osbourn, 2012). Secondary metabolites influence intercellular communication and reproduction in plants, and they are produced as a response to biotic and abiotic stress (Hartmann, 2007). They serve as a defense mechanism for plants against various herbivores and microorganisms (Bošković, 2017). On the other hand, some secondary metabolites play a role in attracting pollinating insects and other animals (Kaufman, 1999; Briskin, 2000; Wink, 2003). There are 14 basic classes of secondary metabolites, which are presented in Table 1 (Wink, 2003).

Table 1. Classes of Plant Secondary Metabolites according to Wink (2003)

Classes of Plant Secondary Metabolites	**Approximate Number**
Alkaloids	21000
Amines	100
Cyanogenic glycosides	60
Glucosinolates	100
Non-protein amino acids	700
Monoterpenes	2500
Sesquiterpenes	5000
Diterpenes	2500
Triterpenes, saponins, sterols	5000
Tetraterpenes	500
Flavonoids, Tannins	5000
Polyacetylenes, fatty acids	1500
Polyketides	750
Phenylpropanoids	2000

Numerous studies have confirmed that secondary metabolites have beneficial effects on human health, and are therefore referred to as biologically active components. The greatest interest in phytochemical research has been focused on phenolic compounds and their potential applications in medicine, pharmacy, and agriculture. They play a very important physiological and morphological role in plant growth and reproduction, protection against pathogens and predators, and also contribute to the formation of color and sensory properties

of flowers, fruits, and vegetables (Bošković, 2017). In plant organisms, polyphenols perform a range of functions that have a significant impact on the ecophysiology of plants: they act as antioxidants, antimicrobial agents, and visual attractants for some pollinating insects (Heim et al., 2002). As natural sources of polyphenolic compounds, the literature most often mentions aromatic and medicinal herbs, fruits, vegetables, and cereals (Naczk, Shahidi, 2006).
Flavonoids have shown numerous therapeutic effects: antimicrobial, antiviral, anticancer, anti-inflammatory, and others. The cardioprotective role of flavonoids is attributed to their ability to inhibit lipid peroxidation, capture ("trap") free radical electrons, chelate transition metal ions (Fe2+, Cu2+, Zn2+, and Mg2+), activate antioxidant enzymes, and inhibit oxidases (Heim et al, 2002). Many flavonoids can act as cofactors for numerous enzymes, and they are also used in the fight against skin aging, as anti-cellulite products, and skin whitening products (Bošković, 2017). Flavonoids significantly contribute to strengthening capillaries, anti-inflammatory effects, protection from radiation, softening of the skin, and others (Svobodova, 2003; Malinowska, 2013).

Antioxidant Activity of Plant Extracts

In the past decade, significant attention has been given to the antioxidant activity of biologically active compounds isolated from plants. The bioactive compounds of plants stimulate the immune system, block the formation of carcinogens, reduce oxidation, slow the growth rate of cancer cells, reduce inflammation, trigger apoptosis, prevent DNA damage, and regulate hormones such as estrogen and insulin, whose excess levels are linked with an increased risk of breast and colon cancer (Karamac et al., 2019). Plants contain a wide range of antioxidants, and it is difficult to measure the antioxidant capacity of each compound individually. In order to assess the biological activity of plant extracts, the first step is to determine their antioxidant capacity (Bošković, 2017). A large number of methods have been developed for determining antioxidant activity in plants: total antioxidant capacity, inhibition of lipid peroxidation, DPPH method for antioxidant activity, and the ability to “scavenge” hydroxyl radicals. Repair antioxidants are particularly important as they act through specific mechanisms, restoring or removing damaged vital biomolecules that occur under oxidative stress conditions. The mechanism of action of antioxidants is shown in Figure 1.

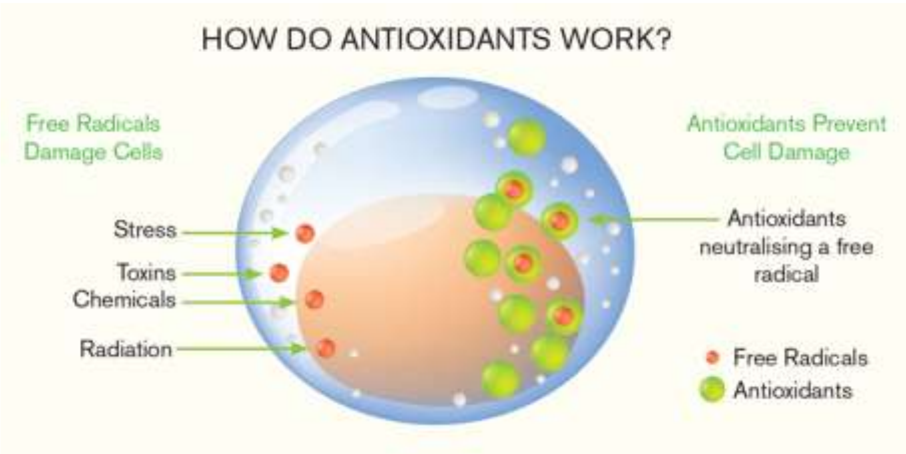

Figure 1. Mechanisms of Action of Antioxidants

It is assumed that polyphenolic antioxidants, such as flavonoids in red wine, along with antioxidants from olive oil and fresh fruits and vegetables, which are abundant in Mediterranean cuisine, may provide protection against coronary heart disease. Many flavonoids, such as quercetin and catechin, have shown to be better antioxidants than vitamins

C and E (Svobodova, 2003). Amarowicz et al. (2008) report that, compared to simple phenolic compounds, tannins are 15-30 times more effective in destroying peroxyl radicals, which is why they are considered important biological antioxidants. Research results on the antioxidant activity of ethanolic extracts from plants Anchusa officinalis, Echium vulgare and E. italicum using multiple methods have confirmed that they possess exceptionally good antioxidant activity (Bošković, 2017a; Bošković, 2018; Bošković, 2022), due to the presence of high amounts of phenols, flavonoids, and tannins in these plants.

Antimicrobial Activity of Plant Extracts

Due to the increasing occurrence of bacterial resistance to a large number of antibiotics, as well as the ability of plants to synthesize biologically active compounds, the use of natural antimicrobial agents of plant origin in the biological control of pathogenic bacteria is gaining greater importance (Đukić, Vesković, 2015). Rapid technological advancement and the application of new, increasingly efficient methodologies have allowed the identification and characterization of numerous antibacterial agents in recent years (Katz and Baltz, 2016).

Plants are characterized by a combination of various active mechanisms with different pharmacological profiles, allowing them to impact multiple ailments, unlike synthetic drugs, which are designed to inhibit or stimulate only one pharmacological pathway (Della Loggia, 2000). The advantage of plant-derived compounds over synthetic drugs lies in the broader pharmacological complexity that plants possess (Bošković, 2017). HPLC analysis of selected plant species from the Boraginaceae family confirmed the presence of numerous pharmacologically active substances, with rosmarinic acid and rutin being the most dominant, both of which have proven antioxidant, anti-inflammatory, and anticancer activities (Bošković, 2017a; Bošković, 2018; Bošković, 2022).

According to research by Skandamis et al. (2006), extracts from certain plant species contain a wide range of reactive groups, so their antimicrobial effect cannot be attributed to a single, specific mechanism but rather involves multiple target sites within the microorganism cell. Phenolic compounds affect the transmembrane pH gradient and membrane integrity, causing leakage of intracellular contents, disruption of transport processes, energy production, and the respiratory chain (Bošković, 2017). The hydrophobicity of plant extracts enables their integration into cell membrane lipids, making the membrane more permeable and leading to apoptosis of the microbial cell. Figure 2 illustrates the mechanisms of action of plant extracts on microbial cells.

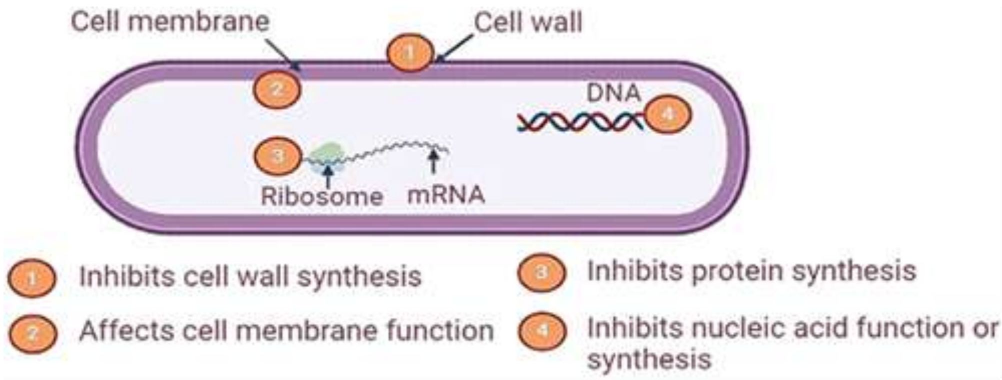

Figure. 2. Mechanisms of Action of Plant Extracts on Microbial Cells

The methods commonly used in practice for determining the antimicrobial potential of medicinal plants and essential oils are the microdilution method and the disk diffusion method. The microdilution method has become the preferred technique for evaluating the antibacterial potency of plant extracts or compounds due to its efficiency, reproducibility, and ability to assess a wide range of concentrations in a small sample volume (Balouiri et al., 2016).

Numerous studies on selected plant species have shown that only certain plant species exhibit exceptionally good antimicrobial activity, expressed by the minimum inhibitory concentration.

MIC value is defined as the lowest concentration of the assayed antimicrobial agent that inhibits the visible growth of the microorganism tested, and it is usually expressed in µg/mL or mg/L (Balouiri et al., 2016). There is a large body of evidence suggesting that plant extracts and polyphenols have the ability to disrupt the structure of the bacterial plasma membrane, causing the formation of pores, leakage, altering electrical charge, altering polarity, increasing permeability, modifying fluidity, delocalizing membrane proteins, and other phenomena responsible for antibacterial activity (Alvarez-Martínez et al., 2021).

According to the results of studies (Bošković, 2022) the applied solvents significantly affected the content of phenolic compounds in and their antimicrobial and antioxidant properties. A large number of studies have confirmed that polar solvents are significantly more effective than non-polar ones in isolating bioactive components, which has led to enhanced antioxidant and antimicrobial properties of plant extracts. The antimicrobial properties of selected plant species were examined using the microdilution method on gram-positive and gram-negative bacteria by Bošković (2018), who found that the ethanolic extract of Anchusa officinalis exhibited excellent antimicrobial activity (MIC=3.94 µg/mL) against Proteus vulgaris, Salmonella enteritidis, Enterococcus faecalis, Enterococcus faecium, Salmonella typhimurium, and Candida albicans, and that the chloroform and acetone extracts were effective against E. faecalis and C. albicans (MIC=7.875 µg/mL). Meanwhile, the chloroform extract of Echium vulgare L. showed the strongest activity against P. mirabilis, S. typhimurium, L. ivanovii, and S. aureus (MIC=3.91 µg/mL), and the ethanolic extract exhibited the greatest antimicrobial activity against K. pneumoniae, S. enteritidis, and C. freundii (3.91 µg/mL) (Bošković, 2022). The observed antimicrobial effects are closely linked to the total phenol concentration and the broad range of biological activities, including antithrombotic, cardioprotective, vasodilatory effects, as well as the high antioxidant potential of the tested extracts (Bošković, 2017).

According to the research by Lakušić et al. (2013), there are significant differences in antimicrobial effects not only between different plant species but also within the same species collected in different geographical regions and at different times, which can be attributed to the impact of climatic and edaphic factors.

Pseudomonas aeruginosa (PA) is a gram-negative bacterium that can cause nosocomial infections, including respiratory tract infections, burn and wound infections, urinary tract infections and bloodstream infections (Wei et al., 2024). Chakotiya et al. (2016) assessed the antibacterial potential of Glycyrrhiza glabra stem extract and Mentha piperita leaf extract against multidrug-resistant P. aeruginosa and their findings revealed that these extracts displayed significant activity, with minimum inhibitory concentrations of 10 µg/mL and 25 µg/mL. While extracts of E. vulgare exhibited very poor antimicrobial potential against Pseudomonas aeruginosa (500 µg/ml) (Bošković, 2022).

CONCLUSION

In recent years, significant efforts have been made to isolate and study biologically active compounds from plants, focusing on their antioxidant and antimicrobial properties. Special attention has been given to the mechanisms of action of these compounds on microbial cells. Biologically active compounds affect the transmembrane pH gradient and the integrity of the microbial cell membrane, causing leakage of intracellular content, disruption of transport and energy production processes, and the respiratory chain. They are also associated with antioxidant activity in biological systems, as they play an important role in absorbing and neutralizing free radicals. Based on a review of the literature, it has been concluded that the plant kingdom represents an inexhaustible source of biologically active compounds with antimicrobial and antioxidant properties, which should continue to be explored to contribute to the development of plant-based antimicrobial and antioxidant agents.

REFERENCES

Alvarez-Martínez, F.J., Barrajon-Catal, E., Herranz-Lopez, M., Micol, V. (2021). Antibacterial plant compounds, extracts and essential oils: An updated review on their effects and putative mechanisms of action. Phytomedicine 90, p. 153-167.

Amarowicz, R., Naczk, M., Zadernowski, R., Shahidi, F. (2008). Antioxidant activity of condensed tannins beach pea, canola hulls, evenings primrose and faba bean. J. Food Lipids 7, p. 195-2015.

Balouiri M, M. Sadiki M, Ibnsouda S.K (2026). Methods for in vitro evaluating antimicrobial activity: a review. J. Pharm. Anal. 6, p. 71–79.

Bošković, I. (2017). Antimicrobial and antioxidant activity of plant extracts from family Boraginaceae. PhD thesis. University of Montenegro, p. 1-132.

Bošković, I., Đukić, D., Mašković, P., Mandić, L. (2017a). Phytochemical composition and biological activity of Echium italicum L. plant extracts. Bulgarian Chemical Communications, 49 (4), p. 836 – 845.

Bošković, I., Đukić, D., Mašković, P., Mandić, L., Perović, S. (2018). Phytochemical composition and antimicrobial, antioxidant and cytotoxic activities of Anchusa officinalis L. extracts. Biologia, 73(4), p. 1035-1041.

Bošković, I., Đukić, D., Mašković, P., Mandić, L. (2022). Influence of solvent type on the phenolic content and antimicrobial and antioxidant properties of Echium vulgare L. Extracts. Farmacia, 70 (4), p. 665-670.

Briskin, D. (2000). Medicinal Plants and Phytomedicines. Linking Plant Biochemistry and Physiology to Human Health. Plant Physiology, 124 (2), p. 507-514.

Chakotiya, A.S., Chawla, R., Thakur ,P., Tanwar, A., Narula, A., Grover, S.S., Goel, R., Arora, R., Sharma, R.K. (2016). In vitro bactericidal activity of promising nutraceuticals for targeting multidrug resistant Pseudomonas aeruginosa. Nutrition 32, p. 890–897.

Della Logia, R. (2000). Pharmacology of medicinal plants. Proceedings of the I Conference on Medicinal and Aromatic Plants of South-east European Countries and IV Meeting Days of Medicinal Plants 2000, Aranđelovac Yugoslavia, p. 11-14.

Đukić, D., Vesković, S. (2015). Bioprotektori u proizvodnji hrane, HL print d.o.o, Bački Petrovac, p. 314.

Hartmann, T. (2007). From waste products to ecochemicals: Fifty years research of plant secondary metabolism. Phytochemistry 68, p. 2831-2846.

Heim, K.E., Tagliaferro, A.R., Bobilya, D.J. (2002). Flavonoid antioxidants: chemistry, metabolism and structure-activity relationships. Journal of Nuritional Biochemistry 13 (10), p. 572-584, 2002.

Katz, L., Baltz, R.H. (2016). Natural product discovery: past, present, and future. J. Ind.

Microbiol. Biotechnol. 43, p. 155–176.
Kaufman, P.B., Cseke, L.J., Warber, S., Duke, J.A., Brielmann, H.L. (1999). Natural Products from Plants. CRC Press, Boca Raton, FL.
Karamac, M., Gal, F., Longato, E., Meineri, G., Janiak, M.A., Peiretti, P.G., Peiretti, P.G. (2019). Antioxidant Activity and Phenolic Composition of Amaranth (Amaranth Spp.) during Plant Growth. Antioxidants 8, p. 173.
Khatoon, U., Sharma, L., Dubey, R.K. (2018). Assessment of Bioactive Compounds, Antioxidant Activity and Quantification of Phenols through HPLC in Solanum Species. Ethno. Med. 12(2), p. 87–95.
Kliebenstein, D.J., Osbourn, A. (2012). Making new molecules – evolution of pathways for novel metabolites in plants. Current Opinion in Plant Biology 15, p. 415–423.
Lakušić, B.S., Ristić, M.S., Slavkovska, V.N., Stojanović, D.Lj., Lakušić, D.V. (2013).Variations in essential oil yields and compositions of Salvia officinalis (Lamiaceae) at different developmental stages. Bot Serb. 37 (2), p.127-139.
Malinowska, P. (2013). Effect of flavonoids content on antioxidant activity of commercial cosmetics plant extracts, Herba Polonica 59 (3), p. 63-74.
Naczk, M., Shahidi, F. (2006). Phenolics in cereals, fruits and vegetables: Occurrence, extraction and analysis. Journal of Pharmaceutical and Biomedical Analysis 41 (5), p. 1523-1542.
RBG Willis, K.J. (2017). State of the World's plants, 2017. Kew, London: England: Royal Botanic Gardens.
Saha, M.R., Hasan, S.M.R., Akter, R., Hossain, M.M., Alam, M.S., Alam, M.A., Mazumder, M.E.H. (2008). In vitro free radical scavenging activity of methanol extract of the leaves of Mimusops elengi Linn. Bangladesh Journal of Veterinary Medicine 6 (2), p. 197-202.
Skandamis, P., Koutsoumanis, K., Fasseas K., Nychas G. J. E.(2006). Inhibition of oregano essential oil and EDTA on Escherichia coli O157:H7. Ital. J. Food. Sci. 13, p. 65-75.
Svobodova, A., Psotova, I., Walterova, D. (2003). Natural phenolics in the prevention of UV-induced skin damage. A review, Biomedicin Papers 147, p. 137-145.
Wei, X., Liu, M., Mo, C., Tan, R., Li, S., Liang, H., Li, M. (2024). Molecular characteristics and antibiotic resistance mechanisms of multidrug-resistant Pseudomonas aeruginosa in Nanning, China. BMC Microbiol 24, p. 478.
Wink, M. (2003). Evolution of secondary metabolites from an ecological and molecular phylogenetic perspective, Phytochemistry 64, p. 3-19.
World Health Report, Conquering suffering Enriching humanity Geneva, WHO 1997.
WHO guidelines for assessing quality of herbal medicines with reference to contaminants and residues, WHO Press, Geneva, Switzerland, 2007.

DETERMINATION OF DISTRIBUTION AND INFECTION RATES OF CONTARINIA MEDICAGINIS KIEFFER IN ALFALFA FIELDS OF IĞDIR

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ABSTRACT
Contarinia medicaginis Kieffer (Diptera, Cecidomyiidae) larvae are monophagous pests that swell the base of the flower petals of the clover plant (Medicago sativa L.) and close them towards the tip, forming cone-shaped galls that prevent seed development. This pest was detected in Iğdır province in 2023. This study was conducted to determine the distribution and infestation rate of C. medicaginis in alfalfa fields in Iğdır province. The survey studies were carried out in a total of 40 fields in Iğdır province, including Central (23 fields), Aralık (6 fields), Karakoyunlu (4 fields) and Tuzluca (7 fields) in August and September 2024. Samples were collected randomly from different parts of each alfalfa field by cutting the lower parts of the plant stems with flower clusters. The collected plant stems were placed in transparent nylon bags, labeled with information, and brought to the laboratory. The flowers on each stem were examined under a binocular microscope and the number of gall flowers were counted. Insect infestation rates in fields (%); Field infection rate was calculated with the formula = (Number of infected plants/Total number of plants) x 100. With these studies, the distribution rates of the pest in the alfalfa areas of the province were also determined. It was determined that C. medicaginis spread in 95% of the alfalfa fields in Iğdır province. The infection rates were recorded as 21,6% in the central district, 32,1% in Aralık, 19,8% in Karakoyunlu and 3,6% in Tuzluca. The average number of infested flowers on a stem was determined as 5,4% in the Central district, 3.8% in Aralık, 2.1% in Karakoyunlu and 2,5% in Tuzluca. This study, which was conducted to determine the distribution areas and larval infestation rates of C. medicaginis in alfalfa fields of Iğdır province and its districts, was carried out in a total of 40 alfalfa fields and a total of 2125 flowering alfalfa plants were examined. While no galled flowers were found in 1757 of these flowers, 367 were found to have galled flowers. As a result; It was understood that C. medicaginis was infested at a rate of 17,3% in alfalfa fields in Iğdır province.
Key Words: Iğdır; Alfalfa; Distribution; Infection Rate

INTRODUCTION
Alfalfa is a forage plant rich in protein and vitamins, preferred in areas animal husbandry. Many pests have been identified that feed on alfalfa and negatively affect its yield and quality. These pests are the Alfalfa weevil, Hypera postica Gyllenhal, Sitona humeralis Stephens (Curculionidae), Gonioctena fornicata (Brüggemann) (Chrysomelidae) and Epicauta erythrocephala (Pallas) (Meloidae) from the order Coleoptera; Alfalfa seed capsid Adelphocoris lineolatus (Goeze), Exolygus rugulipennis (Poppius) (Miridae), Aphis craccivora Koch, Acyrthosiphon pisum (Harris) and Therioaghis trifolii Monell (Aphididae) from the order Hemiptera; Nomophila noctuella Denis &Schiffermüller (Crambidae), Agrotis ipsilon Hufnagel and Spodoptera exigua (Hübner) (Noctuidae) from Lepidoptera;

Bruchophagus roddi Gussakovsky (Eurytomidae) from Hymenoptera and Tetranychus spp. (Tetranychidae) from Acarina is species (Çalışkaner & Özer, 1980; Tamer el al., 1997; Shebl el al., 2008; Gözüaçık & Atay, 2016; Gözüaçık, 2019; Gözüaçık & İreç, 2019; Gözüaçık et al., 2020; Gözüaçık et al., 2021). Alfalfa flower midge, Contarinia medicaginis Kieffer (Diptera, Cecidomyiidae) was also included in these species in 2023 (Gözüaçık et al., 2023). This fly is a monophagous pest, 1.8-2.3 mm long, wings are transparent and hairy, Radial vein R4+5 extends towards the wing tip at the apex. There are transverse lines on the dorsal side of the abdominal segments, the tergite x is bilobate, the ovipositor is very thin, the tarsus claws are simple and the empodium is well developed. The eggs are white at first, then yellow, oblong-oval, 1.8 to 2.4 mm long. The larvae are yellowish, approximately 1.5-2 mm long. The pupa and its cocoon are whitish. It spends the winter in the larval stage, or in the puparium inside the cocoon, 3-5 cm deep in the soil. Adults fly and mate at the beginning of the alfalfa flowering. Females lay their eggs by hole the green buds of the flower with their ovipositors. A female lays about 50-70 eggs; embryonal development takes 4-11 days (AgroAtlas, 2024). During feeding, the larvae deform the flowers, as a result of which the corona and staminal columns of the flower overgrow, the pistil dies (Ellis, 2020; Fedotova, 1999; Mirumian, 2011; Simova–Tošıæ, et al., 2000; Skuhravá et al., 2013). The flower base swells and forms galls. (Gözüaçık et al., 2023). Between 7 and 70 larvae can develop in a gall flower. The larval period lasts approximately 10-12 days. They can produce 2-4 generations per year (AgroAtlas, 2024). They damage clover flower buds, causing seed loss. Infected flowers do not produce seeds. C. medicaginis is distributed in the Palearctic region (Figure 1).

Figure 1. Contarinia medicaginis distribution in the world (Cabi, 2024).

This species is an invasive species and is distributed throughout Europe, Central Asia, Kazakhstan, Kyrgyzstan (Fedotova, 2020), Russia: Caucasus, Urals, Middle Volga region, Siberia (Kolomoets, et al., 1989; Mamaeva & Mamaev, 1981) and Armenia (Udvardy, 1975; Mirumian, 2011). Serious damage to alfalfa has been reported in central, southern and southeastern Europe (Darvas et al., 2000). It was detected for the first time in alfalfa fields in Iğdır province of Turkey (Gözüaçık et al., 2023).

This study was conducted to determine the distribution of C. medicaginis in alfalfa fields in Iğdır province and the infestation rate in alfalfa flowers.

MATERYAL VE YÖNTEM

The surveys were carried out in a total of 40 alfalfa fields in the districts of Iğdır province, including Merkez (23 fields), Aralık (6 fields), Karakoyunlu (4 fields) and Tuzluca (7 fields) in August and September in the 2024 year (Figure 2).

Figure 2. Locations where Contarinia medicaginis survey was conducted in Iğdır province (Drawing: M. Güven)

Samples were collected from different parts of each alfalfa field by randomly cutting inflorescences from the lower parts of the plant stems. These collected flower clusters were placed in transparent nylon bags, labeled with information, and brought to the laboratory. Inflorescences on each plant were examined under a binocular microscope and the number of gall flowers was counted. Field infection rate was calculated with the formula = (Number of infected plants/Total number of plants) x 100. With these studies, the distribution rates of the pest in the alfalfa areas of the province were also determined.

CONCLUSION AND DISCUSSION

The studies were carried out in a total of 40 fields in the alfalfa cultivation areas of Iğdır province, in August-September (2024) (Figure 2). In the studies, infested flowers were not found except in 2 clover fields in Tuzluca (Tuzluca Center and Karabulak), while in all other clover fields, flowers infected with C. medicaginis were found. According to these results, it was determined that 95% of the alfalfa fields in Iğdır province where the studies were carried out were infected with C. medicaginis.

The number of flower clusters collected in the alfalfa fields where the studies were carried out, their Infection rates and locations are shown in Table 1.

Table 1. Contarinia medicaginis infestation status in alfalfa fields in Iğdır province

Districts	Locations	Number of uninfected flower clusters	Number of infected flower clusters	Total number of flower clusters	Number of infect flowers	% Infection rate
Merkez	Obaköy	44	6	50	33	12,0
	Hoşhaber	28	3	31	5	9,7
	Kazancı	58	5	63	10	7,9
	Halfeli	64	3	67	5	4,5
	Kasımcan	27	28	55	94	41,8
	Yaycı	36	2	38	4	5,3
	A. Çarıkçı	43	9	52	47	17,3
	Karakuyu	23	29	52	167	55,8
	Çakırtaş	45	21	66	47	31,8
	Y. Çarıkçı	48	4	52	10	7,7
	Yüzbaşılar	48	10	58	27	17,2
	Hakmehmet	49	8	57	26	14,0
	Küllük	31	14	45	30	31,1
	Evci	23	12	35	40	34,3
	Tacirli	38	6	44	14	13,6
	Necefali	6	38	44	538	86,4
	Sarıçoban	10	1	11	7	9,1
	Özdemir	37	2	41	5	4,9
	Kuzugüden	30	9	39	31	23,1
	A. Erhacı	46	3	49	8	6,1
	Y. Erhacı	38	14	52	46	26,9
	Melekli	40	2	42	3	48,8
	Yenimahalle	45	7	52	18	13,5
Total	23	**857**	**236**	**1095**	**1215**	**21,6**
Aralık	Y.Çiftlik	21	18	39	97	46,2
	Babacan	18	13	31	**59**	41,9
	Karahacılı	44	5	49	**8**	10,2
	Kırçiçeği	49	1	50	**2**	2,0
	A.Topraklı	20	35	55	**137**	63,6
	Tazeköy	26	12	38	42	31,6
Total	6	**178**	**84**	**262**	**345**	**32,1**
Tuzluca	Eğrekdere	65	8	73	24	11
	Tuzluca	59	0	59	0	0,0
	Ağabey	91	1	92	3	1,1
	Pirli	123	2	124	6	1,6
	Buruksu	100	8	108	14	7,4
	Karabulak	107	0	107	0	0,0
	Eğrekdere2	80	4	84	**10**	4,8
Total	7	**625**	**23**	**647**	**57**	**3,6**
Karakoyunlu	Zülfikar	28	11	39	23	28,2
	Gölköy	36	1	37	1	2,7
	Bulakbaşı	15	5	20	10	25,0
	A. Alican	18	7	25	15	28,0
Total	4	**97**	**24**	**121**	**49**	**19,8**

When Table 1 is examined, it was determined that a total of 1095 flower clusters were collected from 23 locations in Iğdır Central District, 236 of which were infected and the infection rate was 21.6%; in Aralık, 84 of the 262 flower clusters collected from 7 locations were infected and the infection rate was 32.1%; in Tuzluca, 23 of the 647 flower clusters collected from 7 locations were infected and the infection rate was 3.6%; and in Karakoyunlu, 24 of the 121 flower clusters collected from 4 locations were infected and the infection rate was 19.8%. Studies have reported that 17% to 30%, and sometimes 85%, of alfalfa flowers are damaged (AgroAtlas, 2024).

In the studies, it was determined that there were different numbers of infested flowers in each inflorescence and this number varied between 1 and 14.2 in a flower cluster (Figure 3).

Figure 3. Infested flowers (Photo: C.Gözüaçık)

The highest infection rate was found in Necefali (Center) with 86.4%, followed by Aşağı Topraklı (December) with 63.6%. The highest number of infected flowers on a stem was counted in Necefali (Center) with 14,2. The average number of infested flowers on a stem was determined as 5.4% in the central district, 3.8% in Aralık, 2.1% in Karakoyunlu and 2.5% in Tuzluca (Table 1).

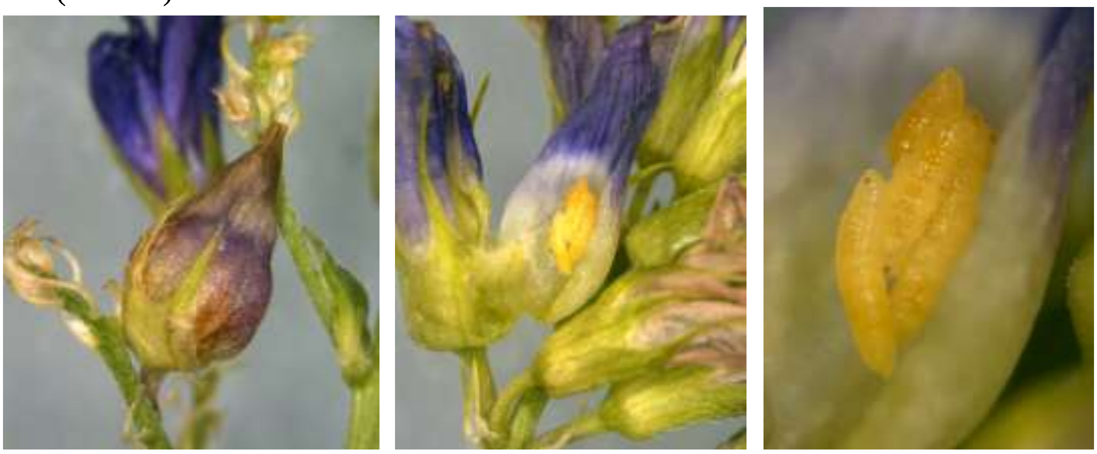

Figure 4. Infested flowers and larvae in the flower (Photo: C.Gözüaçık)

An average of 4 larvae were counted in a infected flower. In our observations, after the larva completes its development in the flower, it falls to the soil with the dead flower and completes its pupa period in this way.

As a result of the studies, it was determined that almost all (95%) of the alfalfa fields in Iğdır province and its districts were infected with C. medicaginis. Galled flowers can be easily seen with the naked eye. The collected 2125 flowering alfalfa plants were examined and galled flowers were detected in 367 of these flowers. Infection rates were recorded as 32.1% in Aralık, 21.6% in the central district, 19.8% in Karakoyunlu and 3.6% in Tuzluca. With this result; It was understood that C. medicaginis was infected at a rate of 17.3% in alfalfa fields in

Iğdır province. It was understood that detailed studies should be done on this flower pest in alfalfa growing areas.

REFERENCES

AgroAtlas, (2024). https://agroatlas.ru/en/content/pests/Contarinia_medicaginis/index.html (Access to: 26.11.2024).

Cabi, (2024). https://plantwiseplusknowledgebank.org/doi/full/10.1079/pwkb.species.15227 (Access to: 26.11.2024).

Çalışkaner, S. & Özer, M. (1980). Ankara bölgesinde yoncalarda zarar yapan Yonca hortumlu böceği (Hypera variabilis Herbst.)'nin biyolojisi ve mücadelesi üzerinde araştırmalar. Ankara Üniversitesi Ziraat Fakültesi, Dip. Son. Yük. Ok. İhtisas Tez Özetleri, 25 s.

Darvas, B., Skuhravá M. & Andersen, A. (2000). Agricultural dipteran pests of the Palaearctic region. pp.: 565–650. In: Papp L. & Darvas B. (eds.): Contributions to a Manual of Palaearctic Diptera. Volume 1. General and Applied Dipterology. Budapest: Science Herald, 978 pp.

Ellis, W.N. (2020). Leafminers and plant galls of Europe. Plant parasites of Europe – leafminers, galls and funi, Amsterdam, The Netherlands

Gözüaçık, C., Doğan, D. & Güven, M. (2023). A new pest in alfalfa (Medicago sativa L.): Contarinia medicaginis Kieffer. Munis Entomology & Zoology, 18 (1): 626-628.

Gözüaçık, C. (2019). Iğdır ili yonca alanlarında potansiyel bir zararlı: Epicauta erythrocephala (Pallas, 1776), (Coleoptera: Meloidae). Umteb 6. Uluslararası Mesleki ve Teknik Bilimler Kongresi, 11-12 Nisan 2019. Iğdır, Türkiye, 266-270.

Gözüaçık, C. & İreç, A. (2019). Yonca Hortumlu Böceği, Hypera postica (Gyllenhal, 1813) (Coleoptera: Curculionidae)'nın Bazı Biyolojik Özellikleri. Iğdır Üniversitesi Fen Bilimleri Enstitüsü Dergisi, 9(3): 1220-1225.

Gözüaçık, C., Gültekin, N. & Velázquez de Castro, A.J. (2021). Notes on biology of alfalfa weevil, Sitona humeralis Stephens, 1831 (Coleoptera: Curculionidae) in alfalfa fields of Iğdır/Turkey province. Biological Diversity and Conservation, 14(1), 98-104.

Fedotova, Z.A. (2000). Gallitsy-fitofagi (Diptera, Cecidomyiidae)pustyn′i gor Kazakhstana: morfologiya, biologiya, rasprostraneniye, filogeniya i sistematika [Phytophage gall midges (Diptera, Cecidomyiidae) of deserts and mountains of Kazakhstan: morphology, biology, distribution, phylogeny and systematics]. Samara, Samara State Agricultural Academy Publ., 803 p. (In Russian).

Kolomoets, T. P., Mamaev, B.M., Zerova, M.D., Narchuk, E.P., Ermolenko, V.M., Dyakonchuk, L.A. (1989). Nasekomyye – galloobrazovateli kul′turnykh i dikorastushchikh rasteniy yevropeyskoy chasti SSSR. Dvukrylyye [Insects are gall formers of cultivated and wild plants in the European part of the USSR. Diptera]. Kiev, Naukova Dumka Publ., 1989, 168 p. (In Russian).

Mamaeva, K.P. & Mamaev B.M. (1981). [Gall midges]. In: Nasekomyye i kleshchi vrediteli sel′sko-khozyaystvennykh kul′tur. T. 4. Pereponchatokrylyye i dvukrylyye [In: Insects and mites pests of agricultural crops. T. 4. Hymenoptera and Diptera]. Leningrad, Nauka Publ., pp. 68-98. (In Russian).

Mirumian, L. (2011). Phytophagous gall midges (diptera: Cecidomyiidae) of Armenia. Acta Societatis Zoologicae Bohemicae, 75: 87-106.

Simova–Tošıæ, D., Skuhravá, M., & Skuhravý, V. (2000). Gall midges (Diptera: Cecidomyiidae) of Serbia. Acta Entomologica Serbica, 5 (1/2): 47-93.

Shebl, M.A., Kamel, S. M., Abu Hashesh, T.A. & Osman, M.A. (2008). The impact of leafcutting bees (Megachile minutissima, Megachilidae, Hymenoptera). Radoszkowski, 1876) artificial nest sites on seed production of alfalfa, Ismailia, Egypt. Agricultura, 5, 33-35.

Tamer, A., Aydemir, M. & Has, A. (1997). Ankara ve Konya illerinde korunga ve yoncada görülen zararlı ve faydalı böcekler üzerinde faunistik çalışmalar. Bitki Koruma Bülteni, 37(3-4), 125-161.

Udvardy, M. (1975). A Classification of the Biogeographical Provinces of the World. IUCN Occasional Paper No. 18. Morges, Switzerland: IUCN, 48 pp.

RENEWABLE ENERGY IN AGRICULTURE: A SYSTEMATIC REVIEW OF INNOVATIONS AND APPLICATIONS

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ABSTRACT
This study aims to systematically examine the application of renewable energy technologies in the agricultural sector, evaluating findings under key themes such as energy efficiency, environmental sustainability, technological innovations, rural development, and economic impacts. Agriculture represents a significant application area for renewable energy technologies due to its high energy demand and environmental impact. In this context, the study's purpose is to highlight the potential benefits, challenges, and future research opportunities associated with the integration of renewable energy technologies in agriculture. The study was conducted using a systematic literature review methodology. The research analysed the impacts of renewable energy technologies in agriculture under thematic categories, including energy efficiency, environmental sustainability, technological innovations, rural development, and economic impacts. The selection of studies was guided by predefined inclusion and exclusion criteria. In conclusion, this study highlights the substantial contributions of renewable energy technologies to agricultural sustainability, resilience, and economic growth. Their broader adoption is essential for transitioning the agricultural sector into a more environmentally friendly, economically viable, and technologically advanced industry. By addressing existing challenges and leveraging emerging opportunities, renewable energy integration can significantly contribute to a sustainable and resilient agricultural future. These gaps present a unique opportunity to advance digital agriculture and improve resource efficiency.
Keywords: Renewable Energy, Sustainability in Agriculture, Solar Energy Applications, Wind Energy, Bioenergy and Agriculture.

INTRODUCTION
Agriculture is an essential component to worldwide food security and economic development. However, the growing global population, rapid increase in energy demand, climate change,

and depletion of natural resources are placing unprecedented pressure on the agricultural sector (FAO, 2021; IPCC, 2022). These challenges threaten the sustainability of agricultural production systems, increasing the need for innovative and sustainable solutions to meet the demand for food, feed, and fiber (Emezirinwune et al., 2024; Rehman et al., 2024).

Traditional agricultural production methods, which rely heavily on fossil fuel use, have not only resulted in high energy costs but also accelerated environmental degradation through increased greenhouse gas emissions. In this context, the use of renewable energy technologies in agriculture is considered a significant step toward sustainable agricultural practices (Sudharshan et al., 2020; Shi et al., 2024). These technologies have considerable potential for minimising environmental issues while boosting energy efficiency (Majeed et al.,2023; Burg et al., 2022; Koçyiğit & Demiryürek, 2024; Rehman et al., 2024).The agricultural sector is heavily dependent on conventional energy sources due to its energy-intensive processes. Irrigation, harvesting, food processing, and storage are all fundamental agricultural tasks that rely heavily on fossil fuels. Nevertheless, this reliance has made the sector both environmentally and commercially unsustainable.

Renewable energy solutions offer an opportunity to reduce this dependency, minimize environmental impacts, lower energy costs, and enhance energy security in rural areas (Khan et al., 2022; Demiryürek et al., 2024; Shi et al., 2024). The purpose of this study is to evaluate the integration of renewable energy technologies into agricultural production systems, highlighting the opportunities they offer and the challenges they face. In this context, the study aims to analyze the application areas of renewable energy technologies and assess their economic, environmental, and social impacts. Additionally, it seeks to provide strategies for policymakers and practitioners to promote the integration of renewable energy solutions into agriculture.

This research focuses on the following questions:

❖ What are the prominent areas where renewable energy technologies are used in agriculture?

❖ What are the key barriers to adopting these technologies, and how can they be overcome?

❖ How do renewable energy solutions contribute to the sustainability of agricultural production systems?

❖ What strategies can encourage the integration of these technologies for policymakers and practitioners?

The scope of this research systematically analyzes 43 empirical studies conducted between 2010 and 2024 on agriculture and renewable energy technologies. These findings highlight the need for targeted strategies and interdisciplinary collaboration to integrate renewable energy solutions into agricultural systems effectively.

The study aims to fill gaps in the literature and guide policymakers and practitioners toward making the agricultural sector more resilient, efficient, and sustainable.

CONCEPTUAL FRAMEWORK

The integration of renewable energy sources into agriculture plays a critical role in achieving sustainable development goals. The agricultural sector, due to its high energy consumption, holds significant potential for the application of renewable energy technologies. Solar energy reduces energy costs in irrigation systems, while wind energy enhances electricity access, particularly in rural areas. Bioenergy encourages energy production by utilizing agricultural waste, while IoT and digital technologies make agricultural processes more efficient. Another key renewable energy solution, hybrid energy systems, combines various renewable energy sources such as solar, wind, and biomass to address agricultural energy needs with innovative solutions.

Studies by Faizan A. Khan et al. (2022) and Elkadeem et al. (2019) demonstrate the cost-effectiveness and sustainability advantages of hybrid systems. These systems present significant opportunities for enhancing energy supply security and reducing energy costs in rural areas. IoT-based smart agriculture technologies, when integrated with renewable energy systems, optimize energy and resource use in agricultural processes. Rehman et al. (2024) emphasize how IoT technology can optimize energy usage and minimize operational expenses in agricultural practices. The integration of digital technologies into renewable energy systems is particularly critical for improving water management in regions facing water scarcity. Bioenergy supports sustainability goals by transforming agricultural waste into a valuable resource for energy production.

Research conducted by Liu et al. (2014) and Mahdavi & Vera (2023) emphasize the potential of bioenergy to reduce carbon emissions and enhance energy supply. Research in this area underscores the need to promote the wider adoption of bioenergy systems. To accelerate the adoption of renewable energy systems, effective policy and incentive mechanisms are essential. Troost et al. (2015) and Borchers et al. (2014) illustrate how regional policies influence the success of energy projects. However, policy gaps in developing countries hinder the widespread implementation of renewable energy applications. The impact of renewable energy projects on ecosystems lies at the heart of sustainable development efforts. Lupp et al. (2014) and Tomaszewska et al. (2024) stress the importance of aligning energy crop production and water management processes with local ecosystems.

This conceptual framework provides a foundation for understanding the current and potential impacts of renewable energy in the agricultural sector. The themes explored in this study highlight the transformative effects of renewable energy applications on agricultural processes and identify research gaps in this area. Future studies could expand this framework to further support the integration of renewable energy into agriculture.

METHODOLOGY

This study adopts a Systematic Literature Review (SLR) approach to comprehensively evaluate the integration of renewable energy technologies in the agricultural sector. The research framework is based on the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure transparency, reproducibility, and methodological rigor. To deepen the analysis, a thematic synthesis was conducted, supported by a matrix table organized around key themes. This visual representation facilitated the systematic and comprehensible presentation of the findings.

Research Process and Objectives

❖ **Assessing the Impact of Renewable Energy Technologies:** Evaluating the effects of renewable energy technologies on agricultural sustainability.

❖ **Identifying Research Gaps:** Highlighting gaps and proposing directions for future studies and policies.

❖ **Showcasing innovative applications:** Investigating the impact of innovative applications on agricultural operations.

Data Collection Mechanism

The data collection process leveraged reliable academic databases and applied inclusion and exclusion criteria to ensure the selection of high-quality studies.

Categories and Details:

❖ **Data Sources:** Trusted academic platforms like Scopus, Web of Science, and Google Scholar were employed.

❖ **Keywords:** Search phrases encompassed terms such as “renewable energy,” “sustainable agriculture,” “utilization of solar energy,” “potential of wind energy,” and “applications of biomass.”

❖ **Document Types:** Only peer-reviewed journal articles and academic research were considered.

Inclusion Criteria:

❖ Peer-reviewed studies specifically addressing renewable energy applications in agriculture.

❖ Articles published between 2010 and 2024 in English or Turkish.

❖ Studies offering theoretical insights or practical applications of renewable energy technologies.

Exclusion Criteria:

❖ Studies not directly related to renewable energy technologies in agriculture.

❖ Non-academic materials such as blogs or unverified reports.

❖ Articles lacking empirical data or outside the specified timeframe.

The key findings from the selected studies were summarized in a matrix table to facilitate cross-theme comparability. This approach ensures that the findings are more accessible and actionable for policymakers, researchers, and practitioners. The methodological approach comprehensively addressed the transformative potential of renewable energy technologies in agricultural systems and contributed to advancements in both academic research and practical applications.

Systematic Literature Review Findings

The selection of 40 studies was strategically guided to ensure a comprehensive and balanced analysis of renewable energy technologies in agriculture.

❖ The chosen studies encompass diverse renewable energy technologies, such as solar energy, biogas, wind energy, IoT-based systems, and hybrid energy solutions. This diversity ensures the inclusion of a broad spectrum of agricultural applications and impacts.

❖ Publications from the last 14 years (2010–2024) were prioritized to capture the most recent advancements, trends, and innovations in the integration of renewable energy within agricultural practices.

❖ Preference was given to peer-reviewed scientific articles and research studies with high practical relevance and robust methodologies.

The studies represent a variety of geographical regions, agricultural practices, and renewable energy technologies, providing a holistic view of the subject matter. This carefully structured selection methodology supports an in-depth exploration of the transformative potential of renewable energy in agriculture. It also enables the identification of impactful innovations, the challenges of implementation, and critical research gaps, contributing to both academic and practical advancements in the field.

Table 1: Matrix-Style Table: Insights from Selected Studies on Renewable Energy in Agriculture

Theme	Author(s)	Journal	Objective	Findings

1	Energy Efficiency	Yaqoob Majeed et al., 2023	Energy Reports	Assessing the role of renewable energy in agriculture	Renewable energy improves efficiency, reduces costs, and enhances sustainability.
2	Renewable Energy Adoption	Albert Moerkerken et al., 2023	Journal of Agricultural Innovations	Identifying factors influencing solar energy adoption in farming	Adoption is linked to farm size, internet access, and innovation levels.
3	Hybrid Energy Systems	Faizan A. Khan et al., 2022	Energy Conversion and Management	Evaluating hybrid energy systems for rural applications	Optimized hybrid systems reduce costs to $0.183/kWh; Northern India is ideal for implementation.
4	Solar Energy Impact	Ch. Mohan Sai Kumar et al., 2023	Sustainable Energy Technologies and Assessments	Assessing solar energy's role in Indian agriculture	Solar energy significantly reduces CO_2 emissions and is cost-effective for agricultural applications.
5	Wind Energy Feasibility	N. Phuangpornpitak & S. Tia, 2011	Renewable Energy Applications	Feasibility study of wind farms in Thailand	GIS identified suitable sites for wind projects, but technical feasibility remains a challenge.
6	Economic Viability	Jin Yang et al., 2012	Economic Feasibility Journal	Evaluating wind energy projects under economic scenarios	Government subsidies and CDM programs enhance profitability of wind energy projects.
8	Sustainable Aquaculture	Clark C. K. Liu, 2013	Journal of Sustainable Aquaculture	Developing renewable energy-driven desalination systems	Renewable-powered systems reduce salt concentration and recycle aquaculture wastewater effectively.
9	Digital Agriculture	Rehman et al., 2024	Agricultural IoT Systems	Integrating IoT and renewable systems in agriculture	IoT-enabled systems optimize energy use and improve operational efficiency.
10	Rural Development	Michael U. Emezirinwune et al., 2024	Sustainable Energy Practices	Assessing hybrid systems in Nigerian agriculture	Hybrid systems enhance energy access, reduce GHG emissions, and boost sustainability.
12	Bioenergy Integration	V. Burg et al., 2022	Circular Energy Practices	Evaluating biogas plants in agriculture	Biogas plants reduce GHG emissions and substitute mineral fertilizers, contributing to the circular economy.
13	Autonomous Systems	Amin Ghobadpour et al., 2019	Renewable Agricultural Systems	Assessing energy efficiency in autonomous vehicles	Electrification using solar and hydrogen enhances operational flexibility and

					efficiency in agriculture.
14	Smart Irrigation	Md. Sudharshan et al., 2020	Smart Irrigation Systems	Developing renewable-powered irrigation systems	Automated irrigation improves plant growth and optimizes water and energy use.
15	GIS in Renewable Energy	Zhan Shi et al., 2024	Energy Sustainability	GIS-based site selection for bioenergy plants	Identified 45-66 optimal locations for bioenergy plants using GIS and multi-criteria decision analysis.
16	Solar-Wind Integration	Malene E. Leirpoll et al., 2021	Bioenergy Innovations	Evaluating combined solar and bioenergy systems	Solar energy outperforms bioenergy on abandoned lands; the combination enhances overall efficiency.
17	Policy Factors	Allison M. Borchers et al., 2014	Energy Policy	Identifying factors influencing renewable energy adoption in the U.S.	Larger, organic farms with internet access are more likely to adopt solar and wind energy systems.
18	Cost Effectiveness	Khan et al., 2022	Energy Conversion and Management	Assessing hybrid systems with storage technologies	Lead-acid flow batteries were found optimal for hybrid systems, offering cost-effective energy storage solutions.
19	Solar Energy Potential	Kumar et al., 2023	Sustainable Energy Technologies	Evaluating solar energy in Indian agriculture	Solar energy reduces CO_2 emissions and alleviates energy shortages in agricultural processes.
20	Wind Energy for Irrigation	Saravana et al., 2013	Renewable Energy	Evaluating wind-powered irrigation systems	Standalone wind systems reduced energy costs for agricultural irrigation in Tamil Nadu, India.
21	Wind Systems Economics	Yang et al., 2012	Energy Policy	Economic feasibility of wind projects in rural China	Wind energy projects are viable with financial incentives from CDM programs and government support.
23	Adoption Factors	Borchers et al., 2014	Energy Policy	Exploring adoption drivers in U.S. farms	Adoption is influenced by farm size, internet access, and state-level policy frameworks.
24	Biomass Utilization	Jing Yan Tock et al., 2010	Agricultural Energy Resources	Investigating banana biomass as a renewable energy source	Efficient utilization of banana biomass could meet 50% of Malaysia's renewable energy

					needs.
25	Rural Energy Projects	Clausen & Rudolph 2024	Renewable Energy for Rural Development	Evaluating renewable projects in Denmark and Scotland	Small-scale renewable projects improved rural energy access but required stronger policy alignment for broader impacts.
26	Renewable Energy in Agriculture	Falchetta et al. 2024	Environmental Development	Evaluating agriculture's contribution to advancing renewable energy-driven sustainable development in rural African regions. Examining agriculture's contribute to reaching renewable energy-based environmentally friendly growth in rural Africa.	Integrated modelling reveals that increased irrigation and productivity improve infrastructure feasibility and support rural development objectives.
27	Sustainable Agricultural Energy	Sriprapakhan et al.2021	Journal of the Saudi Society of Agricultural Sciences	Assessing integrated agricultural bioenergy and conventional agricultural energy frameworks for sustainability.	The IAB framework reduced costs by 66%, emitted fewer harmful gases, and provided higher profit margins compared to CAE.
28	Renewable Energy in Desalination	Tomaszewska et al.2024	Engineering Advance	Reviewing the use of renewable energy sources in desalination of geothermal water for agricultural irrigation.	Integrating renewable energy reduces costs and greenhouse gas emissions while addressing water scarcity challenges in agriculture.
29	Bioenergy from Agricultural Biomass	Liu et al.,2014	Applied Energy	Quantifying the potential and impacts of renewable energy production from agricultural biomass in Canada.	Combining market incentives and policy mandates significantly boosts bioenergy production, causing moderate land use changes while reducing GHG emissions.
30	Energy Crops and Land Use	Lupp et al.,2014	Land Use Policy	Examining the impact of increased energy crop production on ecosystem services in Germany.	Increased energy crop cultivation driven by the German EEG negatively affects ecosystem services, highlighting the need for localized sustainability standards and spatial planning.
31	Renewable Energy in ASEAN Agriculture	Chopra et al.,2022	Resources Policy	Examining the impact of renewable energy, carbon emissions, and deforestation on	Deforestation and increased CO_2 emissions have adverse effects on

				agricultural productivity in ASEAN countries.	agricultural productivity; however, renewable energy plays a significant role in fostering growth and sustainability in the sector.Regional integration does not significantly boost productivity.
32	Renewable Energy and Policy Conflicts	Troost et al.,2015	Land Use Policy	Modeling how farmers in Southwest Germany respond to climate, energy, and environmental policies.	The German EEG reduces participation in agri-environmental schemes like MEKA and shifts priorities from diversification to biogas production, with limited impact on reducing maize cultivation.
33	Renewable Energy and CO_2 Emissions	Ben Jebli & Ben Youssef, 2017	Ecological Indicators	Investigating the causal links between renewable energy, agriculture, and CO_2 emissions in North Africa.	Renewable energy increases emissions in the long run, while agricultural production reduces CO_2 emissions, indicating the need for clean energy sources like solar and wind.
34	Hybrid Renewable Energy Systems	Bertsiou et al.,2018	Renewable Energy	Evaluating the water management and electricity output of a Hybrid Renewable Energy System (HRES) in Fournoi Island.	The HRES fulfills over 86% of annual water demand and significantly contributes to electricity demand in remote areas.
35	Sustainable Bioenergy in Turkey	Rincon et al.,2019	Energy Policy	Assessing the potential of agricultural residues to contribute to Turkey's renewable electricity generation targets.	Biomass from agricultural residues could supply over 101% of Turkey's biomass renewable target by 2023, enhancing energy security and reducing GHG emissions.
36	Hybrid Renewable Energy Systems for Agriculture	Elkadeem et al.,2019	Energy Conversion and Management	Analyzing the feasibility and techno-economic design of a hybrid renewable energy system for agriculture in Dongola, Sudan.	A solar-wind-diesel-battery-converter system proved cost-effective, reducing carbon emissions and fuel consumption by 95%, with a positive ROI of 39.94%.
37	Smart Irrigation	Sudharshan et al.,2019	Procedia Computer	Developing a renewable energy-based smart	The system, powered by solar energy and

	Systems		Science	irrigation system for water management in agriculture.	governed by Arduino, improves water management and enhances crop growth compared to traditional irrigation methods.
38	Hybrid Renewable Energy Systems for Rural Electrification	Jahangir & Cheraghi, 2020	Sustainable Energy Technologies and Assessments	Evaluating the economic and environmental performance of a solar-wind-biomass hybrid system in rural Iran.	The most cost-effective system includes a biogas generator, photovoltaic panels, and batteries, with COE ranging from \$0.128 to \$0.223/kWh and negligible CO_2 emissions compared to coal-based power plants.
39	Agricultural Demand and Renewable Integration	Khanna, 2022	Energy	Investigating the role of agricultural demand-side management (DSM) in reducing renewable energy integration costs in India.	Demand-side management (DSM) in the agricultural sector reduces total costs by 4%, lowers renewable energy curtailment by 4-7%, and minimizes coal power plant cycling expenses, thereby enhancing system flexibility.
40	Globalization, Renewable Energy, and CO2 Emissions	Alam et al.,2023	Gondwana Research	Assessing the impact of globalization, renewable energy, and agriculture on atmospheric CO2 emissions in India.	Economic globalization and agricultural expansion increase atmospheric pollution, while renewable energy exhibits an inverted U-shaped relationship with pollution.
41	Solar Energy–Agriculture–Water Nexus	Supe et al., 2024	Heliyon	Assessing the interplay of solar energy expansion with agricultural land and water resource management in India.	Approximately 40% of solar farms are located on agricultural land, with Karnataka having the highest proportion at 73.55%. Meanwhile, Rajasthan demonstrates the greatest potential for solar energy development.
42	Hybrid Renewable Energy Systems	Patil et al., 2024	Journal of Atmospheric and Solar-Terrestrial	To conduct a techno-economic and environmental assessment of solar, wind, and	The optimized system includes solar, wind, biomass, diesel, and battery

			Physics	biomass hybrid systems for rural electrification in India.	storage, achieving a cost of $0.309/kWh and reducing annual CO_2 emissions to 56,728 kg/year.
43	Renewable Energy in Agriculture	Mahdavi & Vera, 2023	International Journal of Hydrogen Energy	To assess Morocco's potential in utilizing renewable energy sources, including agricultural biomass, for primary energy demand.	Agricultural residues like olive, date palm, and citrus biomasses can complement solar and wind energy to reduce reliance on fossil fuels and lower emissions by 32% by 2030.

CONCLUSION AND DISCUSSION

A total of 43 international peer-reviewed articles examining the relationship between renewable energy and agriculture were systematically analyzed in this study. The articles were categorized under themes such as energy efficiency, hybrid energy systems, solar and wind energy, bioenergy integration, digital agriculture, smart irrigation systems, and the impact of policies. These themes were selected to better understand the roles of renewable energy sources in agricultural sustainability and identify potential applications of relevant technologies. The selection criteria focused on the articles' innovative approaches, the validity of findings, geographical representation, and impacts on agricultural processes.

A comprehensive analysis was conducted to identify gaps in the literature and research needs. Many studies emphasize the positive effects of renewable energy on agricultural processes, highlighting its critical importance for sustainability. For instance, Yaqoob Majeed et al. (2023) and Rehman et al. (2024) demonstrated that integrating IoT technologies with renewable energy improves energy efficiency in agricultural production and optimizes resource use. These studies underscore the benefits of IoT-based energy management systems in processes such as irrigation and crop management.

IoT technologies, through real-time data analysis and automation, reduce energy consumption while enhancing operational efficiency and sustainability in agriculture. These findings reveal the significant potential of IoT-supported renewable energy applications in improving energy efficiency and resource optimization in the agricultural sector. Similarly, studies by Sudharshan et al. (2019) and Ch. Mohan Sai Kumar et al. (2023) highlight the environmental and operational advantages of solar-powered smart irrigation systems in agricultural applications. These studies demonstrate that the use of solar energy reduces CO_2 emissions and optimizes water usage. Solar-powered systems are shown to make a critical contribution to sustainable agricultural practices, emphasizing the vital role of solar energy in water management and environmental sustainability within the agricultural sector.

Research by Liu et al. (2014) and Rincon et al. (2019) highlights the benefits of bioenergy production in effectively utilizing agricultural waste and enhancing energy supply security. These studies show that bioenergy projects not only reduce carbon emissions but also contribute significantly to the circular economy. Utilizing agricultural waste as an energy resource promotes environmental sustainability and provides an alternative and innovative solution for energy production. Faizan A. Khan et al. (2022) and Elkadeem et al. (2019) examined the cost-effectiveness and sustainability benefits of hybrid energy systems. These systems, which combine sources like wind, solar, and biomass, play a critical role in ensuring energy security in rural areas. The studies strongly support the potential of hybrid systems to reduce energy costs and minimize environmental impacts. While renewable energy generally has positive contributions to agricultural processes, notable differences in findings exist due to regional and methodological variations. For example, Ben Jebli and Ben Youssef (2017) argued that renewable energy could increase CO_2 emissions in North Africa over the long term, while Chopra et al. (2022) found that renewable energy use in ASEAN countries reduces emissions and enhances agricultural productivity. These conflicting results may stem from differences in regional energy policies, infrastructure, and implementation practices for renewable energy technologies. Additionally, levels of economic development and energy use habits play a fundamental role in these variations.

Albert Moerkerken et al. (2023) highlighted the structural factors affecting the adoption of solar energy, such as farm size and economic capacity. In contrast, Borchers et al. (2014) emphasized the critical roles of government policies, incentives, and internet access in renewable energy adoption. This indicates that, alongside technological and policy support, socio-economic factors significantly influence renewable energy adoption.

Patil et al. (2024) and Jahangir & Cheraghi (2020) explored the feasibility of hybrid energy systems in different geographical contexts, reaching diverse conclusions. Variations in the availability of local energy resources and the economic viability of hybrid systems underline the influence of regional characteristics on the applicability and efficiency of these systems. A study conducted in India demonstrated that effectively combining renewable energy sources such as solar, wind, biomass, and diesel significantly reduces energy costs and annual carbon emissions.

In contrast, a study in Iran revealed that the economic performance of hybrid energy systems largely depends on the availability of local energy resources and price fluctuations. These differences highlight that the cost-effectiveness and feasibility of hybrid energy systems vary greatly depending on regional energy infrastructure, resource diversity, and government incentives. The studies underscore that renewable energy projects exhibit significant variation based on regional characteristics. Falchetta et al. (2024) emphasized that renewable energy projects in Africa serve as a critical tool for enhancing irrigation systems and agricultural productivity. However, infrastructure deficiencies and financial constraints hinder the widespread adoption of such projects. Similarly, Ch. Mohan Sai Kumar et al. (2023) and Patil et al. (2024) showed that solar and wind energy projects in India provide cost-effective solutions in rural areas, highlighting the economic benefits and environmental sustainability contributions of hybrid energy systems.

In Europe, Lupp et al. (2014) and Troost et al. (2015) examined the ecological impacts of energy crop production and the importance of policies in shaping sustainable energy practices. Sustainable energy policies play a critical role in fostering positive changes in agricultural processes. Chopra et al. (2022) examined how renewable energy initiatives influence agricultural productivity in ASEAN nations, whereas Liu et al. (2014) focused on the role of bioenergy projects in reducing carbon emissions and enhancing energy security in Canada. There is limited research on the integration of bioenergy projects into agricultural processes, particularly in developing countries, which hampers a comprehensive understanding of bioenergy's impact on agricultural productivity. While the influence of policies and incentives on the success of renewable energy projects is evident, more detailed studies assessing the effectiveness of these mechanisms are required. Research that accounts for regional differences could play a significant role in enhancing the feasibility and sustainability of renewable energy projects. Moreover, the limited studies on the integration of digital technologies such as IoT, artificial intelligence, and data analytics with renewable energy reveal that their potential for optimizing energy use and improving resource efficiency has not been fully explored. Future research should investigate how these technologies can be more effectively integrated with renewable energy systems in agriculture. These research gaps present critical opportunities for understanding renewable energy applications in agriculture and fostering innovation in the sector.

This literature review highlights the importance of renewable energy in agricultural processes while showing that applications can vary significantly due to geographic and regional differences. Future studies should examine the economic, environmental, and social impacts of renewable energy projects from a broader perspective and contribute to regional policy development. Such research can provide a crucial foundation for the integration of sustainable agriculture and renewable energy.

RESEARCH GAPS AND OPPORTUNITIES

The effects of renewable energy on agricultural applications vary significantly depending on geographic regions. Studies in Africa highlight infrastructure deficiencies and financial constraints, while research in India emphasizes the cost-effectiveness of hybrid systems. However, it is essential to examine the ecological, social, and economic impacts of renewable energy integration in diverse geographies more comprehensively. For instance, further studies are needed on renewable energy-supported irrigation solutions, particularly in water-scarce regions.

Research on integrating bioenergy resources into agricultural processes remains limited. The efficient use of agricultural waste for energy production has not been adequately explored, particularly in terms of regional policies and technological infrastructure. Additionally, more data is needed on the long-term effects of bioenergy on carbon emissions and environmental sustainability. Despite the potential of IoT and artificial intelligence technologies to enhance agricultural productivity when integrated with renewable energy, there are few studies in this area. Specifically, the impact of IoT-based smart irrigation systems on energy and water savings should be explored in depth. Research should also focus on the feasibility of implementing these technologies in small and medium-sized farms. Policy and incentive mechanisms play a critical role in the success of renewable energy projects. However, mechanisms that consider regional differences and are tailored to local needs have not been adequately investigated. For example, while the impact of government incentives on renewable energy projects in North America has been studied extensively, their effects in developing countries remain underexplored. This gap presents opportunities to design regional energy policies and incentives more effectively.

There are gaps in the literature regarding the long-term environmental and economic impacts of renewable energy on agriculture. Specifically, the cost-effectiveness and CO_2 emission reductions associated with hybrid energy systems need to be detailed further. Moreover, more studies are required to examine the effects of renewable energy systems on ecosystem services and the social outcomes for local communities. Regional studies on the feasibility and effectiveness of hybrid energy systems are also necessary. Systems that combine solar, wind, and biomass resources offer significant opportunities for energy security, but optimization from economic and technical perspectives remains a challenge.

Lessons from successful examples in India and Africa could guide the adaptation of these systems to other geographies. The adverse effects of energy crop production on ecosystems represent a notable research gap. Research by Lupp et al. (2014) and Troost et al. (2015) indicates that these practices may pose risks to ecosystem services, highlighting the need for strategies that balance energy production with environmental conservation. Developing sustainability standards for the production of energy crops that align with local ecosystems is essential. There are opportunities to increase the use of GIS, IoT, artificial intelligence, and optimization models in designing renewable energy systems.

Research like that of Zhan Shi et al. (2024) demonstrates that GIS-based site selection is critical for the success of energy projects. Expanding the application of such innovative technologies could enable more efficient planning of energy systems. These research gaps provide significant opportunities to enhance the integration of renewable energy and agriculture in support of sustainable development. Future studies targeting these gaps can contribute to the more effective use of renewable energy in agricultural applications. Regional-focused and interdisciplinary approaches, in particular, have the potential to significantly expand knowledge in this field.

REFERENCES

Akrofi, M. M., & Okitasari, M. (2022). Integrating solar energy considerations into urban planning for low carbon cities: A systematic review of the state-of-the-art. Urban Governance, 2(2), 102-117. https://doi.org/10.1016/j.ugj.2022.04.002

Algburi, S., Rendal, E., Jaber, Z. K., Fakhruldeen, H. F., Amjad, A., Sapaev, I. B., Farhan, T. T., & Barakat, M. (2024). Evaluating the viability and potential of hybrid solar-wind renewable energy systems in relation to geographical and environmental factors. Results in Engineering. Advance online publication. https://doi.org/10.1016/j.rineng.2024.103473

Ang, T.-Z., Salem, M., Kamarol, M., Das, H. S., Nazari, M. A., & Prabaharan, N. (2022). A comprehensive study of renewable energy sources: Classifications, challenges and suggestions. Energy Strategy Reviews, 43, 100939. https://doi.org/10.1016/j.esr.2022.100939

Ayua, T. J., Uto, O. T., & Fatty, L. K. M. (2023). An investigation of solar energy potential towards improving agriculture using angstrom and newly developed analytical models: In case of The Gambia. Scientific African, 22, e01886. https://doi.org/10.1016/j.sciaf.2023.e01886

Ben Jebli, M., & Ben Youssef, S. (2017). The role of renewable energy and agriculture in reducing CO2 emissions: Evidence for North Africa countries. Ecological Indicators, **74**, 295–301. https://doi.org/10.1016/j.ecolind.2016.11.032

Bertsiou, M., Feloni, E., Karpouzos, D., & Baltas, E. (2018). Water management and electricity output of a Hybrid Renewable Energy System (HRES) in Fournoi Island in Aegean Sea. Renewable Energy, **118**, 790–798. https://doi.org/10.1016/j.renene.2017.11.078

Borchers, A. M., Xiarchos, I., & Beckman, J. (2014). Determinants of wind and solar energy system adoption by U.S. farms: A multilevel modeling approach. Energy Policy, 69, 106-115. https://doi.org/10.1016/j.enpol.2014.02.014

Burg, V., Bowman, G., & Schöbitz, L. (2022). Agricultural biogas plants for circular economy: A comprehensive review. Circular Energy Practices, 18, 45-60. https://doi.org/10.1016/j.resconrec.2022.106770

Burg, V., Rolli, C., Schnorf, V., Scharfy, D., Anspach, V., & Bowman, G. (2023). Agricultural biogas plants as a hub to foster circular economy and bioenergy: An assessment using substance and energy flow analysis. Resources, Conservation and Recycling, 190, 106770. https://doi.org/10.1016/j.resconrec.2022.106770

Chopra, R., Magazzino, C., Shah, M. I., Sharma, G. D., Rao, A., & Shahzad, U. (2022). The role of renewable energy and natural resources for sustainable agriculture in ASEAN countries: Do carbon emissions and deforestation affect agriculture productivity? Resources Policy, 76, 102578. https://doi.org/10.1016/j.resourpol.2022.102578

Clausen, L. T., & Rudolph, D. (2020). Renewable energy for sustainable rural development: Synergies and mismatches. Energy Policy, 138, 111289. https://doi.org/10.1016/j.enpol.2020.111289

Cooney, D., Kim, H., Quinn, L., Lee, M.-S., Guo, J., Chen, S.-L., Xu, B., & Lee, D. K. (2017). Switchgrass as a bioenergy crop in the Loess Plateau, China: Potential lignocellulosic feedstock production and environmental conservation. Journal of Integrative Agriculture, 16(6), 1211–1226. https://doi.org/10.1016/S2095-3119(16)61587-3

Demiryurek, K., Glezman, L., & Tsarenko, I. (2024). The Role of Demographic Processes in the Digital Transformation of Industrial Regions. Lecture Notes in Information Systems and Organization, 347-358.

Elkadeem, M. R., Wang, S., Sharshir, S. W., & Atia, E. G. (2019). Feasibility analysis and techno-economic design of grid-isolated hybrid renewable energy system for electrification of agriculture and irrigation area: A case study in Dongola, Sudan. Energy Conversion and Management, **196**, 1453–1478. https://doi.org/10.1016/j.enconman.2019.06.085

Emezirinwune, M. U., Adejumobi, I. A., Adebisi, O. I., & Akinboro, F. G. (2024). Synergizing hybrid renewable energy systems and sustainable agriculture for rural development in Nigeria. e-Prime - Advances in Electrical Engineering, Electronics and Energy, 7, 100492. https://doi.org/10.1016/j.prime.2024.100492

Falchetta, G., Vinca, A., Troost, A., Tuninetti, M., Ireland, G., Byers, E., Hafner, M., & Zulu, A. (2024). The role of agriculture for achieving renewable energy-centered sustainable development objectives in rural Africa. Environmental Development, 52, 101098. https://doi.org/10.1016/j.envdev.2024.101098

FAO. (2021). The state of food and agriculture 2021: Making agrifood systems more resilient to shocks and stresses. Food and Agriculture Organization of the United Nations. Retrieved from https://www.fao.org

Ghobadpour, A., Boulon, L., Mousazadeh, H., Malvajerdi, A. S., & Rafiee, S. (2019). State of the art of autonomous agricultural off-road vehicles driven by renewable energy systems. Energy Procedia, 159, 204–209. https://doi.org/10.1016/j.egypro.2019.04.002

Guan, J., & Hu, J., & Li, B. (2024). How to restore ecological impacts from wind energy? An assessment of Zhongying Wind Farm through MSPA-MCR model and circuit theory. Ecological Indicators, 163, 112149. https://doi.org/10.1016/j.ecolind.2024.112149

Hoseinzadeh, S., & Astiaso Garcia, D. (2024). AI-driven innovations in greenhouse agriculture: Reanalysis of sustainability and energy efficiency impacts. Energy Conversion and Management: X, 15, 100701. https://doi.org/10.1016/j.ecmx.2024.100701

IPCC. (2022). Climate change 2022: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. Retrieved from https://www.ipcc.ch

Jahangir, M. H., & Cheraghi, R. (2020). Economic and environmental assessment of solar-wind-biomass hybrid renewable energy system supplying rural settlement load. Sustainable Energy Technologies and Assessments, **42**, 100895.https://doi.org/10.1016/j.seta.2020.100895

Jeong, J. S., & Ramírez-Gómez, Á. (2017). Renewable energy management to identify suitable biomass facility location with GIS-based assessment for sustainable environment. Energy Procedia, 136, 139–144. https://doi.org/10.1016/j.egypro.2017.10.310

Khan, F. A., Pal, N., Saeed, S. H., & Yadav, A. (2022). Techno-economic and feasibility assessment of standalone solar photovoltaic/wind hybrid energy system for various storage techniques and different rural locations in India. Energy Conversion and Management, 270, 116217. https://doi.org/10.1016/j.enconman.2022.116217

Khanna, T. M. (2022). Using agricultural demand for reducing costs of renewable energy integration in India. Energy, **254**, 124385. https://doi.org/10.1016/j.energy.2022.124385

KOÇYİĞİT, A. Y., & DEMİRYÜREK, K. (2024). The Role of Agricultural Extension in Adaptation to Climate Change. Agricultural Economics And Climate Change, 161.

Koswatte, I., Iddawala, J., Kulasekara, R., Ranaweera, P., Dasanayaka, C. H., & Abeykoon, C. (2024). Can Sri Lanka be a net-zero nation by 2050?—Current renewable energy profile, opportunities, challenges, and recommendations. Cleaner Energy Systems, 8, 100126. https://doi.org/10.1016/j.cles.2024.100126

Kumar, C. M. S., Ramesh, R., & Anandaraj, S. (2023). Solar energy for Indian agriculture: Applications and potential. Sustainable Energy Technologies and Assessments, 56, 102492. https://doi.org/10.1016/j.renene.2022.02.065

Leirpoll, M. E., Næss, J. S., Cavalett, O., Dorber, M., Hu, X., & Cherubini, F. (2021). Optimal combination of bioenergy and solar photovoltaic for renewable energy production on abandoned cropland. Renewable Energy, 168, 45–56 https://doi.org/10.1016/j.renene.2020.11.159

Liu, C. C. K. (2013). The development of a renewable-energy-driven reverse osmosis system for water desalination and aquaculture production. Journal of Integrative Agriculture, 12(8), 1357–1362. https://doi.org/10.1016/S2095-3119(13)60541-9

Liu, T., McConkey, B., Huffman, T., Smith, S., MacGregor, B., Yemshanov, D., & Kulshreshtha, S. (2014). Potential and impacts of renewable energy production from agricultural biomass in Canada. Applied Energy, 130, 222–229. https://doi.org/10.1016/j.apenergy.2014.05.044

Lupp, G., Steinhäußer, R., Starick, A., Gies, M., Bastian, O., & Albrecht, J. (2014). Forcing Germany's renewable energy targets by increased energy crop production: A challenge for regulation to secure sustainable land use practices. Land Use Policy, 36, 296–306. https://doi.org/10.1016/j.landusepol.2013.08.012

Mahdavi, M., & Vera, D. (2023). Importance of renewable energy sources and agricultural biomass in providing primary energy demand for Morocco. International Journal of Hydrogen Energy, 48(88), 34575–34598. https://doi.org/10.1016/j.ijhydene.2023.05.246

Majeed, Y., Khan, M. U., Waseem, M., Zahid, U., Mahmood, F., Majeed, F., Sultan, M., & Raza, A. (2023). Renewable energy as an alternative source for energy management in agriculture. Energy Reports, 9, 344-359. https://doi.org/10.1016/j.egyr.2023.06.032

Moerkerken, A., Duijndam, S., Blasch, J., van Beukering, P., & van Well, E. (2023). Which farmers adopt solar energy? A regression analysis to explain adoption decisions over time. Renewable Energy Focus, 45, 169-178. https://doi.org/10.1016/j.ref.2023.04.001

Mohan Sai Kumar, C., Singh, S., Gupta, M. K., Nimdeo, Y. M., Raushan, R., Deorankar, A. V., Ananda Kumar, T. M., Rout, P. K., Chanotiya, C. S., Pakhale, V. D., & Nannaware, A. D. (2023). Solar energy: A promising renewable source for meeting energy demand in Indian agriculture applications. Sustainable Energy Technologies and Assessments, 55, 102905. https://doi.org/10.1016/j.seta.2022.102905

Obalalu, A. M., Alqarni, M. M., Odetunde, C., Memon, M. A., Olayemi, O. A., Shobo, A. B., Mahmoud, E. E., Ali, M. R., Sadat, R., & Hendy, A. S. (2023). Improving agricultural efficiency with solar-powered tractors and magnetohydrodynamic entropy generation in copper–silver nanofluid flow. Case Studies in Thermal Engineering, 51, 103603. https://doi.org/10.1016/j.csite.2023.103603

Paletto, A., Bernardi, S., Pieratti, E., Teston, F., & Romagnoli, M. (2019). Assessment of environmental impact of biomass power plants to increase the social acceptance of renewable energy technologies. Heliyon, 5(7), e02070. https://doi.org/10.1016/j.heliyon.2019.e02070

Patil, A. A., Arora, R., Arora, R., & Sridhara, S. N. (2024). Techno-economic analysis of solar, wind and biomass hybrid renewable energy systems in Bhorha village, India. Journal of Atmospheric and Solar-Terrestrial Physics, 265, 106362. https://doi.org/10.1016/j.jastp.2024.106362

Phuangpornpitak, N., & Tia, S. (2011). Feasibility study of wind farms under the Thai very small scale renewable energy power producer (VSPP) program. Energy Procedia, 9, 294–302. https://doi.org/10.1016/j.egypro.2011.09.017

Raihan, A., Hasan, M. A., Voumik, L. C., Pattak, D. C., Akter, S., & Ridwan, M. (2024). Sustainability in Vietnam: Examining economic growth, energy, innovation, agriculture, and forests' impact on CO2 emissions. World Development Sustainability, 4, 100164. https://doi.org/10.1016/j.wds.2024.100164

Rehman, A. U., Alamoudi, Y., Khalid, H. M., Morchid, A., Muyeen, S. M., & Abdelaziz, A. Y. (2024). Smart agriculture technology: An integrated framework of renewable energy resources, IoT-based energy management, and precision robotics. Cleaner Energy Systems, 9, 100132. https://doi.org/10.1016/j.cles.2024.100132

Rikkonen, P., Tapio, P., & Rintamäki, H. (2019). Visions for small-scale renewable energy production on Finnish farms – A Delphi study on the opportunities for new business. Energy Policy, 129, 939–948. https://doi.org/10.1016/j.enpol.2019.03.004

Rincon, L., Puri, M., Kojakovic, A., & Maltsoglou, I. (2019). The contribution of sustainable bioenergy to renewable electricity generation in Turkey: Evidence based policy from an integrated energy and agriculture approach. Energy Policy, **130**, 69–88. https://doi.org/10.1016/j.enpol.2019.03.024

Shanthi Saravana, B., Rajini, V., & Paramasivam, A. (2013). Analyzing wind power potential in Cauvery Delta areas for implementation of renewable energy-based standalone pumping system for irrigation. IERI Procedia, 5, 130–137. https://doi.org/10.1016/j.ieri.2013.11.085

Shi, Z., Marinello, F., Ai, P., & Pezzuolo, A. (2024). Assessment of bioenergy plant locations using a GIS-MCDA approach based on spatio-temporal stability maps of agricultural and livestock byproducts: A case study. Science of The Total Environment, 947, 174665. https://doi.org/10.1016/j.scitotenv.2024.174665

Sriprapakhan, P., Artkla, R., Nuanual, S., & Maneechot, P. (2021). Economic and ecological assessment of integrated agricultural bio-energy and conventional agricultural energy frameworks for agriculture sustainability. Journal of the Saudi Society of Agricultural Sciences, 20(4), 227–234. https://doi.org/10.1016/j.jssas.2021.02.001

Stöhr, M., & Hackenberg, B. (2018). Enhancing synergy effects between the electrification of agricultural machines and renewable energy deployment with semi-stationary energy storage in rural grids. Energy Procedia, 147, 390–396. https://doi.org/10.1016/j.egypro.2018.11.057

Sudharshan, N., Karthik, A. V. S. K., Kiran, J. S. S., & Geetha, S. (2019). Renewable energy based smart irrigation system. Procedia Computer Science, **165**, 615–623. https://doi.org/10.1016/j.procs.2020.01.055

Supe, H., Abhishek, A., & Avtar, R. (2024). Assessment of the solar energy–agriculture–water nexus in the expanding solar energy industry of India: An initiative for sustainable resource management. Heliyon, 10(1), e23125. https://doi.org/10.1016/j.heliyon.2023.e23125

Tock, J. Y., Lai, C. L., Lee, K. T., Tan, K. T., & Bhatia, S. (2010). Banana biomass as potential renewable energy resource: A Malaysian case study. Renewable and Sustainable Energy Reviews, 14(2), 798-805. https://doi.org/10.1016/j.rser.2009.10.010

Tomaszewska, B., Akkurt, G. G., Kaczmarczyk, M., Bujakowski, W., Keles, N., Jarma, Y. A., Baba, A., Bryjak, M., & Kabay, N. (2021). Utilization of renewable energy sources in desalination of geothermal water for agriculture. Desalination, 513, 115151. https://doi.org/10.1016/j.desal.2021.115151

Troost, C., Walter, T., & Berger, T. (2015). Climate, energy and environmental policies in agriculture: Simulating likely farmer responses in Southwest Germany. Land Use Policy, **46**, 50–64. https://doi.org/10.1016/j.landusepol.2015.01.028

Türkmen, B. A. (2020). Renewable energy applications for sustainable agricultural systems. International Journal of Innovative Approaches in Agricultural Research, 4(4), 497–504. https://doi.org/10.29329/ijiaar.2020.320.11

Viana, C. M., Freire, D., Abrantes, P., Rocha, J., & Pereira, P. (2022). Agricultural land systems importance for supporting food security and sustainable development goals: A systematic review. Science of The Total Environment, 806, 150718. https://doi.org/10.1016/j.scitotenv.2021.150718

Yang, J., Chen, W., Chen, B., & Jia, Y. (2011). Economic feasibility analysis of a renewable energy project in rural China. Procedia Environmental Sciences, 8, 2306–2309. https://doi.org/10.1016/j.proenv.2012.01.217

Zakariazadeh, A., Ahshan, R., Al Abri, R., & Al-Abri, M. (2024). Renewable energy integration in sustainable water systems: A review. Cleaner Engineering and Technology, 15, 100722. https://doi.org/10.1016/j.clet.2024.100722

STUDY ON THE USE OF ELECTROSHOCK TECHNIQUES FOR WEED CONTROL

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ABSTRACT

Introduction and Purpose: The crop yield decreases considerably when weeds are not adequately controlled, and producer income decreases accordingly. Furthermore, the environmental damage caused by herbicides is increasingly prompting interest in alternative methods of control. In this context, this study aimed to develop a basic robot using electroshock technology to combat weeds in small production areas. This robot is intended to be used in the fight against weeds, thus aiming to reduce the damage caused by pesticides. **Materials and Methods**: The robot system was assembled in the following order: Installation of the electric shock system, object detection sensor, Bluetooth device, wheels, and Arduino UNO setup. Experiments were then conducted on different types of leaves and stems to evaluate the robot's performance. For the applications on potted plants, the shocking process was performed in three parts: large-leaf plants (group A, leaf length: 8-10 cm), small-leaf plants (group B, leaf length: 4-5 cm), and stems (group C, stem thickness: 5-10 mm). Each experiment was conducted with three replicates. The deformations of the plants were visually assessed immediately after the shocking procedure and 3 hours and 24 hours later for the same region. **Results and Discussion:** According to the results, localized small deformations were first observed in the leaves of group A, followed by growth in the area of the deformation and fractures after 3 and 24 hours. Group B leaves initially showed slight color changes and signs of deformation. After three hours, yellowing was observed, and after 24 hours, wilting and drying continued in some areas. In the stems, slight color changes and slight bending were initially observed; after three hours, the stems began to bend and wilt more severely, and after 24 hours, severe wilting and structural degradation of the plant stem were observed. **Conclusion:** The experimental results show that treatment with electric shocks led to yellowing, wilting, drying, and breaking of the leaves as well as wilting and twisting of the stems. In the context of these results, it was hypothesized that the electroshock

treatment was successful and could be offered as an alternative to chemical control in weed management.
Keywords: Weed Control, Robotic, Electric Shock System, Environment.

GİRİŞ

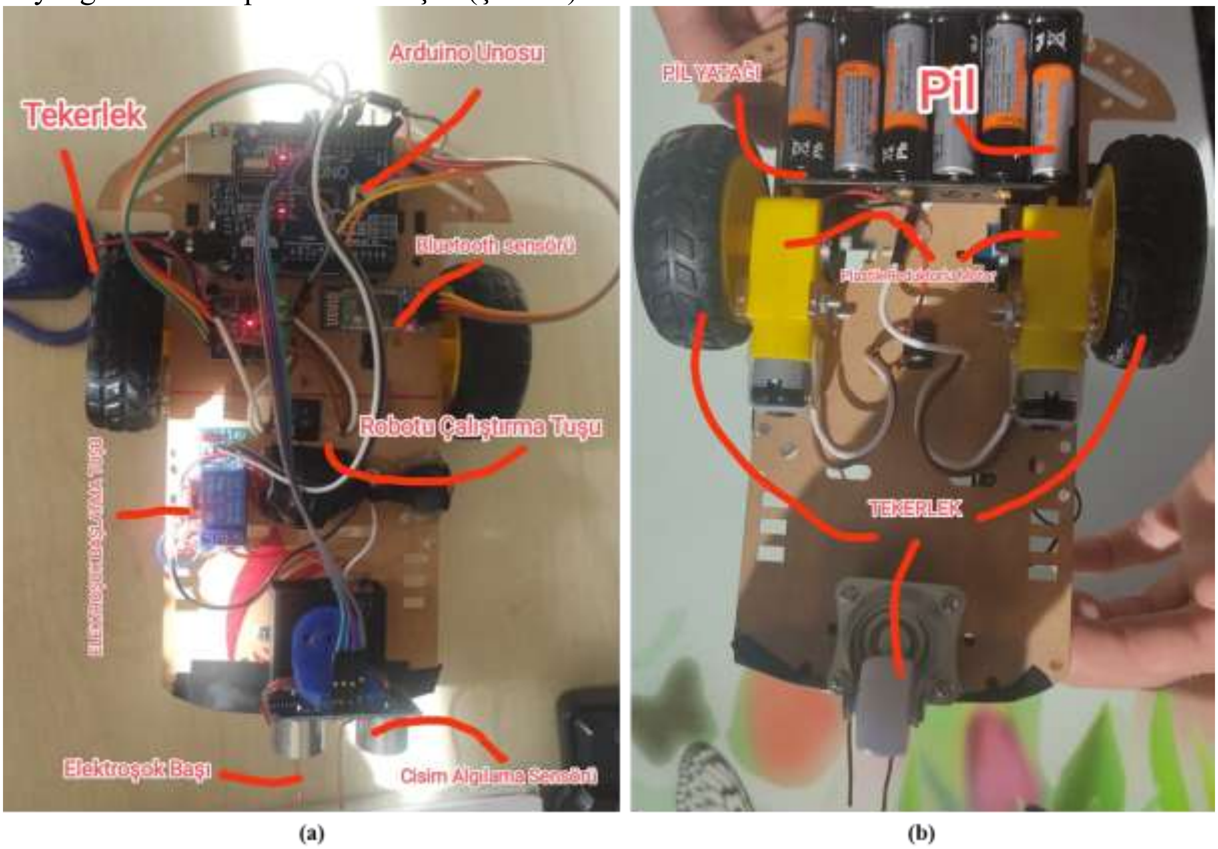
Bitkisel üretim alanlarında istenmeyen, kültür bitkilerinin ışık, sıcaklık, nem, besin elementleri vb. alımını etkileyerek, bitkiyi strese sokan ve gelişimini engelleyen bitkiler yabancı ot olarak adlandırılmaktadır (Sujaritha et al., 2017). Yabancı otları tanımlama da dikkate alınması gereken bir husus, ekili alanlarda neyin istendiği ve neyin istenmediği sorusuna cevap bulmaktır. Diğer bir deyişle, ekili alanlarda kültür bitkisinin gelişimini engelleyen bitkiler yabancı ot olarak değerlendirilirken, aynı bitki bir bahçede süs bitkisi olarak değerlendirilebilir. Ancak tarımsal üretim alanlarında kültür bitkisi dışındaki diğer bitkiler genel olarak yabancı ot olarak değerlendirilmekte ve bunlar farklı mücadele yollarıyla bulunduğu alandan ya uzaklaştırılarak ya da yok edilerek bertaraf edilmektedir.
Yabancı otlar, ekosistemdeki faydalarının yanı sıra, tarımsal ürünlerle doğal kaynaklar için rekabete girerek ürün kalitesini ve üretkenliğini azaltmakta, verimi düşürmekte ve sonuç olarak çiftçilerin maliyetlerini artırmaktadır. Yabancı otlarla mücadelede, tarımsal ekosisteme zarar vermeden, çeşitli kontrol yöntemlerini uyumlu bir şekilde entegre eden etkili ve sürdürülebilir bir yönetim sürecine ihtiyaç vardır. Bu nedenle, yoğun mekanizasyon ve herbisit kullanımından kaçınılmalıdır (Monteiro and Santos, 2022). Bununla birlikte, yabancı otlarla mücadelede bilinen en yaygın yöntem kimyasal mücadele olup, bu yöntemde ise herbisit olarak bilinen yabancı ot öldürücüler kullanılmaktadır. Ancak, kimyasal ilaç kullanımının çevreye olan büyük zararları, çevre politikaları, sivil toplum kuruluşların aktif rol alması vb. faktörler alternatif yöntemlerin araştırılmasına neden olmuştur. Kimyasal mücadeleye alternatif olarak mekanik, fiziksel veya fiziko-mekanik yöntemler kullanılabilmektedir. Bu yöntemlerden yaygın kullanılan bazıları, malçlama, su altında bırakma, farklı toprak işleme tekniklerini kullanma, çapalama, termal yöntem, elektroşok uygulama ve robotiklerin kullanımı sayılabilir.
Yabancı otların zararını azaltmak veya ortadan kaldırmak amacıyla geçmişten günümüze farklı mücadele yöntemlerinin kullanıldığı birçok çalışma gerçekleştirilmiştir (Çolak ve ark., 2019). Shaner (2014), Sujaritha et al., (2017) ve McAllister et al., (2018), yabancı otlarla mücadelede farklı münavebe sistemlerinin, el veya aletler ile mekanik kontrol, biyolojik ve kimyasal mücadelelerin yapılabileceğini bildirmişlerdir. Hinds (2020), diğer yöntemler mümkün olmadığında bile mekanik yabancı ot temizlemenin, etkili bir yabancı ot yönetimi sağlayabildiğini ve bazı durumlarda onları geride bırakabildiğini ifade etmiştir. Bununla birlikte, Mohler et al., (1997) ve McAllister et al., (2018), mekanik olarak yapılan mücadelenin bitkinin gelişme durumuna göre değişeceğini ve yabancı ot boyunun artmasıyla ancak sıra arasında mücadele yapılabileceğini belirtmişlerdir. Partel et al., (2019) ve Rueda-Ayala et al., (2020) mekanik yöntemlerle ot kontrolünün toprak işleme yöntemleriyle güçlü bir ilişki içerisinde olduğunu, Lingenfelter and Curran (2001), ise farklı toprak işleme yöntemlerinin yabanı ot mücadelesinde kullanılabileceğini bildirmiştir.
Yabancı otlarla yapılan diğer bir yöntem termal kontroldür. Bu yöntem, toprakta ve suda kimyasal kalıntı bırakmadan hızlı bir yabancı ot kontrolü sağlayan ateş, alevleme, sıcak su, buhar ve dondurma tekniğine dayanır. Radicetti (2012), termal yöntemlerin yabancı otlara karşı seçici olduğunu, toprağı örselemediğini ve bu nedenle örtülü tohumları yetiştirme yöntemlerinde olduğu gibi toprak yüzeyine çıkarmadığını ifade etmektedir. Scavo and Mauromicale (2020) ise alevlemenin, organik ve geleneksel çiftçilik sistemlerinde en yaygın olarak uygulanan termal yöntem olduğunu bildirmiştir. Pérez-Ruíz et al., (2014), alevle

yakmanın yabancı ot kontrolünde kullanılabileceğini, ancak bu yöntemin riskleri olduğunu ve maliyetinin yüksek olacağını bildirmektedirler. Bunların yanı sıra, yabancı otlarla mücadele de doğal düşman olarak bilinen biyolojik mücadele kullanılabilmektedir. Ancak biyolojik mücadelenin yapılacağı alanda tek çeşit bir yabancı ot olmayacağı için yöntemin uygulanması da zor olacaktır (Heap, 2014; Çolak ve Işık, 2021). Yabancı otlarla mücadele de günümüzde rağbet görmeye başlayan bir mücadele şekli de robotiklerin kullanılmasıdır. Robotikler, hem fiziksel hem de kimyasal yöntemlerin uygulanmasında kullanılmaktadır. Bununla ilgili yapılan çalışmalar insansız kara araçları (İKA), insansız hava araçları (İHA) ve tam otomasyonlu robotları kapsamaktadır (Michaels et al., 2015; Pérez-Ortiz et al., 2016; Lottes et al., 2016; Lottes et al., 2017; Grimstad et al., 2017).
Geleneksel mücadele yöntemlerinin bitkilere ve çevreye olan zararları dikkate alındığında, yabancı otlarla mücadelede zararsız veya zarar riski daha düşük yöntemlerin tercih edilmesine neden olmaktadır. Günümüz tarımında sürdürülebilirliği sağlamak amacıyla hassas ot yönetim sistemleri tercih edilmektedir. Akıllı sensörler, uzaktan algılama sistemleri, hava araçları, uydular, robotikler, nesnelerin interneti gibi akıllı çiftçilik teknolojileri giderek daha yaygın hale gelmektedir (Monteiro et al., 2021). Bu teknolojilerin kullanılabileceği yöntemlerden biri de elektroşok yöntemidir. Elektroşok yönteminde kimyasalların kullanılmaması, çevre dostu olması, hızlı ve etkili sonuçlar sağlaması nedeniyle geniş alanlarda uygulanabilmektedir. Bu nedenle, bu çalışmada, küçük alanlarda kullanmak amacıyla, elektroşok yöntemini baz alan bir robotiğin tasarlanması ve performansının değerlendirilmesi amaçlanmıştır. Bu amaçla, yabancı otlarla mücadelede fiziksel bir yöntem kullanılarak, kimyasal kullanımının azaltılması ve çevre dostu uygulamayla yabancı ot kontrolü sağlanması hedeflenmiştir.

MATERYAL VE YÖNTEM

Bu araştırmada, küçük alanlarda kullanmak amacıyla yabancı otlara elektroşok uygulayacak robotik bir aracın tasarımı hedeflenmiştir. Elektroşok yöntemi, özel olarak tasarlanmış bir cihazla bitkiler üzerinden elektrik akımı geçirilmesini içerir. Akım, bitki hücrelerinin zarlarını bozarak hücre içi sıvıların dışarı çıkmasına ve bu sayede hücre hasarına, sonuçta da bitkinin ölmesine neden olmaktadır. Böylelikle, yabancı otlarla mücadelede fiziksel bir yöntem kullanılarak, kimyasal kullanımının azaltılması amaçlanmıştır. Robotik aracın tasarımında kullanılan malzemeler: elektroşok, tekerlek, arduino premium eğitim seti, güneş paneli, bluetooth sensörü, redüktörlü motor ve güç kaynağı olarak pil kullanılmıştır.
Robotik aracın tasarımı
Elektroşok sistemi ve montajı: robotik aracın yabancı otlarla etkin mücadele edebilmesi için elektroşok sistemi entegre edilmiştir. Piyasada güvenlik amacıyla kullanılan bir adet elektro-şok cihazını parçalarına ayırarak, robotik aracın şasisinin ön kısmına monte edilmiştir (Şekil 1a). Cisim algılama sensörü; aracın hareketi esnasında önüne çıkabilecek nesneleri algılayabilmesi için (yabancı otları algılama) ön tarafına bir cisim algılama sensörü monte edilmiştir. Sensörün doğru bir şekilde yerleştirilip yerleştirilmediğini tespit etmek amacıyla kalibrasyon işlemi yapılmıştır. Bluetooth Aygıtının Yerleştirilmesi; Aracın kontrolünün telefon vb. cihazlardan sağlamak amacıyla kullanılmıştır. Bu aygıt, robotun belirlenen yollar üzerinde hareket etmesini ve yönlendirilmesini sağlamakta, aynı zamanda sensörlerden gelen verilerle entegre bir şekilde çalışmaktadır. Arduino UNO'nun Kurulumu; robotik kodlama ile aracın uzaktan kontrolü, sensörlerden gelen verilerin kullanılabilmesi gibi işlemlerin gerçekleştirilebilmesi için aracın üzerine bir Arduino UNO mikro denetleyici kart monte edildi. Arduino, kolay bir şekilde çevresiyle etkileşime girebilen sistemler tasarlanabilir açık kaynaklı bir geliştirme platformudur. Kullanıcı, bir değişiklik veya ekleme yapması durumunda bu sayede istediği şekilde düzenlemeler yapabilmektedir. Fotoelektrik sensör; Bu sensör ve yazılımı sayesinde aracın yabancı otu ve kültür bitkisini ayırt etmesi amacıyla

kullanılması planlanmıştır. Aracın hareket kabiliyetinin sağlanabilmesi amacıyla iki adet hareket tekerleği ve ön tarafında ise bir adet yönlendirme tekerleği monte edilmiştir. Güç kaynağı olarak ise pil kullanılmıştır (Şekil 1).



Şekil 1. Elektro-şoklayıcı robotik araç: üst (a), alt (b)

Deneysel Dizayn

Robotik aracın montaj işlemleri tamamlandıktan sonra arazi çalışmalarının yapılması planlanmıştı. Ancak Tübitak'ın 2209-A projeleri kapsamında destek alan bu çalışmada, proje bütçesi, bitki ve yabancı otları ayırt edecek sensör alımına yetmediğinden, deneysel testler laboratuvar şartlarında saksı bitkileri üzerinden gerçekleştirilmiştir.

Elektroşokla yabancı otlarla mücadelede robotiğin performansını değerlendirmek için farklı yaprak ve gövde tipleri üzerinde denemeler yapılmıştır. Saksı bitkileri üzerinde yapılan uygulamalarda; Şoklama işlemi, büyük yapraklı bitkiler (A grubu), küçük yapraklı bitkiler (B grubu) ve gövde (C grubu) olmak üzere üç bölümde gerçekleştirilmiştir (Çizelge 2). Deneyler A, B ve C grubu bitkiler için 3 tekerrürlü olarak gerçekleştirilmiştir. Her bir tekerrürde bitkinin belirtilen kısımları şoklanmış ve zamana bağlı olarak değişimleri izlenmiştir. Yaprağa yapılan şoklamalarda; genel olarak yaprağın, yaprak gövdesine bağlı kısmı dikkate alınarak gerçekleştirilmiştir. Değişimleri değerlendirmek amacıyla, bitkiye şoklama yapıldıktan hemen sonra, 3 saat sonra ve 24 saat sonra aynı bölge fotoğraflanmış ve bitki üzerindeki deformasyonlar zamana bağlı olarak sunulmuştur. Çalışmada kullanılan A grubu bitkilerin yaprak boyu 8- 10 cm, B grubu bitkilerin 4 – 5 cm olarak ölçülmüştür. Gövde denemelerinde ise uygulama yapılan bitki gövde kalınlıkları (çapı) 5 – 10 mm arasında değişmektedir.

Çizelge 2. Deneme planı

Deneme Grubu	Uygulama	Tekerrürler
A (Büyük yapraklı)	Şoklamadan hemen sonra Şoklamadan 3 saat sonra Şoklamadan 24 saat sonra	A1, A2, A3
B (Küçük yapraklı)	Şoklamadan hemen sonra Şoklamadan 3 saat sonra Şoklamadan 24 saat sonra	B1, B2, B3
C (Gövde)	Şoklamadan hemen sonra Şoklamadan 3 saat sonra Şoklamadan 24 saat sonra	C1, C2, C3

BULGULAR VE TARTIŞMA

Elektroşoklu yabancı otlarla mücadele aracının etkinliğini değerlendirmek amacıyla aynı bitki türünde farklı yaprak ve gövde tipleri üzerinde yapılan denemelerden elde edilen görsel bulgulara dayanarak gözlemler yapılmıştır. Büyük yapraklı grubunda (A Grubu: A1, A2, A3); elektroşok uygulamasının hemen ardından bitkilerin fotoğraflanmasıyla yapılan gözlemde, yapraklarda bölgesel küçük deformasyonların oluştuğu; 3. ve 24. Saatte yapılan gözlemlerde ise deformasyon alanında büyüme ve yapraklarda kopmalar meydana geldiği tespit edilmiştir (Şekil 2, 3 ve 4).

Küçük yapraklı bitkiler (B Grubu: B1, B2, B3) üzerinde yapılan elektroşok uygulaması, yapraklarda daha çok solmaya ve kıvrılmalara neden olmuştur. Uygulamadan hemen sonra yapılan gözlemlerde ve çekilen fotoğraflarda, yapraklarda hafif renk değişiklikleri ve deformasyon belirtileri görülürken, üç saat sonra çekilen fotoğraflarda yaprakların sararmaya başladığı ve yapısal olarak zayıfladığı tespit edilmiştir. Bununla birlikte, 24 saat sonra çekilen fotoğraflar ise yaprakların solmaya devam ettiğini ve bazı bölgelerde kuruma oluştuğunu göstermiştir (Şekil 5, 6 ve 7).

Bitki gövdeleri (C Grubu: C1, C2, C3) üzerine yapılan elektroşok uygulaması sonrasında ise genel olarak gövdede belirgin derecede solma ve bükülme gözlemlenmiştir. Elektroşok uygulamasının hemen ardından çekilen fotoğraflarda gövdede hafif bir renk değişikliği ve eğilme meydana gelirken, üçüncü saatte yapılan gözlemlerde ve çekilen görüntülerde bu etkilerin arttığı, gövdenin daha belirgin bir şekilde büküldüğü ve solmaya başladığı belirlenmiştir. Yirmi dört saat sonra çekilen fotoğraflar ve yapılan görsel izlenimlere göre, gövdenin ciddi şekilde solduğu ve bitkinin yapısal bütünlüğünün bozulduğu tespit edilmiştir (Şekil 8, 9 ve 10).

1 2 3

Şekil 2. Kod A1, elektroşoktan hemen sonra (1), üç saat sonra (2) ve 24 saat sonraki (3) değişim

1 2 3

Şekil 3. Kod A2, elektroşoktan hemen sonra (1), üç saat sonra (2) ve 24 saat sonraki (3) değişim

1 2 3

Şekil 4. Kod A3, elektroşoktan hemen sonra (1), üç saat sonra (2) ve 24 saat sonraki (3) değişim

1 2 3

Şekil 5. Kod B1, elektroşoktan hemen sonra (1), üç saat sonra (2) ve 24 saat sonraki (3) değişim

1 2 3

Şekil 6. Kod B2, elektroşoktan hemen sonra (1), üç saat sonra (2) ve 24 saat sonraki (3) değişim

1 2 3

Şekil 7. Kod B3, elektro-şoktan hemen sonra (1), üç saat sonra (2) ve 24 saat sonraki (3) değişim

1 2 3

Şekil 8. Kod C1, elektroşoktan hemen sonra (1), üç saat sonra (2) ve 24 saat sonraki (3) değişim

1 2 3

Şekil 9. Kod C2, elektroşoktan hemen sonra (1), üç saat sonra (2) ve 24 saat sonraki (3) değişim

1 2 3

Şekil 10. Kod C3, elektroşoktan hemen sonra (1), üç saat sonra (2) ve 24 saat sonraki (3) değişim

SONUÇ

Deneysel bulgular, elektroşoklu yabancı otlarla mücadele robotunun, farklı yaprak ve gövde tiplerine sahip bitkiler üzerinde etkili olduğunu göstermektedir. Büyük yapraklı bitkilerde kopma, küçük yapraklı bitkilerde sararma ve solma, gövdede ise solma ve bükülme şeklindeki etkiler, elektroşok uygulamasının başarılı olduğunu ortaya koymaktadır. Bu sonuçlar, elektroşoklu yöntemin yabancı ot kontrolünde kimyasal kullanımına alternatif olarak etkili bir çözüm sunabileceğini ve çevre dostu bir yöntem olarak kullanılabileceğini göstermektedir. Her ne kadar yaprak grupları arasında farklılık olsa da, uygulamalar geniş yapraklı saksı bitkileri üzerinde gerçekleştirilmiştir. Sonuçlardan anlaşıldığı üzere elektro şok uygulaması bitkiler üzerinde renk değişimi, solma, kopma, kuruma ve çürüme gibi önemli etkilere neden olmuştur. Ancak sadece geniş yapraklar üzerinde yapılan uygulamanın bütün yabancı otları temsil etmeyeceği de bir gerçektir. Bu nedenle, aynı uygulamaların arazide yabancı otlar üzerinde denenmesinin daha iyi sonuçlar vereceği kanaatindeyiz.

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KAYNAKLAR

Çolak E.Ş. Yüksel, E., Canhilal, R. (2019). Yabancı otların kontrolünde biyolojik mücadele. Erciyes Tarım ve Hayvan Bilimleri Dergisi, 2(3), 23-29.

Çolak E.Ş. Işık D. (2021). Yabancı otlar ile mücadelede güncel yöntem: robotikler. Turkish Journal of Weed Science 24(2): 166-176

Grimstad L. From, P.J. (2017). The Thorvald II agricultural robotic system. Robotics, 6(4), 24.

Heap I. (2014). Herbicide resistant weeds. In Integrated pest management (pp. 281-301). Springer, Dordrecht.

Hinds, J.A. (2020). Whole-Farm Approach to Managing Pests. SARE-Sustainable Agriculture Research and Education. Available online: https://www.sare.org/wp-content/uploads/A_Whole-Farm_Approach_to_Managing_Pests.pdf. Son Erişim 20 Kasım 2024.

Lingenfelter, D. Curran, W. (2001). Weed Management in Pasture Systems. In Agronomy Facts 62; College of Agricultural Sciences, Penn State Extension: Pennsylvania, PA, USA, Available online: https://extension.psu.edu/weed-management-in-pasture-systems Son Erişim 25 Kasım 2024.

Lottes P., Hoeferlin, M., Sander, S., Müter, M., Schulze, P., & Stachniss, L.C. (2016). An effective classification system for separating sugar beets and weeds for precision farming applications. In 2016 IEEE International Conference on Robotics and Automation (ICRA) (pp. 5157-5163). IEEE.

Lottes P., Khanna, R., Pfeifer, J., Siegwart, R., & Stachniss, C. (2017). UAV-based crop and weed classification for smart farming. In 2017 IEEE International Conference on Robotics and Automation (ICRA) (pp. 3024-3031). IEEE.

McAllister W., Osipychev, D., Chowdhary, G., & Davis, A. (2018). Multi-agent planning for coordinated robotic weed killing. In 2018 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS) (pp. 7955-7960). IEEE.

Michaels A., Haug, S., & Albert, A. (2015). Vision-based high-speed manipulation for robotic ultra-precise weed control. In 2015 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS) (pp. 5498-5505). IEEE.

Mohler C. L., Frisch, J. C., & Mt, J. (1997). Evaluation of mechanical weed management programs for corn (Zea mays). Weed Technology, 123-131.

Monteiro, A. Santos, S. Gonçalves, P. (2021). Precision Agriculture for Crop and Livestock Farming—Brief Review. Animals, 11, 2345.

Monteiro, A., & Santos, S. (2022). Sustainable Approach to Weed Management: The Role of Precision Weed Management. Agronomy, 12(1), 118. https://doi.org/10.3390/agronomy12010118

Partel, V. Kakarla, S.C. Ampatzidis, Y. (2019). Development and evaluation of a low cost and smart technology for precision weed management utilizing artificial intelligence. Comput. Electron. Agric. 157, 339–350.

Pérez-Ortiz M., Peña, J. M., Gutiérrez, P. A., Torres-Sánchez, J., Hervás-Martínez, C., & López-Granados, F. (2016). Selecting patterns and features for between-and within-crop-row weed mapping using UAV-imagery. Expert Systems with Applications, 47, 85-94.

Pérez-Ruíz M., Slaughter, D.C., Fathallah, F.A., Gliever, C.J., & Miller, B.J. (2014). Co-robotic intra-row weed control system. Biosystems Engineering, 126, 45-55.

Radicetti, E. (2012). Ecological Weed Management. Ph.D. Thesis, Università degli Studi della Tuscia Di Viterbo, Viterbo, Italy.

Rueda-Ayala, V. Rasmussen, J. Gerhards, R. (2020). Mechanical Weed Control. In Precision Crop Protection-the Challenge and Use of Heterogeneity; Oerke, E.C., Gerhards, R., Menz, G., Sikora, R., Eds.; Springer: Dordrecht, The Netherlands.

Scavo, A. Mauromicale, G. (2020). Integrated Weed Management in Herbaceous Field Crops. Agronomy, 10, 466.

Shaner D.L. (2014). Lessons learned from the history of herbicide resistance. Weed Science, 62(2), 427-431.

Sujaritha M., Annadurai, S., Satheeshkumar, J., Sharan, S. K., & Mahesh, L. (2017). Weed detecting robot in sugarcane fields using fuzzy real time classifier. Computers and Electronics in Agriculture, 134, 160-171.

SUSTAINABILITY AND WASTE MANAGEMENT IN NUTS PRODUCTION

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ABSTRACT
The nut industry, especially walnuts, hazelnuts, almonds and pistachios, is becoming increasingly important worldwide. However, production generates significant amounts of waste, including green shells, hard shells and other by-products, which, if not properly disposed of, can lead to environmental problems. This study examines the potential of converting waste from nut production into value-added products such as biofuel, compost and activated carbon. Relevant scientific studies, reports and industrial practices at international and national levels were reviewed. The physical, chemical and biological properties of nut wastes, their negative impact on the environment and the recovery methods such as composting, biofuel production and activated carbon production were analyzed. The study highlights the composition and quantity of waste generated during nut production, including green shells and hard shells, and emphasizes the potential for energy production through biofuels, the improvement of soil fertility through compost and the development of industrial cleaning solutions through activated carbon. It also highlights the economic and environmental benefits of sustainable waste management in the industry. The adoption of sustainable waste management practices in nut production is crucial for reducing environmental impacts, creating economic value and improving the competitiveness of the sector. It is recommended to develop waste management infrastructure through public-private partnerships, expand technical training programs, and create incentive mechanisms to promote sustainable practices in the industry.

Keywords: shell fruit waste, waste management, sustainability, added value, environmental contribution.

INTRODUCTION
Nuts are agricultural products with high nutritional and economic value that play an important role in the human diet. Worldwide, the production of nuts is increasing every year to meet the growing demand. According to the FAO, approximately 1.2 million tons of hazelnuts, 3.9 million tons of walnuts, 1 million tons of pistachios and 3.6 million tons of almonds were produced worldwide in 2022. (FAO,2024).

Turkey is the world leader in hazelnut production and is also an important producer of walnuts and almonds (Sisman, 2016).The production and processing of nuts generates a considerable amount of organic waste. This waste includes by-products such as the green shell, the hard shell, the seed coat and pruning waste. For example, hazelnut production generates approximately 50% of the product weight as waste, walnut production 60% and almond production 55%. The disposal of this waste using conventional methods or its uncontrolled release into nature leads to environmental problems. The negative environmental impacts of nut fruit waste include pollution of soil and water resources, increased greenhouse gas emissions, impact on biodiversity, visual pollution and the creation of a suitable environment for the proliferation of harmful organisms (Sial et al., 2024).

Within the framework of sustainable agricultural concepts, this waste should be managed in such a way that it does not harm the environment and should be returned to the economy as far as possible (Parsafar et al., 2023).Studies carried out in recent years have shown that nut fruit waste can be utilised in various areas. This waste can be used as raw materials in biofuel production, as organic material in compost production, as feedstock in activated carbon production, as additives in animal feed production and as natural fillers in bioplastics production.

The sustainable management of waste not only offers benefits for the environment, but also has the potential to create an additional source of income for producers. For example, the production of biofuels from waste can reduce energy costs, compost production can increase soil fertility and the production of activated carbon can create a product with high added value (Vasileiadou, 2024).

This study examined the issue of sustainable management of waste generated during the production of nut fruit. International and national scientific studies, reports and industrial applications on this topic were examined. The physical, chemical and biological properties of nut fruit waste, its negative impact on the environment and recycling methods such as composting, biofuel production and activated carbon production were examined.

MATERIAL AND METHODS

This study is a review of existing literature and practices in the field of waste management in nut production. Data was collected from national and international scientific publications, reports and case studies dealing with the utilization of green shells, hard shells and other by-products of nut production. The analysis included a detailed examination of the physical, chemical and biological properties of these wastes, their environmental impact and their potential for conversion into value-added products. Upcycling methods such as composting, biofuel production and activated carbon production were evaluated based on their effectiveness, feasibility and contribution to sustainability.

RESULT AND DISCUSSION

QUANTITY AND COMPONENTS OF WASTE FROM NUT PRODUCTION

The amount of waste generated during the production of nuts varies greatly depending on the type of fruit and harvesting method. The specific production and processing procedures for each type of fruit generate different amounts of waste. The waste rate for walnut production varies between 40-50%, for hazelnut production between 35-45% and for almond production between 30-40% (McNeill et al., 2024).

The chemical composition of this waste shows that it contains a high proportion of organic substances. The shells of walnuts contain 22.2–30.2% hemicellulose, 25.5–27.9% cellulose, and 39.1–52.3% lignin, (Yang et al., 2015; Han et al., 2018) while pistachio shells consist of 20–32% hemicellulose, 30–55% cellulose, and 12–38% lignin. Typically, agricultural biomass waste, such as walnut and pistachio shells, is burned to produce heat (Marett et al., 2017; Robles et al., 2021). In one study, 38.48 % cellulose, 28.82 % hemicellulose and 29.54 % lignin were found in almond shells (Li et al., 2018). The shell of the European hazelnut consists, with some differences between researchers, of 23-25.9 % lignin, 26-15.4 % cellulose, 30-22.4 % hemicelluloses, 3.3-24.6 % extractives and 0.9-5 % ash (Demirbas, 2008; Solís et al., 2023).

The rich content of organic substances and minerals in nut fruit waste makes it possible to utilize this waste in various areas. The high cellulose and lignin content makes it an ideal raw material for the production of biofuels, while the mineral content contributes to efficient composting processes. In addition, the high carbon" content of the shells is an excellent source of raw material for the production of activated carbon. This versatile structure means that waste is no longer just an agricultural by-product, but a sustainable resource. This waste, which can be used as bioenergy, agricultural fertilizer and industrial raw material, becomes an important part of the circular economy (Bae et al., 2014;Taghizadeh-Alisaraei et al., 2017; Jameel et al., 2024)

ENVIRONMENTAL IMPACTS OF NUT WASTE

The production of tree nuts is an agricultural activity that requires careful consideration due to its environmental impact. Nuts such as walnuts, almonds, hazelnuts and pistachios generate significant organic waste during processing, including green shells, hard shells and other residues. If these by-products are not treated properly, they can cause a variety of environmental problems that affect different aspects of the ecosystem (Anonymous, 2024).

Firstly, the green and hard shells produced during processing have a high organic content and can decompose quickly. When these wastes are left on open land without proper management, they release methane, a potent greenhouse gas that has a much greater impact on global warming than carbon dioxide. This decomposition process can also lead to unpleasant odors that affect the quality of life in the surrounding communities (Nordahl et al., 2023).

Another major problem is the potential contamination of water resources. If not disposed of properly, organic leachate from green waste can leach into groundwater or surface waters, affecting water quality and disrupting local ecosystems. This contamination poses long-term environmental risks, including the impairment of biodiversity and the limited usability of water resources for agricultural and domestic purposes. The uncontrolled burning of nut residues is another environmental problem. These by-products are often incinerated for disposal rather than for energy recovery. This practice releases harmful pollutants such as carbon monoxide, nitrogen oxides and particulate matter into the atmosphere, contributing to air pollution and endangering the health of the surrounding population (Siddiqua et al., 2022).

In addition, improper disposal of these residues can change the composition of the soil. Decomposing organic materials, especially those with acidic properties, can lower the pH of the soil, which negatively affects its fertility and agricultural productivity. In addition, unmanaged waste piles can become breeding grounds for pests and harmful microorganisms, increasing the risk of disease in surrounding areas (Lee et al., 2004).

Another critical point is the economic waste associated with the improper disposal of these residues. By-products from tree nuts have significant potential for value-added applications such as biofuel production, composting, bioplastics and activated carbon production. Failure to exploit this potential not only leads to environmental damage, but also represents a missed opportunity for resource optimization and sustainability (Liu et al., 2023).

METHODS USED IN NUTS WASTE MANAGEMENT

COMPOSTING

Composting is an effective method of converting nut fruit waste into organic fertilizer. This process biodegrades the waste, adding important nutrients to the soil and improving its fertility. The shells of fruits such as almonds, walnuts and hazelnuts can be used in this process, improving soil quality. Composting is not only for waste management, but is also a sustainable solution for maintaining soil health as it balances the pH, creating a more suitable environment for plant growth (Lorencin, Strunjak-Perović, & Čož-Rakovac, 2023). This method offers a significant advantage in waste management, as it ensures that the decomposition of materials is controlled and prevents them from harming the environment. In addition, it supports organic farming methods by enriching the soil with organic material, which increases its productivity (Ho et al., 2022). The environmental benefits of composting also include reducing landfill waste and promoting the recycling of organic material (Ayilara et al., 2020).

BIOFUEL PRODUCTION:

Nut fruit waste, especially peels and pits, can serve as a potential raw material for biofuel production. By processing this waste into biomass energy, it is possible to create sustainable energy sources. This method helps to reduce dependence on fossil fuels and lower carbon emissions, contributing to a greener energy future (Shehu et al., 2019). Converting these agricultural by-products into biofuels not only adds value to the waste, but also promotes the use of renewable energy, thereby mitigating the environmental impact of conventional energy production (Demiral al., 2008). In addition, this process can reduce the need for landfilling and incineration, the traditional disposal methods for agricultural waste. Biofuels derived from nut waste can also be used for various applications, from electricity generation to heating, and provide an environmentally friendly alternative to conventional energy sources (Taghizadeh-Alisaraei et al., 2017). In addition, the carbon neutrality of biofuels increases their environmental benefits, as the CO_2 released during combustion is offset by the CO_2 absorbed by the plants during their growth.

ACTIVATED CARBON PRODUCTION

Nut fruit waste, especially walnut and hazelnut shells, can be used to produce activated charcoal. Activated carbon is a versatile material used in industrial cleaning and filtration systems, especially for water and air purification. It works by adsorbing impurities from water and air, making it an essential component for environmental sustainability (Bae et al., 2014). Converting fruit waste into activated carbon not only reduces waste disposal problems, but also provides a valuable product that can be reused in a variety of industrial applications, including gas filtration, waste treatment and even in the food and beverage industry for color removal (Özsin, 2011).

In addition to these applications, the production of activated carbon from agricultural waste such as nutshells is an environmentally friendly method that contributes to the circular economy by converting waste into valuable products. This process adds economic value to waste, reduces the use of landfills and provides an alternative to chemically produced activated carbon, which is often more energy and cost intensive (Omri et al., 2013). In addition, the use of biowaste-derived activated carbon also contributes to a reduction in the overall environmental impact of industrial processes and helps to mitigate pollution.

BIOGAS PRODUCTION

Nut fruit waste, especially from nuts such as almonds, walnuts and hazelnuts, has considerable potential for biogas production. Through the process of anaerobic digestion, in which organic material is broken down in the absence of oxygen, these agricultural residues can be converted into biogas, which consists mainly of methane. This process not only provides an alternative renewable energy source, but also contributes to waste management and pollution reduction (Demirer, 2016; Şenol, 2019). The use of nutshells and other fruit waste for biogas production offers several environmental and economic benefits. Firstly, it helps to eliminate the need to dispose of agricultural by-products, which are usually bulky and non-biodegradable, in landfills. The resulting methane can be used as a sustainable energy source for electricity generation, heating or even as fuel for vehicles. In addition, the digestate remaining after the anaerobic process can be used as organic fertilizer, making a further contribution to the circular economy (Jameel et al., 2024).

Studies have shown that nut fruit waste has a high cellulose and lignin content, which is difficult to decompose, but can produce significant amounts of biogas if properly pretreated or mixed with other organic waste to optimize the digestion process This process can contribute significantly to reducing greenhouse gas emissions in agriculture while promoting the use of clean, renewable energy (Almomani et al., 2020).

BIOCHAR PRODUCTION

The production of biochar from nut fruit waste such as walnut, hazelnut and almond shells has gained attention as a sustainable and efficient way to convert agricultural residues into valuable products. Biochar is a carbon-rich material produced by pyrolysis, a process in which organic materials are heated in the absence of oxygen. This method not only serves as a solution for waste management, but also provides a material that can improve soil fertility, mitigate climate change and improve water retention on agricultural land (Kaya et al., 2018).

The potential of nut fruit waste for the production of biochar lies in the high carbon content of the shells. During pyrolysis, this waste is transformed into biochar with a large surface area and porosity, making it an effective soil conditioner. This biochar can help improve soil structure, bind nutrients and reduce the need for synthetic fertilizers (An et al., 2022). In addition, biochar acts as a long-term carbon sink by storing carbon in the soil for hundreds to thousands of years, helping to reduce greenhouse gas emissions (Lorenz & Lal, 2014).

In addition to the benefits for agriculture, producing biochar from fruit peels can be an environmentally friendly alternative to disposing of these materials, which could otherwise contribute to waste accumulation and pollution. The process also offers an economic advantage as it creates a valuable by-product that can be sold to farmers and landowners as a soil conditioner or used in environmental applications such as water filtration (Rodrigues & Horan, 2018).

ECONOMIC VALUE OF NUT WASTE

Nut fruit waste, which consists of the shells and kernels of fruits such as almonds, walnuts, hazelnuts and pistachios, can be processed into valuable products for industrial use. The economic value of this waste offers significant opportunities for environmental sustainability and waste management (Akubude et al., 2016). Studies on the economic value of this waste show that it not only contributes to environmental sustainability, but can also be a source of income. For example, walnut and hazelnut shells can be used to produce energy from biomass. Calculations show that one ton of walnut shells can generate around 4,000 kWh of energy (Sahu et al., 2018). In addition, the use of this waste in the production of activated carbon increases its market value. The market for activated carbon reached a value of USD 4.75 billion in 2018 and is expected to grow by 12% annually until 2025 (Trnka et al., 2023). Energy production from biomass offers economic benefits as it contributes to meeting local energy needs and is an environmentally friendly energy alternative. The biomass obtained from one ton of nut fruit waste has a value of 50 to 70 US dollars (Čajová Kantová et al., 2022). In addition, compost production from this waste is another economically significant contribution. The conversion of nut fruit waste into organic fertilizer creates an affordable source of fertilizer for sustainable agricultural practices. (Liu et al., 2023).

CONCLUSION

Sustainable waste management in nut production plays a crucial role in reducing the environmental impact, creating economic opportunities and increasing the competitiveness of the sector. The efficient use of by-products such as green shells and nutshells as biofuels, compost and activated carbon can make an important contribution to the circular economy. These practices not only reduce the amount of waste, but also provide additional sources of income for producers while minimizing the sector's environmental footprint. To achieve this, collaboration between the public and private sectors is essential to develop a solid infrastructure for waste management. The dissemination of technical training programs for producers and stakeholders in the sector will increase awareness and acceptance of sustainable practices. In addition, the introduction of incentive mechanisms such as subsidies, tax benefits or grants for initiatives that create added value from waste can encourage investment and innovation in this area. In general, a comprehensive approach that combines education, policy support and infrastructure development will ensure the long-term sustainability and resilience of the nut sector.

REFERENCES

Adejumo, I. O., & Adebiyi, O. A. (2020). Agricultural solid wastes: causes, effects, and effective management. Strategies of sustainable solid waste management, 8(10.5772).

Akubude, V. C., & Nwaigwe, K. N. (2016). Economic importance of edible and non-edible almond fruit as bioenergy material: a review. American Journal of Energy Science, 3(5), 31-39.

Almomani, F., & Bhosale, R. R. (2020). Enhancing the production of biogas through anaerobic co-digestion of agricultural waste and chemical pre-treatments. Chemosphere, 255, 126805.

An, N., Zhang, L., Liu, Y., Shen, S., Li, N., Wu, Z., ... & Han, X. (2022). Biochar application with reduced chemical fertilizers improves soil pore structure and rice productivity. Chemosphere, 298, 134304.

Anonymous, (2024), Almond Board of California. (n.d.). Zero waste: Using everything an orchard grows. Retrieved November 5, 2024, from https://www.almonds.com/

Ayilara, M. S., Olanrewaju, O. S., Babalola, O. O., & Odeyemi, O. (2020). Waste management through composting: Challenges and potentials. Sustainability, 12(11), 4456.

Bae, W., Kim, J., & Chung, J. (2014). Production of granular activated carbon from food-processing wastes (walnut shells and jujube seeds) and its adsorptive properties. Journal of the Air & Waste Management Association, 64(8), 879-886.

Čajová Kantová, N., Čaja, A., Belány, P., Kolková, Z., Hrabovský, P., Hečko, D., and Mičko, P. (2022). “Mechanical and energy properties of pellets formed form walnut shells bledned with spruce sawdust,” BioResources 17(1), 1881-1891. DOI: 10.15376/biores.17.1.1881-1891.

Carmona, R. J., Riquelme, A. A., & Gonzalez, G. (2024). European Hazelnut Shell as a Source of Extractives and Bio-oil. Chemical Engineering Transactions, 109, 349-354.

Chang, C. C., & Li, R. (2019). Agricultural waste. Water Environment Research, 91(10), 1150-1167.

Choudhary, M. P., Charan, H. D., & Acharya, B. (2021). Experimental investigation on biochar production and application: solution to air pollution due to stubble burning as well as amending soil consistency. Journal of The Institution of Engineers (India): Series A, 102(3), 705-712.

Demiral, İ., Atilgan, N. G., & Şensöz, S. (2008). Production of biofuel from soft shell of pistachio (Pistacia vera L.). Chemical Engineering Communications, 196(1-2), 104-115.

Demirbaş, A., (2008), Oils from hazelnut shell and hazelnut kernel husk for biodiesel production. Energy Sources, Part A Recovery, Util. Environ. Eff., 30, 1870-1875.

Demirer, G. N. (2016). Biogas production from pistachio (Pistaciavera L.) de-hulling waste. International journal of green energy, 13(13), 1320-1324.

Han, H.; Wang, S.; Rakita, M.; Wang, Y.; Han, Q.; Xu, Q (2018). Effect of Ultrasound-Assisted Extraction of Phenolic Compounds on the Characteristics of Walnut Shells. Food Nutr. Sci. 9, 1034–1045.

Hebda, T., Brzychczyk, B., Francik, S., & Pedryc, N. (2018). Evaluation of suitability of hazelnut shell energy for production of biofuels. Eng. Rural Dev, 17, 1860-1865.

Ho, T. T. K., Le, T. H., Tran, C. S., Nguyen, P. T., Thai, V. N., & Bui, X. T. (2022). Compost to improve sustainable soil cultivation and crop productivity. Case Studies in Chemical and Environmental Engineering, 6, 100211.
Jameel, M. K., Mustafa, M. A., Ahmed, H. S., jassim Mohammed, A., Ghazy, H., Shakir, M. N., ... & Kianfar, E. (2024). Biogas: Production, properties, applications, economic and challenges: A review. Results in Chemistry, 101549.
Karagöktaş, M., Uygur, V., Aydoğdu, M., & Rastgeldi, İ. (2014). The effects of pistachio nut hull compost on soil fertility: A comparative study with manure. In 9th International Soil Science Congress on "The Soul of Soil and Civilization" Side, Antalya, Turkey (Vol. 2014, pp. 611-616).
Kaya, N., Yıldız, Z., & Ceylan, S. (2018). Preparation and characterisation of biochar from hazelnut shell and its adsorption properties for methylene blue dye. Politeknik dergisi, 21(4), 765-776.
Kesari, K. K., & Jamal, Q. M. S. (2017). Review Processing, properties and applications of agricultural solid waste: Effect of an open burning in environmental toxicology. Perspectives in environmental toxicology, 161-181
Lee, J. J., Park, R. D., Kim, Y. W., Shim, J. H., Chae, D. H., Rim, Y. S., ... & Kim, K. Y. (2004). Effect of food waste compost on microbial population, soil enzyme activity and lettuce growth. Bioresource Technology, 93(1), 21-28.
Li, C., Hu, Y., Zhang, F., Chen, J., Ma, Z., Ye, X., ... & Mellouki, A. (2017). Multi-pollutant emissions from the burning of major agricultural residues in China and the related health-economic effects. Atmospheric Chemistry and Physics, 17(8), 4957-4988.
Li, X., Liu, Y., Hao, J., & Wang, W. (2018). Study of almond shell characteristics. Materials, 11(9), 1782.
Liu, Y., Wang, Y., Zou, L., Bai, Y., & Xiu, H. (2023). Research on the optimum carbonization process of walnut shell based on dynamic analysis. RSC advances, 13(20), 13412-13422.
Liu, Z., de Souza, T. S., Holland, B., Dunshea, F., Barrow, C., & Suleria, H. A. (2023). Valorization of food waste to produce value-added products based on its bioactive compounds. Processes, 11(3), 840.
Lorencin, V., Strunjak-Perović, I., & Čož-Rakovac, R. (2023). Shell waste management and utilization: Mitigating organic pollution and enhancing sustainability. Applied Sciences, 13(1), 623. https://doi.org/10.3390/app13010623
Lorenz, K., & Lal, R. (2014). Biochar application to soil for climate change mitigation by soil organic carbon sequestration. Journal of plant nutrition and soil science, 177(5), 651-670.
Marett, J., Aning, A., & Foster, E. J. (2017). The isolation of cellulose nanocrystals from pistachio shells via acid hydrolysis. Industrial Crops and Products, 109, 869-874.
McNeill, D. C., Pal, A. K., Nath, D., Rodriguez-Uribe, A., Mohanty, A. K., Pilla, S., ... & Misra, M. (2024). Upcycling of Ligno-Cellulosic Nutshells Waste Biomass in Biodegradable Plastic-based Biocomposites Uses-A Comprehensive Review. Composites Part C: Open Access, 100478.
Miladinović, M. R., Zdujić, M. V., Veljović, D. N., Krstić, J. B., Banković-Ilić, I. B., Veljković, V. B., & Stamenković, O. S. (2020). Valorization of walnut shell ash as a catalyst for biodiesel production. Renewable Energy, 147, 1033-1043.
Nordahl, S. L., Preble, C. V., Kirchstetter, T. W., & Scown, C. D. (2023). Greenhouse gas and air pollutant emissions from composting. Environmental science & technology, 57(6), 2235-2247.
Omri, A., Benzina, M., & Ammar, N. (2013). Preparation, modification and industrial application of activated carbon from almond shell. Journal of Industrial and Engineering Chemistry, 19(6), 2092-2099.

Özsin, G. (2011). Production and characterization of activated carbon from pistachio-nut shell (Master's thesis, Middle East Technical University).
Parsafar, B., Ahmadi, M., Jahed Khaniki, G. R., Shariatifar, N., & Rahimi Foroushani, A. (2023). The impact of fruit and vegetable waste on economic loss estimation. Global Journal of Environmental Science and Management, 9(4), 871-884.
Robles, E.; Izaguirre, N.; Martin, A.; Moschou, D.; Labidi, J. Assessment of Bleached and Unbleached Nanofibers from Pistachio Shells for Nanopaper Making. Molecules **2021**, 26, 1371.
Rodrigues, S., & Horan, E. (2018). The role of biochar in sustainable agriculture, and climate change mitigation for sustainable cities. Sustainable Development Research in the Asia-Pacific Region: Education, Cities, Infrastructure and Buildings, 437-447.
Salcedo-Parra, O. J., & Colleagues. (2022). Fruit peels as a sustainable waste for the biosorption of heavy metals in wastewater: A review. Molecules, 27(7), 2124.
Saracoglu, M. S., & Coruh, M. K. (2023). Thermal degradation properties, kinetic, thermodynamic and reaction mechanism of pyrolysis of biomass shells: pistachio, almond, walnut and hazelnut as bioenergy potential. Biomass Conversion and Biorefinery, 1-26..
Shehu, I., Akanbi, T. O., Wyatt, V., & Aryee, A. N. (2019). Fruit, nut, cereal, and vegetable waste valorization to produce biofuel. Byproducts from agriculture and fisheries: adding value for food, feed, pharma, and fuels, 665-684.
Shu, H., Zhang, P., Chang, C. C., Wang, R., & Zhang, S. (2015). Agricultural waste. Water Environment Research, 87(10), 1256-1285.
Sial, T. A., Rajpar, I., Khan, M. N., Ali, A., Shan, M., Rajput, A. B., & Shah, P. A. N. (2024). Impact of Fruit and Vegetable Wastes on the Environment and Possible Management Strategies. In Planet Earth: Scientific Proposals to Solve Urgent Issues (pp. 307-330). Cham: Springer International Publishing.
Siddiqua, A., Hahladakis, J. N., & Al-Attiya, W. A. K. (2022). An overview of the environmental pollution and health effects associated with waste landfilling and open dumping. Environmental Science and Pollution Research, 29(39), 58514-58536.
Sisman, M. Y. (2016). Agricultural and Food Policies in Global Trade the Case of Almonds and Hazelnuts (Doctoral dissertation, Auburn University).
Solís A., Rocha S., König M., Adam R., Garcés H., Candia C., Muñoz R., Azócar L., 2023, Preliminary assessment of hazelnut shell biomass as a raw material for pellet production. Fuel, 333 (2) 126517.
Şenol, H. (2019). Biogas potential of hazelnut shells and hazelnut wastes in Giresun City. Biotechnology reports, 24, e00361.
Taghizadeh-Alisaraei, A., Assar, H. A., Ghobadian, B., & Motevali, A. (2017). Potential of biofuel production from pistachio waste in Iran. Renewable and Sustainable Energy Reviews, 72, 510-522.
Trnka, J., Kantová, N. Č., Holubčík, M., Čaja, A., Najser, T., & Najser, J. (2023). Comparison of Energy Properties of Pellets from Shells of Different Nut Species. BioResources, 18(1).
Vasileiadou, A. (2024). From Organic wastes to Bioenergy, Biofuels, and value-added products for urban sustainability and circular economy: a review. Urban Science, 8(3), 121.
Yang, W., Shimizu, I., Ono, T., & Kimura, Y. (2015). Preparation of biodegradable foam from walnut shells treated by subcritical water. Journal of Chemical Technology & Biotechnology, 90(1), 44-49.

DEVELOPING A BASIC QGIS-BASED AGRICULTURAL MANAGEMENT SYSTEM: INTEGRATING PARCEL, IRRIGATION, AND SATELLITE DATA LAYERS

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ABSTRACT
Agricultural management increasingly relies on Geographic Information Systems (GIS) to optimize land use, monitor crop health, and efficiently manage resources such as water and soil nutrients. An open-source GIS platform called QGIS provides a flexible and affordable way to create agricultural management systems that are suited to particular requirements and regional circumstances. This preliminary study aims to develop a basic QGIS-based agricultural management system that combines parcels, irrigation networks, and satellite data layers to provide farmers and land managers with actionable insights for precision agriculture, resource management, and sustainable practices. As material, vector data namely, parcel boundaries and irrigation networks, were used. On the other hand, satellite-based raster data such as images with different band combinations, Normalized Difference Vegetation Index (NDVI), Land Surface Temperature (LST), Digital Elevation Model (DEM), etc. were considered. Data were processed in QGIS, where different layers were created for each data type. The parcel boundaries were used as the base layer, while irrigation systems and satellite-derived data were overlaid for spatial analysis. In the application, the suitability of parcels for agricultural activities was assessed with satellite images. Heights and slopes in irrigation areas could be calculated and thus land management can be optimized. Factors such as plant health and water stress could be questioned spatially and temporally. The distance of parcels to agricultural irrigation lines could be measured and both cost calculation and product selection can be made more appropriately. By leveraging QGIS and remote sensing data, this system offers a practical and accessible tool for precision agriculture, ultimately contributing to more efficient, sustainable, and climate-resilient farming practices.
Key Words: Agriculture; Geographic Information System; Remote Sensing; Precision Farming; Sustainable Agriculture

INTRODUCTION
Agricultural management has increasingly turned to Geographic Information Systems (GIS) to optimize land use, monitor crop health, and efficiently manage resources such as water and soil nutrients. Among the various GIS platforms available, QGIS stands out due to its open-source nature, flexibility, and extensive range of plugins and tools (Nishimura, 2023). The integration of diverse data sources into a comprehensive GIS system can significantly support informed decision-making in agriculture. Parcel data provides detailed information about the

boundaries and ownership of agricultural fields, which is essential for managing land resources, planning crop rotations, and ensuring compliance with agricultural policies (Esri, 2024). Irrigation data includes information about irrigation systems, water sources, and distribution networks, which is critical for conserving water resources and optimizing irrigation practices, especially in regions facing water scarcity (Saha et al., 2020).

Satellite data, particularly from platforms like Sentinel 2, offers high-resolution imagery that can be used to derive various vegetation indices, such as the Normalized Difference Vegetation Index (NDVI). These indices are invaluable for monitoring crop health, assessing biomass, and detecting stress factors such as drought or pest infestations (Rouse et al., 1974). Additionally, Land Surface Temperature (LST) data provides insights into vegetation water stress, while Digital Elevation Models (DEM) help in understanding terrain characteristics that influence agricultural practices (Gorelick et al., 2017). By integrating these diverse data layers in QGIS, this study aims to create a basic agricultural management system that supports precision farming practices. The system will enable farmers and land managers to gain actionable insights into irrigation efficiency, vegetation health, and terrain suitability, thereby enhancing resource management and promoting sustainable agricultural practices (Mulla, 2013; Zhang & Kovacs, 2012). By leveraging the capabilities of QGIS and remote sensing data, this system offers a practical and accessible tool for precision agriculture, ultimately contributing to more efficient, sustainable, and climate-resilient farming practices (Pettorelli et al., 2005; Fereres & Soriano, 2007).

MATERIAL AND METHOD

Study Area

This study focuses on all agricultural lands within the boundaries of Çimenyenice village, Hafik district, Sivas province, Turkey. The study area encompasses approximately 1700 hectares (Figure 1) and comprises of 2415 parcels, which are highly productive for agricultural production. The irrigation needs of these parcels are met through an irrigation system managed by the State Hydraulic Works Directorate, consisting of approximately 136 irrigation valves. Çimenyenice is notable for its extensive agricultural areas and diverse crop production; agriculture and livestock farming play a significant role in the region's economy. The region is characterized by a continental climate, with hot and dry summers and cold, snowy winters.

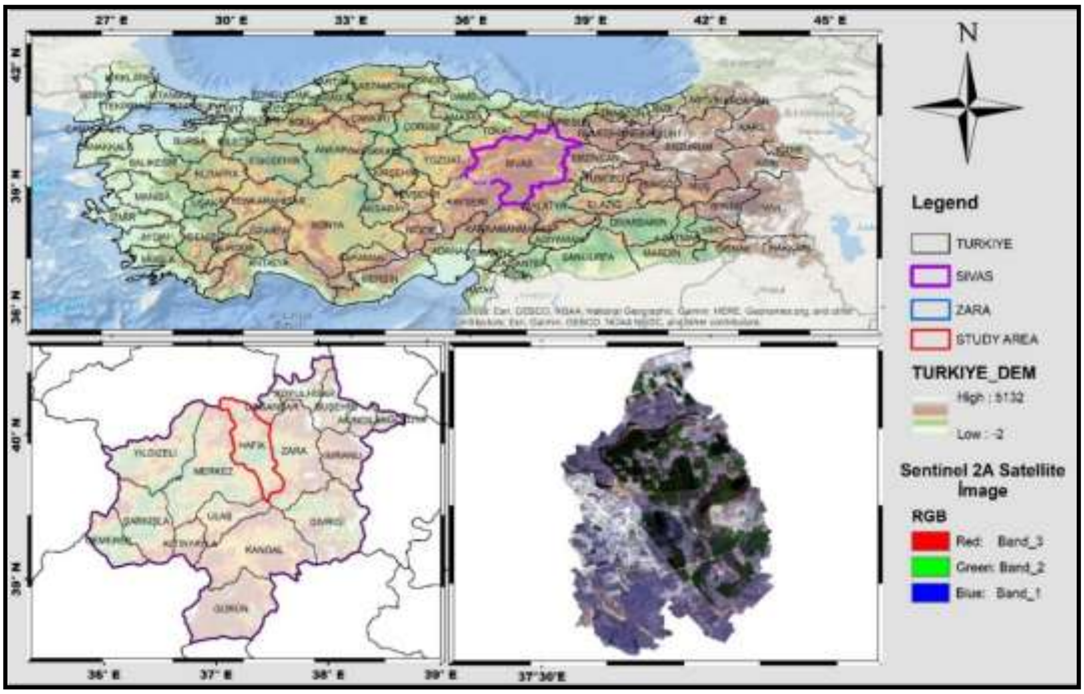
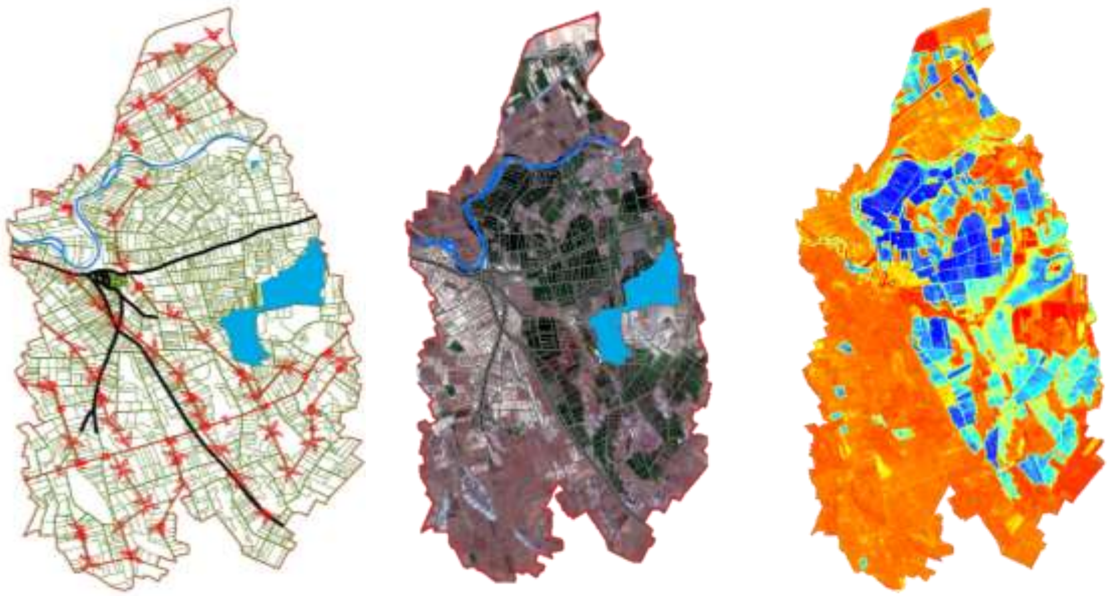


Figure 1. Location map of the study area; province, district and village borders

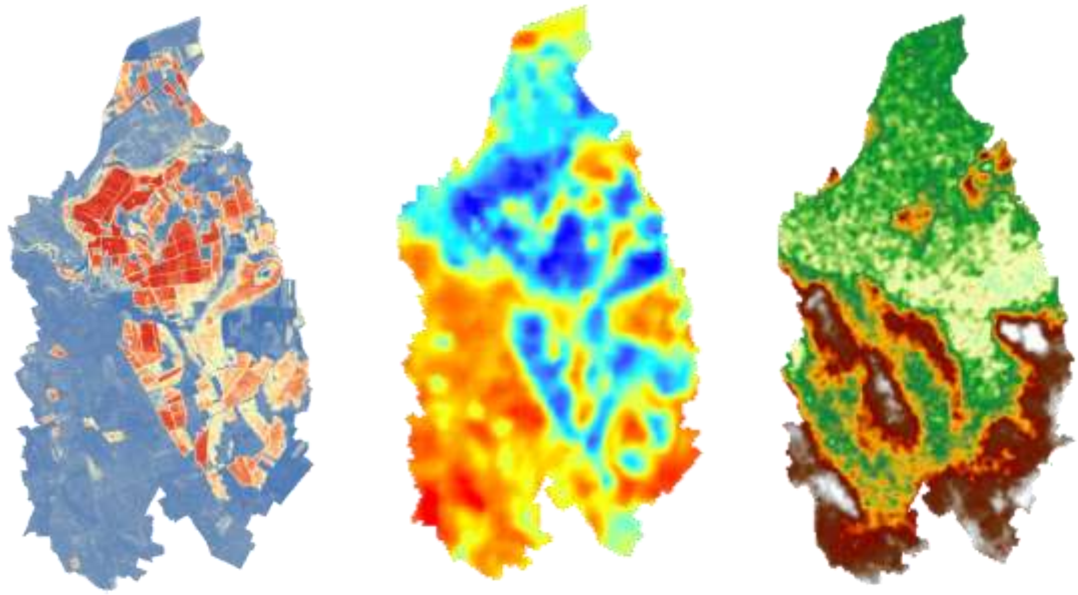
Materials

The study employed both vector and raster data. Vector data included village boundaries, parcel boundaries, roads, rivers, lakes, irrigation valve locations, and irrigation line data. Raster data consisted of satellite imagery (Sentinel 2), Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI), Land Surface Temperature (LST), and Digital Elevation Model (DEM) data (Figure 2).

Sentinel 2 satellite imagery was segmented as natural color band RGB using SNAP software. As seen by the human eye, vegetation appears GREEN, separated areas generally appear WHITE, and water areas appear BLUE.



Vector Data Satellite Image NDVI



NDWI LST DEM

Figure 2. Vector and Raster Datasets

Method

NDVI values are taken into consideration for the evaluation of vegetation health. NDVI changes are calculated with the formula shown in equation (1) using Sentinel 2 satellite bands.

$$NDVI = \frac{NIR - RED}{NIR + RED} \quad (1)$$

NDWI values are used to monitor changes in water content of plants. For the calculation of NDWI, Sentinel 2 satellite bands with the formula shown in equation (2) were used.

$$NDWI = \frac{NIR - SWIR}{NIR + SWIR} \quad (2)$$

The LST data was used to monitor surface temperatures, which provide information about water stress of plants. For the LST calculation, the surface temperature band of Landsat 8 satellite data was calculated with the formula shown in equation (3).

LST= [(STband) * 0.00341802 + 149] +273.15 °C (3)

DEM data was used to calculate the terrain slope within the parcel. For the DEM data, the "Shuttle Radar Topography Mission" data was clipped to suit the study area. With QGIS software, parcel boundaries were used as the base layer; road, river, lake, irrigation line and satellite-derived data (NDVI, NDWI, LST, DEM) were overlaid for spatial analysis. All layers were aligned with appropriate projections to ensure correct spatial relationships.

RESULTS AND DISCUSSION

Using the open source GIS software – QGIS, a basic and easy-to-use agricultural management system has been developed for issues such as irrigation efficiency, plant health, water stress monitoring and agricultural crop pattern mapping. Thanks to the integration of parcel boundaries and irrigation system data, missing or overlapping areas within the irrigation coverage have been identified. This analysis contributes to the optimization of the system by identifying areas where water is used inefficiently in the irrigation network.

Within the scope of the study, plant health and water stress was monitored using NDVI and LST data and areas experiencing poor growth, disease potential or water stress were identified. In addition, land slopes within the parcels were calculated using DEM data and steep slopes were identified. It was emphasized that these areas were not suitable for some agricultural products or carried an erosion risk. The findings obtained allow agricultural activities to be managed more efficiently and sustainably.

Using Sentinel 2 satellite imagery, it is possible to view whether parcels are used in agricultural activities and query their reflectance values (Figure 3).

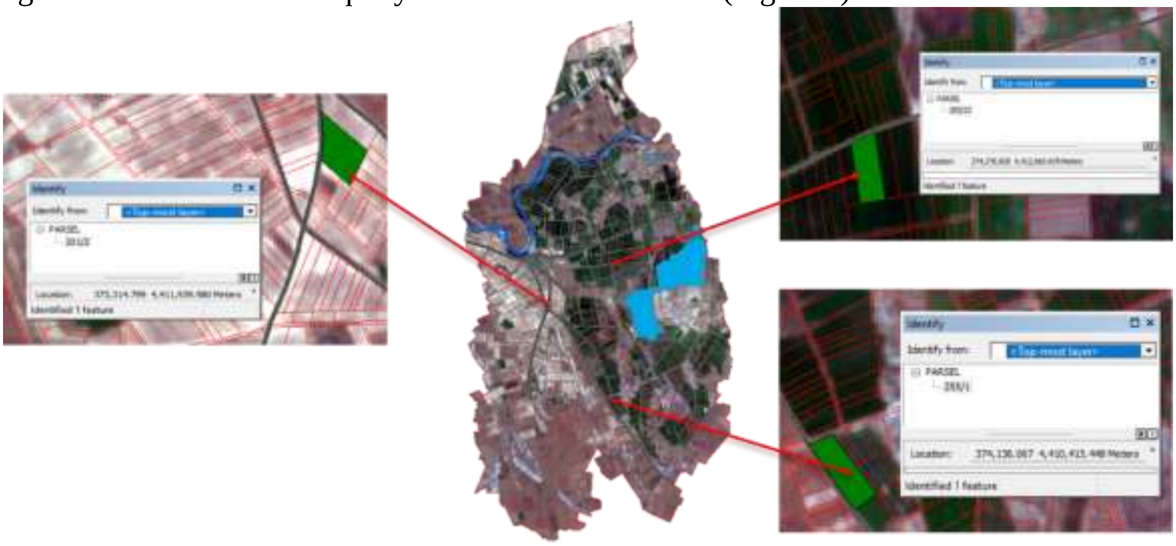


Figure 3. Querying parcel reflectance information

The elevations of the parcels can be queried using DEM data. Studies on irrigation management can be conducted using the slope map produced from DEM (Figure 4).

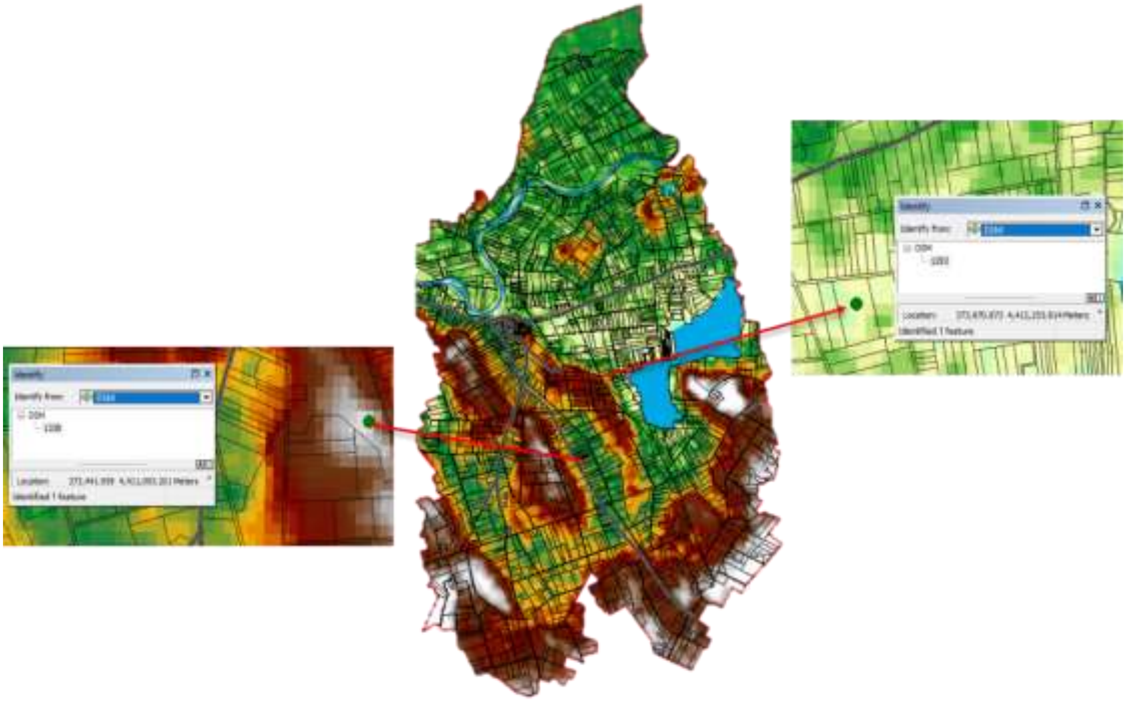


Figure 4. Querying their separation

By using the NDVI data, locations where plant health is poor or plant growth is inadequate can be identified in agricultural areas. Improvement work can be carried out for the identified locations (Figure 5).

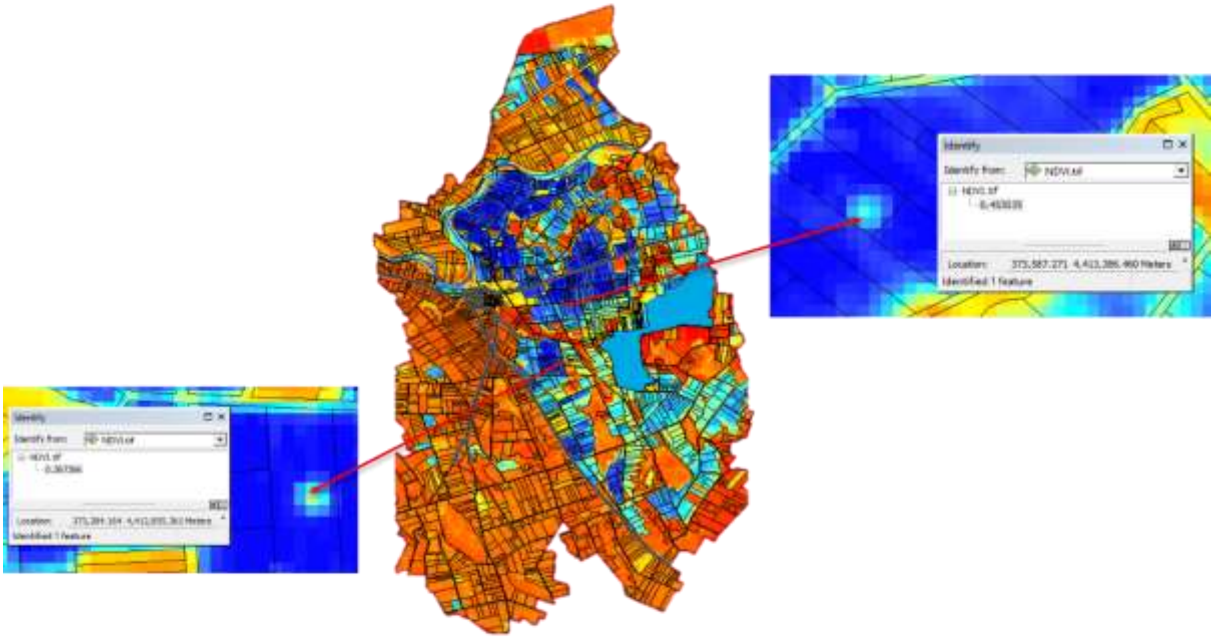


Figure 5. Questioning the health of plants

By using NDWI data, information can be obtained about the water content of plants in agricultural areas (Figure 6).

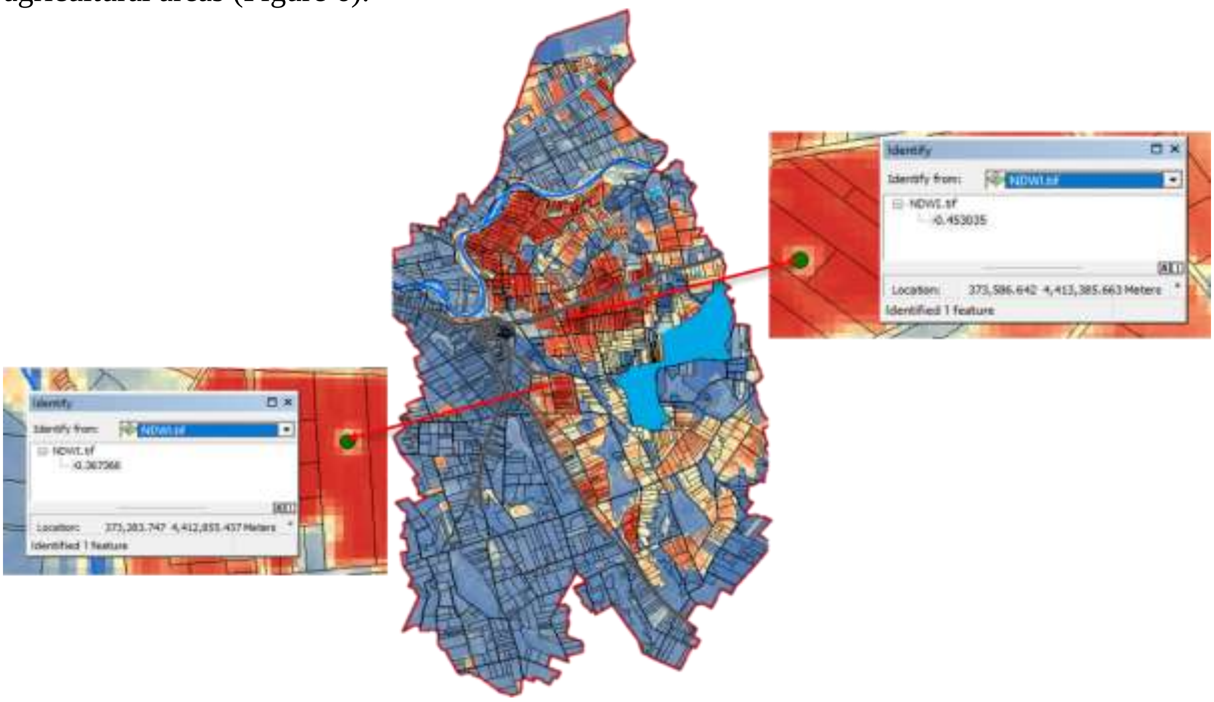


Figure 6. Querying the water content of plants

By the LST data, surface temperatures of plants can be queried in plot scale. Information about the stress status of the plant can be obtained through spatial and temporal LST analyses (Figure 7).

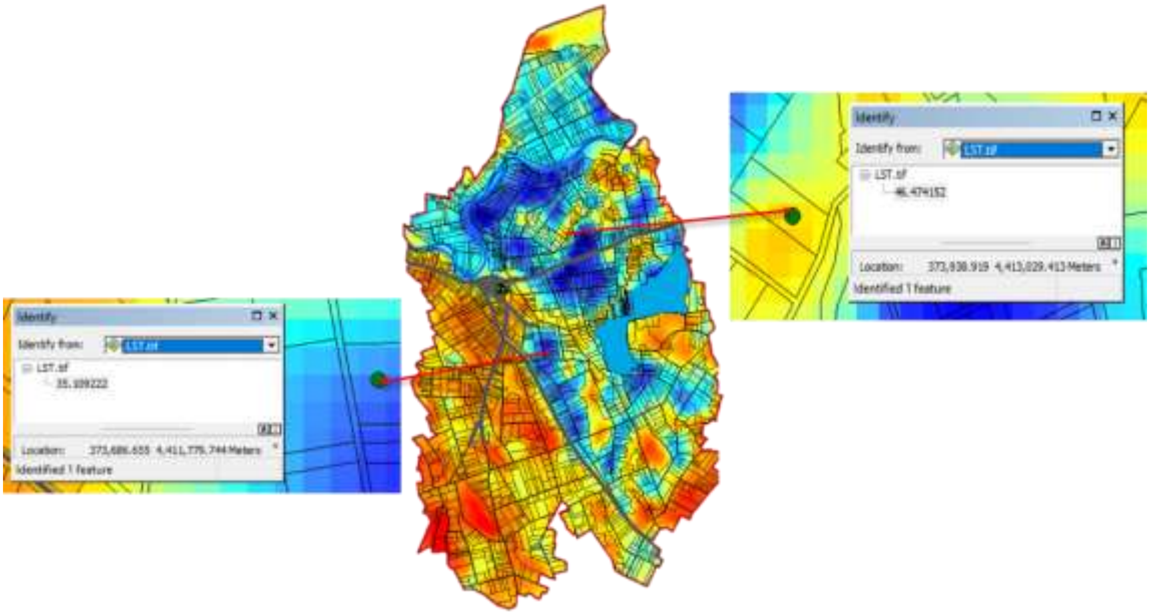


Figure 7. Querying the LST of the plots

The distances of the agricultural plots to the irrigation lines can be determined. In this way, the irrigated or dry agricultural activities to be carried out on the relevant plot will contribute to sustainable agricultural management (Figure 8).

Figure 8. Querying the distance of parcels to irrigation lines

CONCLUSION

This study demonstrates the development of a basic QGIS-based agricultural management system that integrates parcel boundaries, irrigation systems, and satellite data layers such as NDVI, NDWI, LST, and DEM. By combining various datasets, this system provides valuable information on irrigation efficiency, plant health, and land suitability, enabling more informed decisions for sustainable agricultural practices. Thematic maps and spatial analyses obtained from the system provide farmers and land managers with the opportunity to improve irrigation strategies, monitor plant health, and make better decisions on water use and crop selection. By utilizing QGIS and remote sensing data, this system provides a practical and accessible tool for precision agriculture, thus contributing to more efficient, sustainable, and climate resilient agricultural practices. Future studies can extend these methods and incorporate additional data layers and more advanced analysis tools to improve agricultural management strategies.

REFERENCES

Esri. (2024). The Role of GIS in Modern Agriculture. Retrieved from Esri Community.

Fereres, E., & Soriano, M.A. (2007). Deficit irrigation for reducing agricultural water use. Journal of Experimental Botany, 58(2), 147-159.

Gorelick, N., Hancher, M., Dixon, M., Ilyushchenko, S., Thau, D., & Moore, R. (2017). Google Earth Engine: Planetary-scale geospatial analysis for everyone. Remote Sensing of Environment, 202, 18-27.

Mulla, D.J. (2013). Twenty-five years of remote sensing in precision agriculture: Key advances and remaining knowledge gaps. Biosystems Engineering, 114(4), 358-371.

Nishimura, K., (2023). Development of QAgriSupport, a GIS-based Agricultural Production Process Management System, and Foregis, a Mobile Application. Japan Agricultural Research Quarterly, 57(1), 79-87.

Pettorelli, N., Vik, J.O., Mysterud, A., Gaillard, J.M., Tucker, C.J., & Stenseth, N.C. (2005). Using the satellite-derived NDVI to assess ecological responses to environmental change. Trends in Ecology & Evolution, 20(9), 503-510.

Rouse, J.W., Haas, R.H., Schell, J.A., & Deering, D.W. (1974). Monitoring vegetation systems in the Great Plains with ERTS. In Third Earth Resources Technology Satellite-1 Symposium, Volume I: Technical Presentations (NASA SP-351, Vol. I), 309-317.

Saha, R., Mitran, T., Mukherjee, S., Das, I.C., & Kumar, K.V. (2020). Groundwater Management for Irrigated Agriculture Through Geospatial Techniques. In Geospatial Technologies for Crops and Soils (pp. 455-488). Springer.

Zhang, C., & Kovacs, J.M. (2012). The application of small unmanned aerial systems for precision agriculture: A review. Precision Agriculture, 13(6), 693-712.

ANALYZING CROP DEVELOPMENT USING SENTINEL-2 BASED NDVI TIME SERIES

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ABSTRACT
Monitoring crop development in agricultural production, increasing productivity, and ensuring efficient use of resources are crucial for sustainable farming practices. Remote sensing data, especially Normalized Difference Vegetation Index (NDVI) derived from Sentinel-2 satellite imagery, provide a powerful information for assessing crop health and monitoring growth processes in agricultural areas. This study analyzes the growth patterns of different crop types, such as wheat, sugar beet, forage crops, and pasture, over the growing season in the Zara district, evaluating spatial variations in agricultural parcels. Monthly Sentinel-2 NDVI images were processed using the Google Earth Engine platform, and growth stages and peak periods were identified for each crop type. The results revealed that each crop type exhibited distinct growth patterns, with wheat showing high NDVI values during April and May, indicating early growth potential, sugar beet reaching its peak in August, and forage crops exhibiting multiple harvest cycles with suitable growth. Furthermore, it was observed that the NDVI values of pasture areas remained at lower levels compared to other agricultural crops. These findings demonstrate that the Sentinel-2 NDVI time series can serve as an essential decision-support tool in agricultural management and precision farming applications. The study suggests that such analyses should be integrated with additional data, such as meteorological information and soil properties, to optimize irrigation, fertilization, and agricultural production planning.
Keywords: Agriculture; Remote Sensing; Sustainable Agriculture.

INTRODUCTION
Monitoring and analyzing crop development are crucial for ensuring food security and optimizing agricultural practices. With the advent of advanced remote sensing technologies, it has become possible to observe and analyze crop growth patterns with unprecedented accuracy and detail. Among these technologies, the Sentinel-2 satellite, part of the European Space Agency's Copernicus program, stands out due to its high-resolution multispectral imaging capabilities (Drusch et al., 2012).
The Normalized Difference Vegetation Index (NDVI) is a widely used indicator derived from satellite imagery that measures vegetation health and vigor (Rouse et al., 1974). By analyzing NDVI time series data, researchers can gain insights into the phenological stages of crops, assess their health, and predict yields (Pinter et al., 2003). This approach is particularly valuable for large-scale agricultural monitoring, where traditional ground-based methods are often impractical (Lozano-Tello et al., 2023).

In recent years, studies have demonstrated the effectiveness of using Sentinel-2 NDVI data for mapping and monitoring various crops, including winter wheat and other staple crops (Mashonganyika et al., 2021; Choudhary et al., 2019). The high temporal and spatial resolution of Sentinel-2 data allows for detailed tracking of crop growth dynamics throughout the growing season (Jeba et al., 2024). This capability is essential for precision agriculture, enabling farmers to make informed decisions about irrigation, fertilization, and pest management (Chakrabarthy, 2016).

In this study, we aim to analyze crop development using Sentinel-2 based NDVI time series. By leveraging the high temporal and spatial resolution of Sentinel-2 data, we can track the growth dynamics of various crops throughout the growing season. This analysis will not only enhance our understanding of crop phenology but also provide valuable information for precision agriculture, enabling farmers to make informed decisions about irrigation, fertilization, and pest management.

MATERIALS AND METHODOLOGY

Study Area

This study was conducted within the boundaries of the Zara district in Sivas province, located in the Central Anatolia Region of Turkey (Figure 1). Zara is a district with significant agricultural and livestock activities in the regional economy, possessing vast agricultural lands and a variety of crop patterns. The district exhibits the characteristic continental climate of Central Anatolia, where hot and dry summers, along with cold and snowy winters, directly influence agricultural activities.

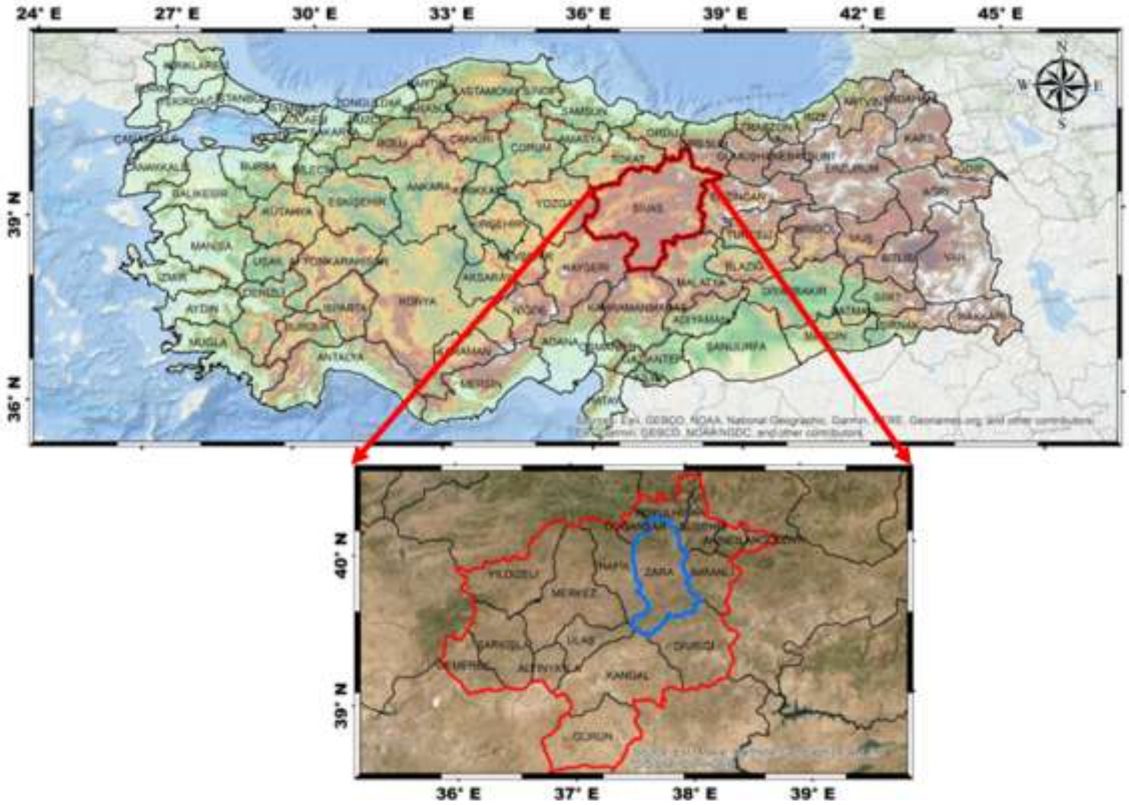

Figure 1. Location map of the study area; provincial and district boundaries

The high spatial and spectral resolution of Sentinel-2 satellite imagery allows for detailed analyses of the study area. The diversity of landforms and crop patterns makes it an ideal example for monitoring the spatial and temporal changes in agricultural development through NDVI time series. Moreover, the density of agricultural lands and the presence of various crop groups in the region make this study both locally valuable and methodologically generalizable.

Materials

In this study, Sentinel-2 images covering the study area were first identified. This process was carried out using the Copernicus Browser (URL-1), where the study area was marked and the images were filtered (Figure 2). During the initial filtering phase, a cloud cover threshold of 30% was applied. However, upon reviewing the images individually, it was found that although the overall cloud cover was 30%, the parcels within the study area were cloud-free. Therefore, without considering the cloud cover constraint, suitable cloud-free images for each month were selected.

Figure 2. Copernicus Browser

In the next phase, the NDVI values of the selected images were calculated and visualized using the Google Earth Engine (GEE) platform (URL-2) (Figure 3). GEE is a powerful platform that allows for the processing of satellite imagery and geographic data in a cloud-based environment (Gorelick et al., 2017). Used in various application fields such as environmental monitoring, agriculture, and disaster management, GEE offers the capability to analyze large datasets rapidly (Hansen et al., 2013). The platform provides a user-friendly analysis environment with a vast data library and support for both JavaScript and Python APIs.

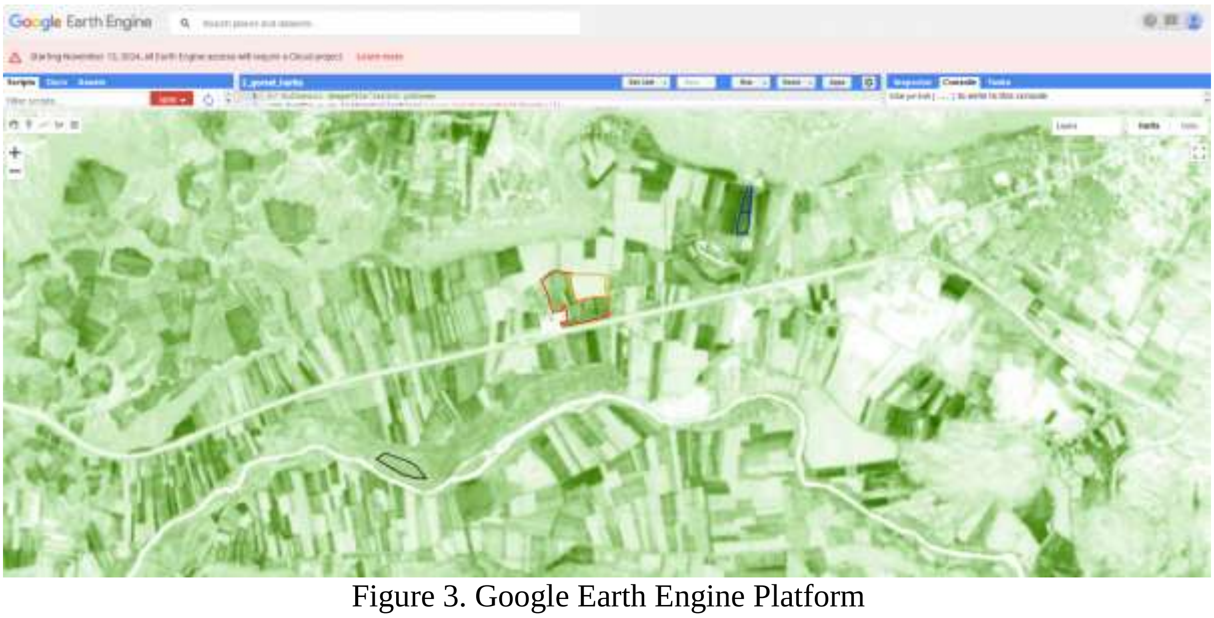

Figure 3. Google Earth Engine Platform

Method

In this study, the NDVI (Normalized Difference Vegetation Index) values of agricultural areas planted with wheat, sugar beet, and forage crops in the Zara district were calculated and analyzed using Sentinel-2 satellite imagery. First, for the year 2023, one Sentinel-2 satellite image was selected for each month between March and December. These images were chosen from scenes with low cloud cover to ensure the accuracy of the analysis. The preprocessing of the images was carried out using the Google Earth Engine (GEE) platform. The powerful computational infrastructure provided by GEE enabled rapid analysis of large datasets. The NDVI values for each image were calculated using Equation (1) in the GEE platform.

$$NDVI := Index(NIR, RED) = \frac{NIR - RED}{NIR + RED} \quad (1)$$

For Sentinel-2 satellite imagery, the NIR and RED bands are represented by B8 and B4, respectively. In this context, the NDVI calculation was performed using Equation (2).

$$NDVI := Index(B8, B4) = \frac{B8 - B4}{B8 + B4} \quad (2)$$

The B8 (Near Infrared) and B4 (Red) bands of Sentinel-2 have a spatial resolution of 10 meters and represent crop development in agricultural areas with high accuracy. The high resolution of these bands provides a significant advantage, particularly in analyzing fine spatial and temporal variations between different crop types.

After the NDVI calculation, the NDVI variations in the parcels of different agricultural crops were examined. The following steps were followed during the analysis process:

- Monthly Evaluation: NDVI images for each month were processed to compare the development patterns of wheat, sugar beet, and forage crops throughout the growing season.
- Spatial Analysis: NDVI maps were produced to identify spatial differences in the selected agricultural areas. These maps enabled the detection of problematic areas in crop development (e.g., low NDVI values).
- Tracking Temporal Dynamics: NDVI time series were created for each parcel, allowing a detailed examination of the development processes of agricultural crops.

RESULTS

This study presents significant findings regarding the temporal dynamics of NDVI values obtained from Sentinel-2 satellite imagery for the period of March to December 2023, for different land uses such as wheat, sugar beet, and forage crops. Additionally, an area of pastureland was selected for the analysis of changes in NDVI values of natural vegetation. The results obtained from these four different land uses are explained in detail.

Wheat

The monthly changes in the NDVI values of wheat are shown in Figure 4. Starting from March, a moderate increase in NDVI values was observed, reflecting the early vegetative growth phase of the crop. In the April-May period, there was a rapid increase in NDVI values, which peaked in May. This indicates the peak of the crop's growth phase. From June onward, a sharp decline in NDVI values was observed, signaling the onset of the crop's senescence phase and the beginning of the harvest period.

Figure 4. Monthly changes in the NDVI values of wheat

Sugar Beet

The monthly changes in the NDVI values of sugar beet are presented in Figure 5. The low levels of NDVI values until June indicate the early growth phase. From June onwards, a steady increase in NDVI values was observed, reaching its peak in August. During this period, the crop experienced its most intense growth phase. After August, the decline in NDVI values signifies the completion of the growth phase and the onset of the harvest period.

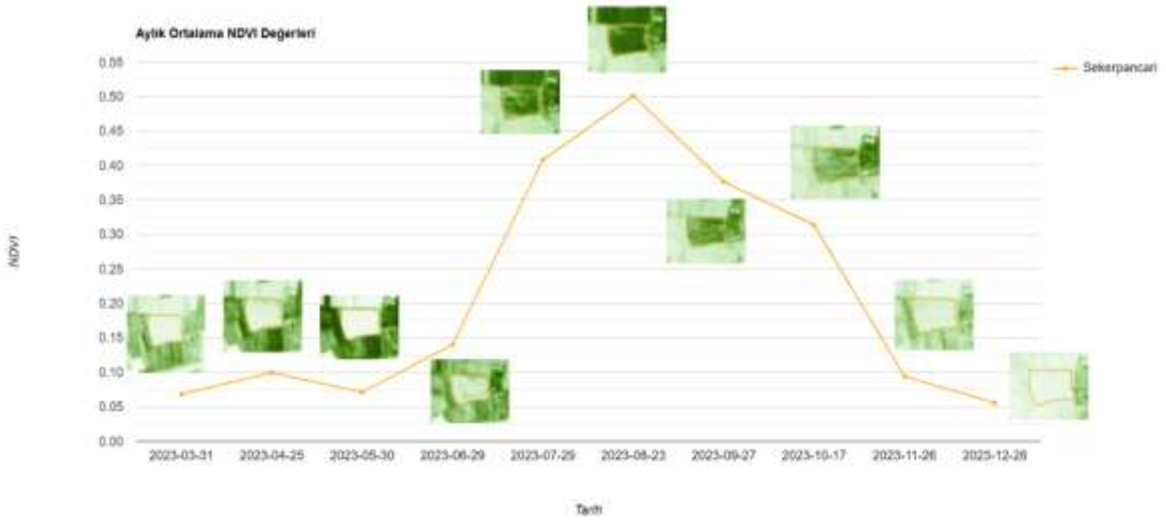

Figure 5. Monthly changes in the NDVI values of sugar beet

Forage Crop

The monthly changes in the NDVI values of forage crops are presented in Figure 6. Starting at low levels in March, the NDVI values gradually increased in April and May. However, a sudden decrease was observed in June, followed by a rise again in August. The NDVI value peaked in September and declined in October. These periodic changes in the NDVI curve of the forage crop indicate that the crop is harvested multiple times throughout the year and regrows afterward.

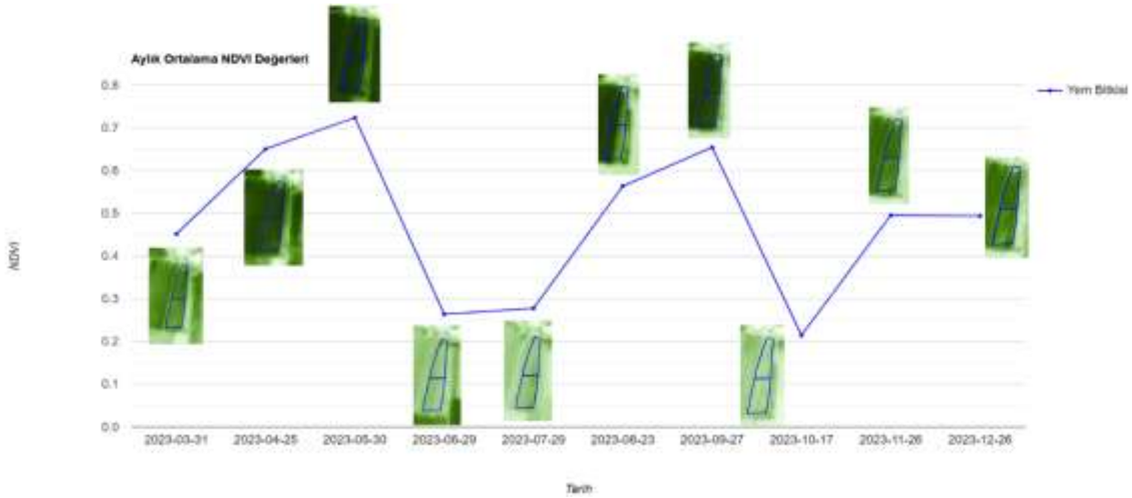

Figure 6. Monthly changes in the NDVI values of forage crops

Grazing Areas

In this study, in addition to the three crop types, a grazing area was selected for the analysis of changes in the NDVI values of natural vegetation. The monthly changes in the NDVI values for the grazing area and their corresponding visuals are presented in Figure 7. Grazing areas were observed to have generally lower NDVI values compared to the other agricultural crops analyzed. Notably, the increase observed during the spring months peaked in June. A gradual decline occurred during the summer months, followed by a slight recovery in the autumn, influenced by end-of-season rainfall.

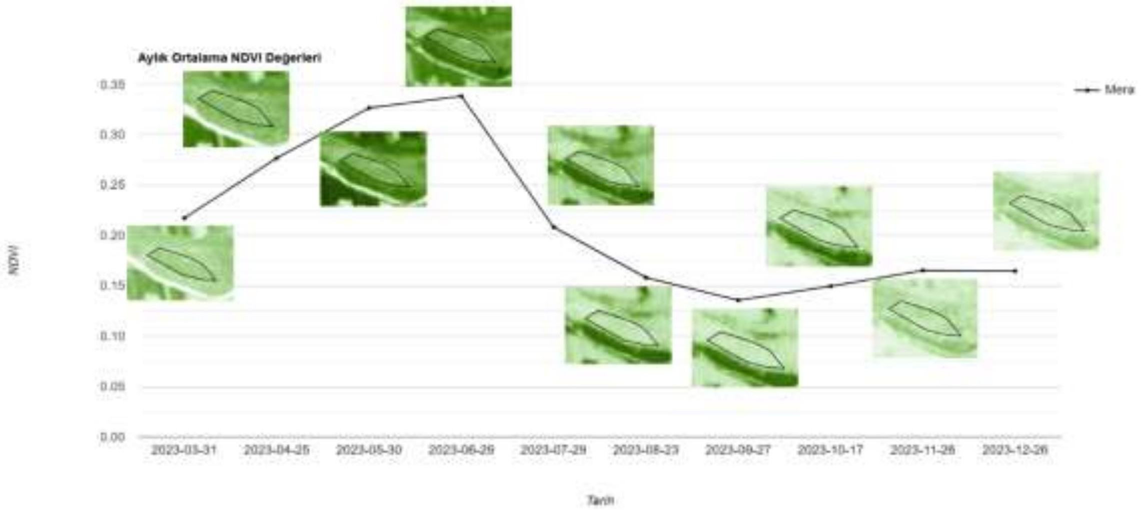

Figure 7. Monthly changes in the NDVI values of the grazing area

The differences in the NDVI values of wheat, sugar beet, forage crops, and grazing areas clearly highlight the phenological cycles of the crops and land use patterns. The comparative graph shown in Figure 8 presents the NDVI curves of these four crop types together.

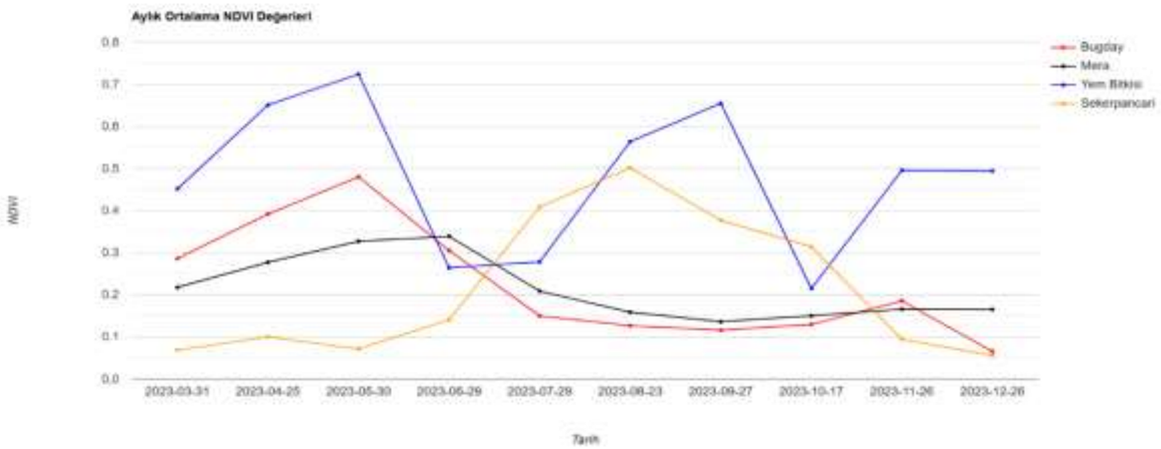

Figure 8. NDVI values of four different land types

Wheat and sugar beet exhibited curves with a clear peak in NDVI values, followed by a sharp decline, clearly indicating their annual growth and harvest cycles. The forage crops, on the other hand, showed multiple peaks and declines in the NDVI curve, highlighting the ability of this species to be harvested multiple times. The pasture areas had lower NDVI values, indicating that the density of natural vegetation in these areas is limited compared to agricultural fields.

This analysis demonstrates that NDVI values are an effective tool for monitoring the phenological stages of agricultural products and assessing crop health. Specifically, the long growth period of sugar beet and the multiple harvest cycles of forage crops are important dynamics to consider in agricultural management planning.

CONCLUSION

This study comprehensively analyzed the spatial and temporal changes in NDVI (Normalized Difference Vegetation Index) values of wheat, sugar beet, forage crops, and pasture areas cultivated in the Zara district using Sentinel-2 satellite imagery. The results of the analysis clearly revealed the differences in growth periods and peak stages of each crop. It was found that wheat reached its highest NDVI values in April and May, demonstrating its growth potential in the early stages, while sugar beet reached its maximum growth stage, particularly in August. Forage crops exhibited development suitable for multiple harvest periods, while pasture areas were observed to have lower NDVI values compared to other agricultural crops. These findings have provided a better understanding of the growth processes and spatial distribution of agricultural products, offering a significant foundation for improving decision support systems in precision agriculture practices. Future studies are recommended to integrate meteorological data, soil properties, and data from various satellite platforms to enhance the accuracy of analyses and plan agricultural production more effectively.

REFERENCES

Chakrabarthy, S. (2016). Resource-intensive agricultural activities and their impact on the hydrological regime. Journal of Hydrology, 540, 1-12.

Choudhary, K., Shi, W., Boori, M.S., & Corgne, S. (2019). Agriculture phenology monitoring using NDVI time series based on remote sensing satellites: A case study of Guangdong, China. Optical Memory and Neural Networks, 28, 204-214.

Drusch, M., Del Bello, U., Carlier, S., Colin, O., Fernandez, V., Gascon, F., ... & Bargellini, P. (2012). Sentinel-2: ESA's optical high-resolution mission for GMES operational services. Remote Sensing of Environment, 120, 25-36.

Gorelick, N., Hancher, M., Dixon, M., Ilyushchenko, S., Thau, D., & Moore, R. (2017). Google Earth Engine: Planetary-scale geospatial analysis for everyone. Remote Sensing of Environment, 202, 18-27.

Hansen, M. C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S. A., Tyukavina, A., ... & Townshend, J. R. G. (2013). High-resolution global maps of 21st-century forest cover change. Science, 342(6160), 850-853.

Jeba, R.P., Kirthiga, S.M., Issac, A.M., Bindhu, V.M., Srinivasan, R., & Narasimhan, B. (2024). An improved framework for mapping and assessment of dynamics in cropping pattern and crop calendar from NDVI time series across a heterogeneous agro-climatic region. Environmental Monitoring and Assessment, 196, 1141.

Lozano-Tello, A., Siesto, G., Fernández-Sellers, M., & Caballero-Mancera, A. (2023). Evaluation of the use of the 12 bands vs. NDVI from Sentinel-2 images for crop identification. Sensors, 23(16), 7132.

Mashonganyika, F., Mugiyo, H., Svotwa, E., & Kutywayo, D. (2021). Mapping of winter wheat using Sentinel-2 NDVI data. Frontiers in Climate, 3, 715837.

Pinter, P.J., Hatfield, J.L., Schepers, J.S., Barnes, E.M., Moran, M.S., Daughtry, C.S.T., & Upchurch, D.R. (2003). Remote sensing for crop management. Photogrammetric Engineering & Remote Sensing, 69(6), 647-664.

Rouse, J.W., Haas, R.H., Schell, J.A., & Deering, D.W. (1974). Monitoring vegetation systems in the Great Plains with ERTS. In Third Earth Resources Technology Satellite-1 Symposium, Volume I: Technical Presentations (NASA SP-351, Vol. I), 309-317.

URL-1 https://browser.dataspace.copernicus.eu

URL-2 https://earthengine.google.com

BACTERIAL FLORA ON THE SURFACE OF GRAPE FRUITS: GENERAL INFORMATION AND ITS IMPORTANCE FOR FRUIT QUALITY

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ABSTRACT

Introduction and Aim:
The surface of grape fruits harbors a diverse bacterial flora that plays a critical role in the overall quality and post-harvest life of the fruit. These microorganisms include both beneficial and potentially harmful species, influencing grape health, fermentation processes, and storage stability. Understanding the composition and function of this bacterial flora is essential for improving grape quality and preventing spoilage. This study aims to summarize the bacterial communities on grape surfaces, their interactions with the fruit, and their impact on fruit quality and post-harvest management.

Discussion and Conclusion:
The bacterial flora on grape surfaces originates from various sources, including the vineyard environment, soil, and agricultural practices. Beneficial bacteria, such as lactic acid bacteria, contribute positively by enhancing fermentation processes and suppressing pathogens. Conversely, spoilage bacteria, such as Acetobacter and certain species of Pseudomonas, can lead to undesirable effects, including fruit rot and quality deterioration. Factors such as grape variety, climatic conditions, and pesticide use significantly influence the composition of this microbial community.

Recent studies have highlighted the potential of manipulating bacterial flora to improve fruit quality. For example, applying biocontrol agents or promoting beneficial microbes through sustainable agricultural practices can enhance grape health while reducing the reliance on chemical interventions. Advanced molecular techniques, such as next-generation sequencing, have provided deeper insights into bacterial diversity, allowing for more targeted approaches to managing microbial communities.

The bacterial flora on grape surfaces plays a dual role, acting as both a protector and a potential threat to fruit quality. Managing this microbial community through ecological and biotechnological strategies offers a promising pathway to enhance grape quality, extend shelf life, and reduce spoilage. Future research should focus on understanding specific bacterial interactions and developing innovative approaches to harness beneficial microbes effectively.

Key Words: Vitis vinifera L., disinfestation, 16S V3/V4 metabarcoding, bacterial diversity, microbiota

GİRİŞ

Mikrobiyal topluluklar, doğadaki ekosistemlerin işleyişinde kritik roller oynar ve bitki-mikrop etkileşimlerinin bir yansıması olarak tarımsal ürünlerin yüzeyinde de karşımıza çıkar. Üzüm (Vitis vinifera) gibi meyvelerin yüzeyinde bulunan bakteriyel çeşitlilik, hem meyvenin kalitesini hem de raf ömrünü doğrudan etkiler. Bu topluluklar; meyvenin yetiştirilme koşullarından çevresel faktörlere kadar pek çok etkene bağlı olarak şekillenmektedir.

Meyve yüzeyinde bulunan mikroorganizmalar, ürünlerin olgunlaşma sürecini, tat ve aroma gibi duyusal özelliklerini ve genel besin değerini önemli ölçüde etkiler. Laktik asit bakterileri gibi yararlı mikroorganizmalar, fermente ürünlerin kalitesini artırabilirken, patojenik bakteriler meyvenin çürümesine veya insan sağlığı için tehdit oluşturabilecek sağlık risklerine yol açabilir. Özellikle tarımda kullanılan pestisitler, çevresel faktörler ve hasat sonrası uygulamalar, bu mikrobiyal toplulukların dengesini değiştirebilir ve meyve kalitesini etkileyebilir. Meyve yüzeyindeki mikrobiyal çeşitliliğin ve işlevlerinin anlaşılması, hem tarımsal üretimde sürdürülebilirlik sağlanması hem de tüketiciye güvenli ürünlerin sunulması açısından önemlidir.

Mikrobiyal etkilerin meyve kalitesi üzerindeki incelenmesi, sadece üzüm değil, tüm meyve çeşitleri için gıda güvenliği ve ürün dayanıklılığı konularında derinlemesine araştırmaları gerektirir. Bu bağlamda, meyve yüzeyindeki bakteriyel türlerin ve bu türlerin sağladığı katkıların veya oluşturduğu risklerin analizi, hem üretim süreçlerini hem de nihai tüketici memnuniyetini geliştirmek için hayati bir öneme sahiptir.

Bu araştırmanın amacı, üzüm yüzeyindeki bakteriyel florayı detaylı bir şekilde incelemek, bu mikroorganizmaların meyve kalitesi üzerindeki etkilerini değerlendirmek ve sağlıklı ürünlerin elde edilmesine yönelik öneriler sunmaktır. Böylece, tarım sektöründe daha verimli ve güvenilir yöntemlerin geliştirilmesine katkı sağlanması hedeflenmektedir.

ARAŞTIRMA VE BULGULAR

Üzüm Yüzeyindeki Bakteriyel Türlerin Belirlenmesi

Üzüm yüzeyindeki bakteriyel floraların belirlenmesi için kullanılan çeşitli yöntemler arasında kültür bazlı yöntemler, moleküler teknikler ve yeni nesil dizileme (NGS) yöntemleri bulunmaktadır. Kültür bazlı yöntemlerde, üzüm örnekleri steril koşullarda alınarak uygun besiyerlerinde inkübe edilip, bakteriyel koloniler izole edilir. Bunun yanı sıra, moleküler tekniklerde 16S ribozomal RNA (rRNA) gen dizileme yöntemi, bakteriyel türlerin belirlenmesinde sıklıkla kullanılmaktadır. Bu yöntem, bakteriyel DNA'nın çıkarılması ve genetik dizilerin analiz edilmesiyle, kültürlenmesi zor veya bilinmeyen bakterilerin tespit edilmesine olanak tanır (Alderson & Jones, 2016).

Bakteriyel Çeşitliliğin Coğrafi ve Çevresel Faktörlere Göre Değişimi

Üzüm yüzeyindeki mikrobiyal çeşitlilik, yetiştirilme koşullarına, bölgesel iklim faktörlerine ve çevresel etmenlere bağlı olarak büyük ölçüde değişim göstermektedir. Farklı iklim koşulları, toprak yapıları ve sulama yöntemleri, bakteriyel floraların kompozisyonunu doğrudan etkileyebilir. Örneğin, Akdeniz ikliminde yetişen üzümlerin yüzeyindeki bakteriyel çeşitlilik, soğuk iklim bölgelerinde yetişen üzümlere kıyasla farklılıklar gösterir. Ayrıca, pestisit kullanımı ve organik tarım uygulamaları da bu floraların çeşitliliğini etkileyebilir (Capron et al., 2019). Coğrafi faktörlerin bakteriyel çeşitlilik üzerindeki etkisini anlamak için yapılan çalışmalarda, farklı üzüm yetiştiren bölgelerden alınan örnekler üzerinde yapılan DNA analizleri, bu varyasyonları ortaya koymaktadır (Beuchat, 1996).

Üzüm Yüzeyindeki Domine Edici Bakteri Türleri

Üzüm yüzeyinde en yaygın ve domine edici bakteriyel türler arasında Lactobacillus, Pediococcus, Enterobacter, Pseudomonas ve Acetobacter gibi türler yer almaktadır. Lactobacillus ve Pediococcus türleri, üzüm yüzeyindeki fermente süreçlere katkı sağlayarak şarap üretimi gibi endüstriyel uygulamalarda faydalıdır. Ancak, Pseudomonas ve Acetobacter gibi türler, meyve çürümesine ve bozulmasına neden olabilen patojenik organizmalar olarak bilinir (Bokulich & Mills, 2012). Bu türlerin varlığı, üzümün kalitesini doğrudan etkileyebilir. Özellikle, bozulmaya yol açan bakterilerin varlığı, meyve kalitesinin düşmesine ve raf ömrünün kısalmasına sebep olabilir.

Bakteriyel Floranın Meyve Kalitesine Etkileri

Meyve yüzeyindeki bakteriyel floraların, özellikle fermente mikroorganizmaların etkisi, meyvenin tat, aroma ve genel kalite özelliklerini şekillendirir. Yararlı bakteriler, üzümde fermente süreçlere yardımcı olurken, zararlı bakteriler meyvenin bozulmasına neden olabilir. Acetobacter türleri, üzümdeki şekerleri asetik aside dönüştürerek bozulmaya yol açar, bu da meyvenin kalite kaybına ve tüketiciye sunulabilecek ürünün sağlıksız hale gelmesine neden olabilir (Harris & Van Harn, 2005). Bu bakteriyel çeşitlilik, aynı zamanda üzümün besin değerini de etkileyebilir, çünkü bazı bakteriyel türler besin maddelerinin biyoyararlanabilirliğini artırabilir veya azaltabilir.

METODOLOJİ

Bu çalışmada, üzüm yüzeyindeki bakteriyel florayı belirlemek için kapsamlı bir yöntemler dizisi kullanılmıştır. Araştırma kapsamında aşağıdaki adımlar izlenmiştir:

Örnekleme Süreci

Örneklerin Toplanması: Farklı bölgelerden ve yetiştirme koşullarından elde edilen üzüm numuneleri rastgele seçilmiştir.

Sterilite Sağlama: Kontaminasyonu önlemek için steril eldiven ve ekipman kullanılmış, numuneler steril kaplarda taşınmıştır.

Saklama Koşulları: Toplanan üzüm örnekleri soğuk zincir altında (-4°C) laboratuvara ulaştırılmıştır.

Yüzey Bakterilerinin İzolasyonu

Yıkama Yöntemi: Üzüm yüzeyindeki bakteriler, steril fosfat tamponlu salin (PBS) çözeltisi ile yıkama yapılarak süspansiyon haline getirilmiştir.

Hızlı Santrifüj ve Filtrasyon: Yıkama sıvısından bakteri hücrelerinin konsantre edilmesi için santrifüj işlemi uygulanmıştır.

Kültür ve İdentifikasyon

Besiyeri Kullanımı: Elde edilen süspansiyonlar, seçici ve genel besiyerlerine (ör. Nutrient Agar, MacConkey Agar) ekilmiştir.

İnkübasyon Koşulları: Plaklar, 25°C ve 37°C'de, aerobik ve mikroaerofilik ortam koşullarında 24-72 saat inkübe edilmiştir.

Koloni Morfolojisi: Oluşan koloniler, renk, şekil ve büyüklük gibi kriterlere göre ön incelemeye tabi tutulmuştur.

Moleküler Tanımlama

DNA Ekstraksiyonu: Kolonilerden genetik materyal, ticari DNA ekstraksiyon kitleri kullanılarak elde edilmiştir.

16S rRNA Analizi: Bakterilerin tür düzeyinde tanımlanması amacıyla 16S rRNA gen bölgesi PCR ile çoğaltılmış ve sekanslanmıştır.

Bioinformatik Analizler: Sekans verileri, BLAST ve diğer veri tabanları ile karşılaştırılarak bakteri türleri tespit edilmiştir.

Çevresel Faktörlerin Değerlendirilmesi

Coğrafi Farklılıklar: Örnekleme yapılan bölgelerin iklimsel ve toprak özellikleri incelenmiştir.

Çevresel Parametreler: pH, sıcaklık, nem gibi üzüm yetiştirme koşullarının bakteriyel çeşitlilik üzerindeki etkisi analiz edilmiştir.

TARTIŞMA VE SONUÇ

Bu çalışmada elde edilen bulgular, üzüm yüzeyindeki bakteriyel floranın meyve kalitesine olan etkilerini açıkça ortaya koymuştur. Özellikle Lactobacillus ve Pediococcus gibi yararlı bakterilerin, fermentasyon süreçlerini destekleyerek üzümün tat ve aroma özelliklerini geliştirdiği gözlemlenmiştir. Bununla birlikte, Acetobacter ve Pseudomonas türlerinin meyve yüzeyindeki varlığı, kalite kaybı ve bozulma risklerini artırmaktadır. Bu durum, tarım ve gıda sektöründe mikrobiyal yönetim uygulamalarının önemini bir kez daha vurgulamaktadır. Son yıllarda, yeni nesil dizileme gibi moleküler tekniklerin, üzüm yüzeyindeki bakteriyel çeşitliliği anlama konusundaki katkısı büyüktür. Bu teknolojiler, sadece mevcut bakteriyel türlerin tanımlanmasına olanak tanımakla kalmayıp, aynı zamanda mikrobiyal etkileşimlerin derinlemesine anlaşılmasını da sağlamaktadır. Bu bağlamda, mikroorganizma topluluklarının tarımsal üretim süreçlerinde nasıl yönlendirilebileceğine dair yeni yaklaşımlar geliştirilmesi gerekmektedir. Örneğin, biyokontrol ajanlarının kullanımı veya faydalı mikrobiyal türlerin teşvik edilmesi, pestisitlere olan bağımlılığı azaltabilecek ve üzüm kalitesini artırabilecek sürdürülebilir uygulamalardır.

Coğrafi ve çevresel faktörlerin, bakteriyel çeşitlilik üzerindeki belirgin etkileri, farklı bölgelerde yapılan çalışmalarla desteklenmiştir. Akdeniz gibi sıcak ve nemli bölgelerde yetiştirilen üzümlerin yüzeyinde gözlemlenen bakteriyel türler, soğuk iklimlerde yetişenlerden oldukça farklıdır. Bu farklılıklar, sadece üzüm çeşitliliği ve yetiştirme yöntemleri açısından değil, aynı zamanda tüketicilere sunulan nihai ürün kalitesinde de kendini göstermektedir. Bu araştırmanın sonuçları, gıda güvenliği ve hijyen standartlarının önemini ortaya koymakla birlikte, tarımsal uygulamalarda sürdürülebilirlik açısından da önemli veriler sunmaktadır. Gelecekteki çalışmalar, özellikle bakteriyel floranın spesifik etkileşimlerini daha detaylı şekilde incelemeye ve bu etkileşimlerin meyve kalitesi üzerindeki etkilerini optimize etmeye odaklanmalıdır. Böylece hem ekonomik hem de ekolojik açıdan daha etkili tarım ve gıda yönetim sistemleri oluşturulabilir.

Bu çalışma ile üzümlerin yüzeyindeki bakteriyel floraların meyve kalitesi üzerindeki etkileri derinlemesine incelenmiştir. Elde edilen bulgular, bakteriyel floraların yalnızca lezzet ve görünüm üzerinde değil, aynı zamanda sağlıklı besin değerleri üzerinde de etkili olduğunu göstermektedir. Dolayısıyla, üzüm üretiminin tüm aşamalarında hijyenin sağlanması büyük bir öneme sahiptir. Ayrıca, meyve yüzeyindeki bakteriyel floraların sağlık üzerindeki olası tehlikeleri nedeniyle uygun gıda güvenliği önlemlerinin alınması önemlidir.

Gelecek çalışmalar, bu bakteriyel floraların kontrolü için daha etkili yöntemlerin geliştirilmesine katkıda bulunmalıdır. Ayrıca, farklı üzüm çeşitleri üzerinde yapılan benzer çalışmalar, bu konudaki bilgimizin derinleşmesine yardımcı olacaktır. Özellikle sağlıklı gıda üretimi için, mikrobiolojik kontrol yöntemleri ve hijyen standartlarının uygulanması önerilmektedir. En nihayetinde, bu araştırma hem tarım pratiğine hem de gıda güvenliği alanına katkı sağlamayı hedeflemektedir.

KAYNAKLAR

Alderson, P.G., & Jones, R. (2016). Microbial Ecology of Grapes: Impacts on Quality and Wine Safety. Journal of Applied Microbiology, 121(4), 856-865.

Beuchat, L.R. (1996). Pathogenic Microorganisms Associated with Fresh Produce. Food Safety and Technology, 5(2), 203-208.

Gao, Q., & Li, S. (2012). Control of Foodborne Pathogens on Fresh Fruits and Vegetables: Current Methods and Future Directions. Food Control, 28(2), 273-280.

Bokulich, N.A., & Mills, D.A. (2012). Future Directions in Wine Microbiology: The Importance of Microbial Starter Cultures. Food Microbiology, 27(3), 245-254.

Harris, R.J., & Van Harn, J. (2005). Impact of Yeasts and Bacteria on Wine Quality. World Journal of Microbiology and Biotechnology, 21(3), 339-347.

Capron, M.P., et al. (2019). Impact of Food Microflora on Quality and Safety: Wine and Fresh Fruits. Critical Reviews in Food Science and Nutrition, 59(12), 1905-1928.

Alderson, P.G., & Jones, R. (2016). Microbial Ecology of Grapes: Impacts on Quality and Wine Safety. Journal of Applied Microbiology, 121(4), 856-865.

Beuchat, L.R. (1996). Pathogenic Microorganisms Associated with Fresh Produce. Food Safety and Technology, 5(2), 203-208.

Bokulich, N.A., & Mills, D.A. (2012). Future Directions in Wine Microbiology: The Importance of Microbial Starter Cultures. Food Microbiology, 27(3), 245-254.

Capron, M.P., et al. (2019). Impact of Food Microflora on Quality and Safety: Wine and Fresh Fruits. Critical Reviews in Food Science and Nutrition, 59(12), 1905-1928.

Gao, Q., & Li, S. (2012). Control of Foodborne Pathogens on Fresh Fruits and Vegetables: Current Methods and Future Directions. Food Control, 28(2), 273-280.

Harris, R.J., & Van Harn, J. (2005). Impact of Yeasts and Bacteria on Wine Quality. World Journal of Microbiology and Biotechnology, 21(3), 339-347.

Alderson, P.G., & Jones, R. (2016). Microbial Ecology of Grapes: Impacts on Quality and Wine Safety. Journal of Applied Microbiology, 121(4), 856-865.

Beuchat, L.R. (1996). Pathogenic Microorganisms Associated with Fresh Produce. Food Safety and Technology, 5(2), 203-208.

Bokulich, N.A., & Mills, D.A. (2012). Future Directions in Wine Microbiology: The Importance of Microbial Starter Cultures. Food Microbiology, 27(3), 245-254.

Capron, M.P., et al. (2019). Impact of Food Microflora on Quality and Safety: Wine and Fresh Fruits. Critical Reviews in Food Science and Nutrition, 59(12), 1905-1928.

Gao, Q., & Li, S. (2012). Control of Foodborne Pathogens on Fresh Fruits and Vegetables: Current Methods and Future Directions. Food Control, 28(2), 273-280.

Harris, R.J., & Van Harn, J. (2005). Impact of Yeasts and Bacteria on Wine Quality. World Journal of Microbiology and Biotechnology, 21(3), 339-347.

WHEN BEAUTY TURNS BEAST: ORNAMENTAL PLANTS THAT BECOME WEEDS

GÜZELLIĞIN CANAVARA DÖNÜŞMESI: SÜS BITKILERININ İSTILACI YABANCI OT OLMASI

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ÖZET

Kentsel alanların önemli değerlerinden olan peyzaj süs bitkileri kentin ekosistemine sağladıkları önemli faydaların yanında sebep oldukları olumsuzluklarda mevcuttur. Bitkiler istila ettikleri yerel türlerin ekolojisini bozarak çevresel sorunlar ve ekonomik kayıplar yaşatarak önemli problemler meydana getirmişlerdir. İstilacı olan peyzaj süs bitkileri hızlı gelişim göstermeleri ve çoğalma kapasitelerinin fazla olmasıyla diğer türlere üstünlük sağlarlar. Bu nedenle, istilacı bitkilerin gözetim altına alınması gerekmektedir. Tercih edilecek süs bitkileri belirlenirken estetik ve işlevsel özelliklerinin yanında istilacı olabilme ihtimallerininde göz önünde bulundurulması gerekmektedir. Bir alanın doğal bitkileri içerisinde yer almayıp başka alanlardan getirilerek çeşitli amaçlar için yetiştirilen bitkilerin istilacı olma potansiyelleri yüksektir. Süs bitkileri bu kategoride değerlendirilen bitkilerin başında gelmektedir. Süs bitkileri dünya çapında bitki istilasının en önemli yoludur. Çok sayıda yerli olmayan bitkiler süs bitkisi olarak kullanılmakta ve mevcut politikalar, bu türlerin istilalarına çözüm bulamamaktadır. Yasal tedbirler genellikle satışı veya ekimi yasaklanan birkaç yüksek riskli türle sınırlıdır. Bu sınırlı sayıdaki türlerin dışındaki bitkiler güvenli olduğu izlenimini verebilmektedir. İstilacı olma riski henüz tespit edilmemiş türlerin yaygın olarak kullanılması gelecekte büyük bir sorun teşkil edebilecektir. Bunun için bu bitkilerin iyi gözlemlenmesi ve istilacılık potansiyellerinin oluşmaya başlandığı andan uygun yöntemlerle istilanın önüne geçilmesi gerekmektedir. Aksi halde biyoçeşitliliğe ciddi zararlar vererek telafisi olmayan durumların meydana gelmesi kaçınılmaz olacaktır.

Anahtar Kelimeler: İstilacı Bitkiler, Peyzaj, Süs Bitkileri, Yabancı Ot.

ABSTRACT

Landscape ornamental plants, which are one of the important values of urban areas, have important benefits for the ecosystem of the city as well as the negativities they cause. The plants have caused significant problems by disrupting the ecology of the local species they invade, causing environmental problems and economic losses. Invasive landscape ornamental plants are superior to other species due to their rapid growth and high reproduction capacity. Therefore, invasive plants should be taken under surveillance. When determining the ornamental plants to be preferred, the possibility of invasiveness should be taken into consideration in addition to their aesthetic and functional features. Plants that are not included in the natural plants of an area but brought from other areas and grown for various purposes have a high potential to be invasive. Ornamental plants are among the plants considered in this category. Ornamental plants are the most important way of plant invasion worldwide. A large number of non-native plants are used as ornamentals and current policies do not address their invasion. Legislative measures are usually limited to a few high-risk species whose sale

or cultivation is prohibited. Plants outside this limited number of species can give the impression of being safe. The continued widespread use of species whose risk of invasiveness has not yet been recognised could pose a major problem in the future. Since many non-native plants are commercially important and widely used for various purposes, a total ban on their import and use is an impractical solution in terms of control. For this reason, these plants should be well observed and the invasion should be prevented with appropriate methods as soon as their invasion potential starts to occur. Otherwise, it will be inevitable to cause serious damage to biodiversity and to create situations that are difficult to compensate.
Keywords: Invasive Plants, Landscape, Ornamental Plants, Weeds.

GİRİŞ

"İstilacı tür" doğal bitki örtüsüne çok önemli zararlar vererek ekosistemleri kolayca istila eden bitki türlerini tanımlayan bir kavramdır (Callaway ve Aschehoug, 2000; MacDougall ve Turkington, 2005). Pimentel ve ark., (2000) göre "istilacı yabancı türler" kavramı; "Bölgeye çeşitli yollarla giren ve insan sağlığına tehdit oluşturan, ekonomik, çevresel ve ekolojik sorunlara neden olan veya zarar vermesi olası yabancı türler" olarak tanımlanmaktadır.

İstilacı bitkiler; geniş tolerans sınırları, çevreye uyum yetenekleri ve yüksek üreme potansiyelleri gibi karakteristik özellikleri nedeniyle diğer türlere göre daha rekabetçidirler. Bu nedenle taşındıkları yeni alanlarda hızla gelişir ve yayılırlar, bu da onlara alandaki diğer tüm bitki türlerine karşı üstünlük sağlar (Önen, 2015; Kayaçetin, 2020).

İçinde bulunduğumuz coğrafyanın büyük bir kısmını kapsayan bitkilere, hem ekonomik açıdan getirileri hem de estetik açıdan ihtiyaç her zaman var olmuştur. Sürekli olarak gelişen dünyada süs bitkileri sektörü, bitkisel üretimin bir parçası olarak giderek daha fazla önem kazanmaktadır. Bitkilerin süs bitkisi olarak değerlendirilmesi ve bu alandaki araştırma-geliştirme faaliyetleriyle birlikte, şehirlerde dış mekan süs bitkilerinin kullanımı da benzer bir şekilde ilerleme kaydetmiştir (Akça ve ark., 2019). Süs bitkileri yetiştiriliciği ABD tarımının en hızlı büyüyen bölümüdür. Tarımsal üretim, Amerika Birleşik Devletleri'nin geniş bölgelerinde gıdadan süs bahçeciliğine doğru kaymıştır. Ancak yeşil endüstri, istilacı bitkilerin yayılmasına önemli bir katkıda bulunmaktadır. Yerli olmayan süs bitkilerinin 5.000'den fazla türü ekimden kaçmış ve asgari düzeyde yönetilen habitatlarda doğallaştırılmıştır (Morse ve ark.,1995).

Son yıllarda, insanların yaşam kalitesinin yükselmesiyle beraber insan ve doğayı bir araya getiren kentsel açık alanların önemi daha çok anlaşılmaktadır. Ülkemizin çeşitli kamu kurum ve kuruluşları, belediyeler ve özel firmaların liderliğinde park, cadde, yol, kavşak, meydan, üniversite kampüsleri ve millet bahçelerinde peyzaj çalışmalarında fazlasıyla bitkisel materyal kullanılmıştır. Peyzaj alanlarında artan süs bitkilerinin kullanımı bitkilerin aynı zamanda istilacı olarak anılmasına neden olmuştur.

İstilacı bitki türleri; ekolojik faktörlere karşı yüksek toleransları, kısa yaşam döngüleri, hızlı büyüme yetenekleri, derin kök sistemleri, ışık rekabetinde üstünlükleri, yüksek üreme kapasiteleri, allelopatik etkileri ve güçlü adaptasyon kabiliyetleri gibi nedenlerden dolayı diğer türlere kıyasla daha rekabetçi bir yapıya sahiptirler. Ayrıca, herbivorlardan kaçınma ve vejetatif üreme stratejilerini benimsemeleri bu bitkilerin saldırgan bir şekilde gelişerek diğer bitki türleri üzerinde üstünlük sağlamalarını mümkün kılar. Bu bitki türleri, yeni yerleştikleri alanlarda besin elementi döngüsü ile ekosistemin fonksiyon ve süreçlerini olumsuz etkiledikleri gibi yerli türlerin sayısında ve yoğunluğunda da azalmaya yol açarlar (Çorbacı ve ark. , 2022).

İstilacı bitkiler sessizce ve sürekli olarak parklara, koruma alanlarına, yaban hayatı sığınaklarına ve kentsel alanlara kısaca tüm peyzaj sahalarına saldırmaktadır. Amerika Birleşik Devletleri'nde istilacı bitkiler 100 milyon dönümlük araziyi ele geçirerek ve her yıl %10 oranında artmaktadır (Pimentel ve ark., 2000). Zamanla istilacı bitki türleri ekosistemlerdeki yerel türlerin çeşitliliğini ve yayılmasını olumsuz etkileyerek, ekolojik sorunlara ve ekonomik kayıplara yol açmaktadır. Ayrıca bu türler, tehdit ve tehlike altında olan türlerin yaşam alanlarını daraltır (Wilcove ve ark., 1998). İstila süreçleri, var olan ekosistemin yapısıyla ilgili olarak istilacı yabancı bitki türlerinin yerli türlerden gelen rekabetin sona ermesi sonucu tahrip olan ekosistemlerde son derece elverişli koşullar ortaya çıkarmaktadır (Önen, 2015). İstilaya uğramış bölgelerde istilacı bitkilerin yayılma kapasitelerindeki artış, biyolojik çeşitliliğin etkilenmesine yol açmakta ve bu durum sonucunda biyoçeşitlilik yok olmakla karşı karşıya kalmaktadır (Vila ve ark., 2010). Bu yüzden peyzaj ve süs bitkileri tercih edilirken bitkilerin istilacı tür olup olmadıklarına bakılmalı ve ona göre bitkisel tasarımlar yapılmalıdır.

KAVRAMSAL ÇERÇEVE

İstilacı Süs Bitkilerinin Ekonomik Ve Ekolojik Etkileri

Egzotik süs bitkilerinin kullanımı sıklıkla saldırgan istilacıların ortaya çıkmasına neden olmuştur. Birçok egzotik süs bitkisinin istilacı olmasının altında yatan neden, bahçıvanlar, peyzajcılar ve fidanlık endüstrisi için son derece arzu edilen olumlu özelliklere sahip olmaları ve olumsuz ve çeşitli çevresel koşullar altında kolayca üremeleri, hızla yerleşmeleri ve büyümeleridir. Örneğin, bu bitkiler genellikle büyük miktarlarda meyve ve tohum üretir ve tohumları rüzgar, su veya yaban hayatı yardımıyla uzak bölgelere kolayca dağılır. Bu istilacı süs bitkilerine örnek olarak kokar ağaç (Ailanthus altissima), kurtbağrı (Ligustrum spp.) ve kadın tuzluğu (Berberis thunbergii) verilebilir. Bazı istilacı süs bitkileri vejetatif olarak yeraltı rizomları, toprağa değdikten sonra kolayca köklenen gövdeler veya bitki gövdesi parçalarının maceracı köklenmesi yoluyla yayılır. Bu özellikler bahçıvanlar için de arzu edilir çünkü bu avantajlı özelliklere sahip bitkiler arka bahçe peyzajındaki veya su bahçesindeki boş alanları hızla dolduracaktır. İngiliz sarmaşığı (Hedera helix) ve su sümbülü (Eichornia crassipes) bilinen iki örnektir. Hızlı büyüme, genel olarak istilacı bitkilerin bir başka özelliğidir. Bahçıvanlar ve peyzajcılar genellikle bir bahçedeki yamaları hızla doldurabilecek veya yabani otlarla rekabet etmek için zemini hızla kaplayabilecek bitkiler ararlar. Fidanlık açısından bakıldığında, hızlı yerleşen ve hızlı büyüyen bitkiler, üretim tesislerinde minimum yatırımla hızlı bir kar sağlar, bu da üretim maliyetlerini düşürür ve bir işletmenin kar hanesine mali destek sağlar. İstilacı süs bitkileri ayrıca genellikle toprak tipi, su gereksinimleri ve besin seviyeleri gibi olumsuz ve çeşitli çevresel koşullara uyum sağlar ve genellikle ciddi hastalık ve böcek istilalarından yoksundur. Bu özellikler fidanlık yetiştiricileri ve tüketiciler için caziptir, çünkü minimum bakım gerektirirler ve daha az gübre ve pestisit uygulamasına ihtiyaç duyarlar. Bu olumlu özellikleriyle, istilacı veya potansiyel istilacı bitkilerin kar payı, istilacı olmayan yerli bitkilere göre genellikle çok daha yüksektir (Li,2004).

Süs bitkileri bahçelerde ve diğer yönetilen peyzaj alanlarında kullanılmak üzere çoğaltılmıştır. Ancak istilacı süs bitkileri ekili alanlardan kaçarak doğal alanları istila edebilir ve burada hızla kolonileşir, yerleşir ve çoğalırlar. İstilacı süs bitkilerinin doğal alanlara girmesinden kaynaklanan doğrudan parasal kayıpları ölçen bir rapor olmamasına rağmen, sınırlı sayıda istilacı bitki için ekonomik etkiler tahmin edilmiştir. Örneğin, mor salkım otu (Lythrum salicaria) yem kayıpları ve kontrol maliyetleri açısından yılda 45 milyon dolara mal olmaktadır (Hall, 2000; Pimentel ve ark., 1999).

Mor salkım otu yılda 285.000 dönümlük bir alana yayılmaktadır. Buna ek olarak, süs amaçlı istilacı bitkiler ekosistemlere parasal olmayan önemli ölçüde zarar vermiş, ekolojik ekosistem işlevinin ve biyolojik çeşitliliğin kolayca belirlenemeyen bir kaybına katkıda bulunmuştur. Mor salkım otunun yayılması, ortaya çıkan sulak alanların temel yapısını değiştirmiş, 44 yerli bitkinin biyokütlesinin azalmasına neden olmuş ve bu yerli bitkilere bağımlı olan yerli yaban hayatını azaltmıştır (Hall, 2000; Pimentel et al., 1999).

İstilacılar bir kez yerleştikten sonra kaynaklar için yerel bitkilerle etkili bir şekilde rekabet eder. Tipik örnekler arasında İngiliz sarmaşık ve kudzu bulunur. Her iki tür de vejetatif çoğalma yoluyla hızla çoğalır ve hızla büyüyüp yerleşir. Arka bahçeleri, terk edilmiş veya bozulmuş tarlaları, yol geçişlerini, boş binaları, ormanlık alanları ve orman kenarlarını hızla aşmaktadır. İngiliz sarmaşık ve kudzu'nun yoğun büyümesi ve yeşil, mumsu yaprakları, güneş ışığının yerli bitkilere ve diğer bitkisel fidelere ulaşmasını engelleyen kalın bir gölgelik oluşturur. Sarmaşıklar dallara ve ağaçların tamamına tırmanıp onları sarabilir, güneş ışığını kısıtlayabilir ve sonunda boğulan bitki örtüsünü öldürebilir. Böyle bir durumu anlatmak için “sarmaşık çölü” terimi kullanılmıştır (Reichard ve White, 2001).

Bazı istilacı bitkiler toprağın su ve tuz içeriğini değiştirerek ekosistemi değiştirir, dolayısıyla bir bölgenin hidrolojisini ve tuzluluğunu değiştirir. Amerika'nın güneybatısını işgal eden tuzlu sedir ağaçları (Tamarix spp.), buharlaşmayı artırarak su rezervlerini azaltır ve böylece çöl kıyısı alanlarını değiştirir (Walker ve Smith, 1997). Kaliforniya kıyılarındaki buz bitkisi (Mesembryanthemum crystallinum) topraktan tuzu alıp yüzeye biriktirerek bu ekosistemleri yerli bitkiler için yaşanmaz hale getirir. Sarı iris (Iris pseudacorus), rizomlarıyla yükseltilmiş bir tohum yatağı oluşturarak Potomac Nehri bataklığını dişbudak (Fraxinus) ve söğütleri (Salix) tercih eden bir mesic ormanına dönüştürmede etkili oldu (Hall, 2000). Bazı istilacı bitkiler, daha da agresif istilacılar yaratmak için yakından ilişkili yerli bitkilerle de melezleşebilir. Bradford armutu genellikle az sayıda tohum üretir. Ancak diğer armut türleri ile melezleştirildiğinde, üretilen yüksek canlılıktaki tohumlar, Amerika Birleşik Devletleri'nin güneydoğusunda sıklıkla gözlemlendiği gibi, doğal alanlarda son derece rekabetçi hale gelir (Yi Li ve ark., 2010).

İstilacı ve yabancı bitki türleri doğal yaşam alanları için önemli bir tehdittir. Doğallaşma eğilimi gösterebilen bu türler, doğal besin zinciri üzerinde yıkıcı bir etkiye sahiptir. İstilacı türler genellikle doğal türlerden farklı bir fenolojiye sahiptir. Yapraklanma yabani bitkilere göre daha erkendir ve normalden daha geç faaliyetten kesilirler. Kısacası vejetasyon süreleri daha uzundur. Bunun nedeni yüksek ekolojik toleranslarıdır. Bu istilacı bitkiler hayatta kalmak için birçok strateji geliştirir. Gelişimleri genellikle hızlıdır ve erken yaşlarda olgunluğa ulaşırlar. İstilacı bitki türlerinin birçoğu stolon, rizom ve toprakta köklenen sürgünler sayesinde vejetatif olarak çoğalma yeteneğine sahiptir. Bu türler çoğunlukla rüzgarla tozlaşma eğilimindedir. Meyveler rüzgarlar, sular ve kuşlar tarafından taşınarak çok geniş yayılma alanlarına ulaşır. Bu özelliği sayesinde koloniler doğal yaşam alanlarından uzak yerlerde kurulabilir. Asıl sorun küresel biyoçeşitlilikte ortaya çıkmaktadır. Biyoçeşitlilik, bakteriler, mantarlar, bitkiler ve tek hücreli organizmaların mükemmel bir karışımından oluşan karmaşık bir yapıdır. Biyoçeşitliliği oluşturan tüm organizmalar ekosistemlerin canlı unsurlarıdır ve bu organizmalar gezegendeki yaşamın devamlılığını sağlar. Doğallaştırılan bu türler, istilacı karakterleri ile bölgede bulunan yabani bitki türlerini yok ederler. Sadece belirli türlerle yetinmeyip tüm organizma topluluğunu yok edebilirler. Doğallaşmış istilacı türler, bulundukları ekosistemin normal süksesyon aşamalarını değiştirme eğilimindedir ve uzun vadede ekosistem üzerinde etkilidir. Doğallaştırılmış istilacı bitki türleri bölgede var olan yabani türleri ortadan kaldırır. Sadece belirli türlerin yerini almakla kalmazlar. Tüm organizma topluluğunu yok edebilirler. Doğallaşmış istilacı bitki türleri, bulundukları ekosistemdeki süksesyon aşamalarını değiştirme eğilimindedir ve uzun vadede ekosistem üzerinde etkiye sahiptir (Akbulut ve Karaköse, 2018).

Mevcut Kontrol Yöntemleri Ve Sınırlamaları

İstilacı süs bitkilerinin kontrolü ve yok edilmesi teknik olarak zor, genellikle karmaşık ve maliyetlidir. İstilacı bitkilerin yayılmasıyla başa çıkmak için mevcut yönetim teknikleri aşağıdaki yöntemlerden herhangi birini veya bunların bir kombinasyonunu içerir: mekanik veya fiziksel uzaklaştırma, herbisit uygulaması ve biyolojik kontrol. Ancak bu yöntemler istilacı süs bitkileri için etkisiz veya uygulanamaz olabilir. Bazı istilacı bitkileri ortadan kaldırmak için elle çekme, çapalama, sürme, biçme, parçalama, kök çekme (güçle sürme), zincirleme ve buldozerleme gibi mekanik uzaklaştırma yöntemleri kullanılmıştır. Ancak Japon kızamığı ve çok çiçekli gül (Rosa multiflora) gibi yaygın istilacı süs bitkisi türleri için bu yöntemlerin uygulanması genellikle çok pahalı veya pratik değildir. Amerika Birleşik Devletleri'nde otlatılan meraların çoğunda yabancı ot kontrolünün birincil yöntemi kimyasal mücadele olsa da, herbisitler genellikle kirliliğe neden olur ve hedef olmayan türlere zarar verebilir. Herbisitler seçici olmayabilir ve tek çeneklilerin ve kelebek çalısı (Buddleia davidii) gibi tabanından hızla yeniden kurulabilen bazı iki çenekli süs bitkilerinin kontrolünde etkisiz olabilir (University of Florida IFAS Extension, 2004).

Faydalı böcekler veya mikrobiyal patojenlerin kullanıldığı biyolojik kontrol kapsamlı bir şekilde değerlendirilmiş ve bazı istilacı bitkileri kontrol etmek için başarıyla kullanılmaktadır. Ne yazık ki, biyolojik kontrol şu anda çoğu istilacı bitki için mevcut değildir ve bazı biyolojik kontrol ajanları seçici olmamaları nedeniyle istilacı süs bitkilerine uygulanamayabilir. Örneğin, multiflora gülüne saldıran yerel bir virüs potansiyel bir biyolojik kontrol ajanı olarak önerilmiştir. Multiflora gülü, ılıman Amerika Birleşik Devletleri'nin çoğunda istilacıdır. Başlangıçta süs bitkisi olarak ve otlayan sığırları meralarda ve çiftlik evlerinden uzak tutmak için "canlı çit" olarak tanıtılmıştır. Multiflora gülü agresif bir şekilde büyür ve kuşburnu ile beslenirken kuşlar tarafından dağıtılan çok sayıda tohum üretir. Bu istilacı çalı, birçok yerli bitkiyi dışlayan yoğun çalılıklar üretir (National Park Service, 2004). Ancak yerli virüs, ticari değeri olan diğer gülleri de enfekte ettiği ve gül endüstrisine önemli zararlar verebileceği için multiflora gülünün yayılmasını kontrol etmek için kullanılmamıştır. Virüsün ayrıca elma ve bazı çilek türleri gibi gülle akraba olan ekonomik açıdan değerli diğer bitkileri de enfekte ettiği tespit edilmiştir (Szafoni, 1991).

Kimyasal uygulama, ağaçların köklerinden kesilmesi ve hızla meydana gelen küçük dallara herbisit uygulanması yoluyla gerçekleştirilir. Kimyasal mücadelede en yaygın ve başarılı olan herbisitlerden biri 2,4-D’dir. Ayrıca, eğer genç bitki fideleri ve küçük dallar sayıca fazla veya yoğun değilse, bunların elle sökülmesi yöntemini kullanarak mekanik mücadele yöntemi gerçekleştirilebilir (Petrova ve ark., 2013).

TÜRKİYE’DE KULLANILAN BAZI İSTİLACI SÜS BİTKİLERİ

Türkiye, dünya üzerindeki coğrafi konumu ve iklim çeşitliliği sayesinde oldukça zengin ve özgün bir floraya sahip bir ülkedir. Avrupa ve Güneydoğu Asya floraları arasında bir köprü işlevi gören Türkiye, aynı zamanda üç farklı floristik bölge olan Avrupa-Sibirya, İran-Turan ve Akdeniz bölgelerinin kesişim noktasında yer alır. Akdeniz, Karadeniz ve Karasal iklimlerin etkisi altında olan Türkiye, her bir iklim tipine özgü bitki örtüleriyle büyük bir biyolojik çeşitliliğe ev sahipliği yapmaktadır (Karaer ve ark., 2015).

Yapılan araştırmalar sonucunda, Türkiye’deki bitki çeşitliliği 12.816 taksona ulaşmış olup, bunların 4.040’ı (%33,15) endemik türlerden oluşmaktadır (Özhatay ve ark., 2017). Türkiye’nin yabancı florası 340 takson içerirken, bunların 321’i kapalı tohumlular, 17’si açık tohumlular ve 2’si eğrelti otlarıdır. Ayrıca, Türkiye’deki yarı doğal habitatların neredeyse tamamı, doğallaşma kapasitesine sahip yabancı taksonlar tarafından istilaya uğramaktadır (Uludağ ve ark., 2017). Küresel İstilacı Türler Veri Tabanı (GISD), Türkiye’de yaygın olarak bulunan 19 farklı istilacı yabancı bitkiyi bildirmiş ve bu türlerin ekosistem sağlığı açısından tehdit oluşturduğunu belirtmiştir (Atasoy ve Çorbacı, 2018). Küreselleşen dünyada seyahat ve ticaretin de küreselleşmesi, doğal olmayan bu türlerin dünyanın çeşitli bölgelerinde yeni dağılım alanları bulmasına olanak sağlamaktadır (Wagner ve ark., 2017).

İstilacı özellikleri barındıran birçok süs bitkisi, yalnızca dünyada değil, Türkiye'de de yaygın bir şekilde kullanılmaktadır. Ancak, Amerika ve Avrupa'da bu istilacı bitkilerin oluşturduğu tehdit nedeniyle, pek çok bitkinin ülkeye girişi ve kullanımı yasaklanmış veya kısıtlanmıştır. Bu durum, kentsel alanlardan doğal alanlara sıçrayarak ekosistemlere zarar verme potansiyeline sahip bitkilerin tespit edilmesi ve kontrol edilmesi gerektiğini göstermektedir. Türkiye'de son yıllarda, şehirlerin gelişimine paralel olarak tasarlanan yeşil alanlarda süs bitkisi kullanımında artış gözlemlenmektedir. Bu duruma bakıldığında bitkilerin çoğu egzotik olması ve bu egzotik bitkilerin barındırdığı olumsuz özellikler yeterince dikkate alınmamaktadır. Böylece, istilacı olan bu süs bitkilerinin dikkatsizce kullanılmasının gelecekte ekolojik ve ekonomik sorunlar yaratabileceği düşünülmektedir (Nedir, 2019).

Tablo 1: Türkiye’de kullanılan bazı istilacı süs bitkileri (Nedir, 2019).

S.	Bilimsel Adı	Türkçe Adı	İngilizce Adı	Familya	Formu
1	Acacia dealbata Link.	Gümüşi akasya,	Acacia bernier	Fabaceae	Ağaç
2	Acer negundo L.	Dişbudak yapraklı akçaağaç	Box elder	Sapindaceae	Ağaç
3	Acer pseudoplatanus L.	Dağ akçaağacı	Sycamore Maple	Sapindaceae	Ağaç
4	Albizia julibrissin Durazz.	Gülibrişim	Silktree	Fabaceae/ Leguminosae	Ağaç
5	Ailanthus altissima(Miller) Swingle	Kokar ağaç	Tree of heaven	Simaroubaceae	Ağaç
6	Berberis thunbergii DC.	Japon kadıntuzluğu	Japanese barberry	Berberidaceae	Çalı
7	Broussonetia papyrifera(L.) L’Hér. Ex Vent.	Acem dutu, Kâğıt dutu	Paper mulberry	Moraceae	Ağaç
8	Buddleja davidii Franchet	Kelebek çalısı	Butterfly bush	Scrophulariaceae	Çalı
9	Lantana camara L.	Ağaç minesi	Lantana	Verbenaceae	Çalı
10	Lonicera japonica Thunb. ex Murray	Japon hanımeli	Japanese honeysuckle	Caprifoliaceae	Sarmaşık
11	Nandina domestica Thunb.	Cennet bambusu	Nandina	Berberidaceae	Çalı
12	Parthenocissus quinquefolia(L.) Planch.	Amerikan sarmaşığı	Virginia creeper	Vitaceae	Sarmaşık
13	Paulownia tomentosa (Thunb.) Steud.	Tüylü pavlonya	Princess tree Royal paulownia	Scrophulariaceae	Ağaç
14	Robinia pseudoacacia L.	Yalancı akasya	Black locust	Fabaceae/ Leguminosae	Ağaç

Bu çalışmada, kentsel yeşil alanlarda (kamusal ve özel alanlar dahil) süs bitkisi olarak kullanılan ve istilacı özellik gösteren 15 odunsu bitki türü (Tablo 1) belirtilmiştir (Nedir, 2019). Bu bağlamda belirtilen türlere istinaden Iğdır üniversitesi Şehit Bülent Yurtseven kampüsünde bulunan istilacı süs bitkileriin genel özellikleri, kullanım amaçları ve olası tehditlerine yönelik bilgiler verilerek bitkilendirme olanaklarına ilişkin çeşitli önerilerde bulunulmuştur.

Acer Negundo L.

A. negundo, yaklaşık yüksekliği 20 m'yi bulan ve 1 m'ye kadar gövde çapına ulaşan çok gövdeli bir ağaçtır. Sürgünler yeşil olup ikinci yılda menekşe rengine döner. Kabuğu gri-kahverengi olup koyu griye döner ve sığ çatlaklıdır. Tomurcuklar karşılıklı, küçük, 2-5 mm, iki pullu ve ipeksi beyaz renktedir. Yapraklar 15-35 cm uzunluğunda, 3-5 (7) yaprakçıklı, pinnat, açık yeşil fakat alt kısmı daha soluktur. Broşürler loblu ve tırtıklıdır. Broşür şekli değişkendir çifti 3 lobludur. Erkek çiçekler sarkık stamenli corymb'lerde doğarken dişi çiçekler küçük sarkık salkımlarda doğar. Her iki çiçek türü de küçük ve soluk sarımsı yeşil renktedir. Çiçeklerin bir kısmında stamenlerin varlığı ile pistilli çiçeklerin morfolojisinde çok fazla değişiklik vardır. Meyve, 60 dereceden daha az bir açıyla birbirinden ayrılan, 4 cm uzunluğa kadar iki kaynaşmış kanatlı samaradan meydana gelir. Samaralar döküldüğünde ayrılır ve tek bir buruşuk tohum içerir (Cabı, 2024).

Dişbudak yapraklı akçaağaç, güneşli ve gölgelik alanlarda kolayca yetişebilen, toprak bakımından fazla seçici olmayan bir ağaçtır. Ancak, en iyi gelişimini iyi drene olmuş, nemli topraklarda gösterir. Bu tür, güçlü sel baskınlarına ve belirli derecede kuraklığa karşı dayanıklıdır. Yayılış gösterdiği ve istila ettiği alanlarda çabuk büyür. Çoğunlukla yıkıntı alanlar, parklar, yol kenarları, nehir kıyıları ve taşkın yataklarında bulunur. Farklı ekolojik koşullarda yetişebilen bu ağaç, besin açısından fakir topraklarda bile güçlü bir yapı sergileyebilir. Ayrıca, güneşli ile gölgelik alanlar arasında, bozulmuş habitatlar, ormanlar, yol kenarları ve demiryolu alanlarında da yetişmesi mümkündür (Petrova ve ark., 2013).

Acer Negundo L., Kuzey Amerika ve tropik Güney Amerika'ya özgü bir ağaç türüdür ve 19. yüzyılın sonlarına doğru Avrupa'ya süsleme amacıyla getirtilmiştir. Çabuk büyümesi nedeniyle, özellikle demiryolu ve park ağaçlandırmalarında, aynı zamanda erozyon kontrolü sağlamak amacıyla tercih edilmiştir. Günümüzde, bu ağaç türü, birçok kentte parklar, yol kenarları, demiryolları ve kent ormanlarında süs bitkisi olarak yetiştirilmektedir. Ancak, rüzgarla yayılan tohumları, hedef dışı alanlara ulaşarak doğal ortamlarda yayılmakta ve bu alanları istila etmektedir. Bozulmuş ve insan etkisi altındaki habitatlarda, özellikle nehir, yol ve demiryolu kenarlarında kolayca yetişebilir. Ortama uyum sağladığında hızla yayılır, bu da yerel bitki örtüsünü tehdit ederek bu türlerin yayılmasını engeller. Türkiye'de, plansız bir şekilde yol ağaçlandırmaları, erozyon kontrolü ve süs bitkisi olarak tercih edilen bu bitki, biyolojik çeşitlilik açısından tehlike oluşturabilir. Bu nedenle, Acer Negundo'nun kullanımının ülkemizde sınırlanmalı ve kontrol altına alınmalıdır (Aksoy, 2015).

Görsel kalitesi ve Peyzaj açısından daha yüksek öneme sahip olan Acer negundo 'Flamingo' ve A. negundo 'Aureo-variegatum' gibi bazı kültüvarlar peyzaj sahalarında tercih edilmektedir. Iğdır Üniversitesi Şehit Bülent Yurtseven kampüsünde bu tür genel anlamda yol ağacı olarak tercih edilmiştir. Bitkinin yol ağacı olarak tercih edilmesi hem kaldırımlara hemde altyapıya zarar verebilir. Bu nedenle bitkisel tasarımada sınırlı sayıda tercih edilmeli ve kontrol altında olmalıdır.

Ailanthus Altissima (Miller) Swingle

Kokarağaç Simaroubaceae familyasına aittir. Çin ve Kuzey Vietnam'a özgü, Avrupa'da ve Antarktika hariç diğer tüm kıtalarda istilacı hale gelen bir ağaçtır. En çok kentsel habitatlarda ve ulaşım koridorları boyunca bol miktarda bulunur, ancak doğal habitatları da istila edebilir. Ailanthus, taşlı ve steril topraklardan zengin alüvyal tabanlara kadar geniş bir yelpazede antropojenik ve doğal alanlarda yetişir (Kowarik ve Säumel, 2007).

Bir bitkinin bir bölgeye girişi genellikle insanların bilinçli müdahalesiyle gerçekleşir. Süs bitkileri, erozyon kontrolü veya ağaçlandırma amaçlı ithal edilip dikilir. Ancak, bazı bitkiler, özellikle kokarağaç gibi hızlı çimlenen, çok sayıda tohum üreten ve gövde sürgünlerinden yeniden gelişebilen türler, bulundukları alanda hızla yayılabilir. Kokarağaç, rüzgarla taşınabilen milyonlarca tohum üreterek çevresindeki bölgelere hızla yayılır. Nehirlerin akışı ve yollardaki yoğun trafiğin de tohumların yayılmasını artıran faktörlerdendir. Bu bitki, toprağın işlenmesi, karıştırılması, tahrip edilmesi veya yangın gibi durumlara karşı dayanıklı olup, bu koşullarda daha da istilacı hale gelmektedir. Ayrıca kokarağacın çevreye olumsuz etkileri, sağlık ve güvenlik tehditleri ile estetik sorunlar oluşturduğu da gözlemlenmektedir. Bu bitki, yayılmaya başladığı alanlarda toprağı kalın bir örtüyle kaplayarak yerli bitki türlerinin yok olmasına neden olmaktadır. Özellikle Akdeniz adalarında kokarağacın istilası, tür çeşitliliğini %24 oranında azaltmıştır. Ekosistem hizmetleri, tarım, hayvanlar ve insanlar üzerinde büyük etkiler yaratmaktadır. Türkiye'de kokarağaç, sadece tarihî alanlar ve orman kenarları gibi tarım dışı alanlarda değil, tarım alanlarında mesela Iğdır'da bazı meyve bahçelerinde fazla sayıda görülmektedir. Bu nedenle, bitkinin yayılmasını kontrol altına almak için yakma, biçme ve ilaçlama gibi yöntemler uygulanması gerekebilir. Kesim sonrası hızlıca çoğalabilen sürgünler nedeniyle mekanik mücadele önemlidir. Dünyada kokarağaç, erozyon kontrolü, gölgeleme ve süs bitkisi olarak kullanılan bir türdür ve Türkiye'de de bu amaçlarla dikilmektedir. Ancak, bu türün hızla yayılması, ekosistemi bozarak büyük sorunlar yaratabilir. Kuzey Kıbrıs Türk Cumhuriyeti'nde 1995'teki büyük yangın sonrası yeniden ağaçlandırmada tercih edilen türlerden biri olmuştur. Ancak, ekosistem üzerindeki potansiyel zararı göz önünde bulundurulmadan bu bitkinin dikimine devam edilmesi, ilerleyen yıllarda daha büyük sorunlara yol açabilir. Kokarağaç, zayıf topraklarda ve stresli ortamlarda hızla büyüyebilmesi nedeniyle hızla yayılabilir ve bu durum, ilerleyen yıllarda Türkiye için büyük bir çevresel tehdit oluşturabilir (Uludağ, 2015). Süs bitkilerinin arasına karışarak peyzaj sahalarını olumsuz şekilde etkilemektedir. Her toprak ve rakımda hızla büyüyebilen bu ağaç farklı problemleri çözmekde uygun tür olsa da Kokarağaç bir alana yerleştikten sonra mücadelesi çok zordur. Kök sisteminin ve sürgünlerin yok edilmesi gerekmektedir. Süs bitkisi olarak kullanırken dikkat etmek belli alanlarda kullanmak önerilir. Iğdır Üniversitesi Şehit Bülent Yurtseven kampüsünde bu tür peyzaj sahasında kullanılmamış fakat dere kenarında kendiliğinden çoğalarak yıllarca kapladığı alan giderek artmaktadır.

Berberis Thunbergii DC.

Anavatanı Japonya olan B. thunbergii, 60-190 cm yüksekliğe gelişim gösteren, kavisli dallara sahip, çok yıllık, kompakt, odunsu çok sayıda saplı, alternatif, hafif mavimsi yeşil ila yeşil ila koyu kırmızımsı mor, kama şeklinde, dişsiz yaprakları olan bir çalıdır. Nisan sonu veya mayıs aylarında üretilen sarı çiçekler, 6 mm genişliğinde, uzun salkımlar halinde, daralmış şemsiye benzeri kümeler halinde veya bazen tek başına büyüyen bir bitkidir. Çiçeklerin, görünüm olarak dört sepal'e benzeyen, ancak genellikle sepal'lerden daha küçük olan ve her birinin tabanında iki bez bulunan altı yaprağı vardır. Çiçekler biseksüeldir ve dalların alt kısımları boyunca sarkık kümeler halinde gelişim gösterirler. Meyveler oval, kuru veya az sulu fakat sert meyvelerdir, kırmızı renktedir, 8-13 mm uzunluğundadır, kışa kadar kalıcıdır (Cabı, 2024).

Berberis thunbergii, estetik açıdan dikkat çeken yaprakları ve grup halinde kullanıldığında sağladığı görsel etki ile peyzaj uygulamalarında öne çıkar. Görünümünün yanı sıra, budanabilmesi sayesinde geçirimsiz çit formlarında da başarılı bir şekilde kullanılabilir. Küçük ve büyük ölçekli parklarda, refüjlerde, konut bahçelerinde, kentsel alanlarda, kampüslerde ve millet bahçelerinde formu ve yapraklarının güzelliği ile özellikle gruplar halinde kullanılmasıyla oldukça etkili bir türdür. Sık dokusu ve budama imkânı sayesinde çit bitkisi olarak sıkça tercih edilir. Ayrıca, sürgünlerinin dikenli yapısı sayesinde geçirimsiz çitler oluşturma yeteneği de sunar (Pulatkan ve ark., 2018).

Berberis thunbergii Türkiye'de istilacı tür olarak bilinmesede, yoğun kullanımı ile meyve veya tohumların kuşlar tarafından dağılmasıyla peyzaj ve doğal alanlarını tehdit edebileceği tahmin edilmektedir. Bu nedenle sınırlı şekilde kullanılmalıdır. Iğdır Üniversitesi Şehit Bülent Yurtseven kampüsünde guruplar halinde ve şev alanlarında toprak kaymalarını önlemek için peyzaj alanlarında tercih edilmiştir.

Buddleja Davidii Franchet
Buddleja davidii Franchet bahçelerde ve bozulmuş alanlarda yaşayan çok yıllık, yarı yaprak döken, çok gövdeli bir çalıdır. B. davidii, 1800'lerin sonlarında Çin'den Birleşik Krallık'a getirilmesinden bu yana bahçecilik ve insan kültürünün önemli bir bileşeni haline gelmiştir. Bir peyzaj bitkisi olarak popülerliğine rağmen B. davidii, bahçelerin dışında doğallaşma ve çok çeşitli fiziksel koşullarda bozulmuş doğal alanları hızla istila etme ve domine etme yeteneği nedeniyle sorunlu kabul edilmektedir (Tallent-Halsell, 2009). Kelebek çalısının çiçek salkımları, 30 cm uzunluğa kadar uzayabilen belirsiz korymboz salkımları halinde düzenlenmiş dalların terminal ucunda görünür. Doğadaki hermafrodit çiçekler genellikle lila ve mor renkteyken çeşitlerin çiçekleri beyazdan sarı ve kırmızıya kadar değişir. Yaprakların üst yüzeyi koyu yeşil ve tüysüzdür oysa alt yüzeyi beyaz-kaba tüylüdür yıldız şeklinde ve salgılı tüylere sahiptir (Cabı, 2024).
Fazla bakım gerektirmemesi güzel çiçekleri ve kelebekleri üzerine çekmesiyle peyzaj değeri yüksektir. Kültüvarının çok sayıda olması ve bahçelerde kullanılması istila riskini arttırmaktadır. Hızlı büyümesi ve uzun ömürlü olmasından dolayı alt yapı ve ekosistem değişikliğini engellemek için daha fazla dikkat edilmesi gerekir. Iğdır Üniversitesi Şehit Bülent Yurtseven kampüsünde gurup halinde dikilmiş çiçekleri ve görselliğinden fayda sağlamak amaçlanmıştır.

Robinia pseudoacacia L.
Yalancı akasya Kuzey Amerika menşeli, kışın yaprak döken ve baklagiller (Fabaceae) familyasından olan bir ağaçtır. Genellikle 12-18 m arasında boylanırken, bazı örnekleri 35 m kadar uzanabilir. Gövde çapı 30-75 cm arasında değişir, ancak 1 metreyi aşan ağaçlar da tespit edilmiştir. Kök ve gövde sürgünlerinden hızla çoğalabilen bu ağaç, toprak altında uzayan kökleriyle güçlü bir kök sistemi oluşturur ve kökleri, ağaç boyundan daha geniş bir alana yayılabilir. Köklerinde azot bağlayan bakteriler bulunur. Yalancı akasya, orman ve ağaçlandırma projeleri gibi çeşitli amaçlarla yetiştirilmekte ve farklı çeşitleri geliştirilmiştir. Anavatanı kesin olmamakla birlikte, ABD'nin güneydoğusu olarak kabul edilir. Bu tür, orijinal bölgesinin dışında Kanada'nın güneyi de dâhil olmak üzere Kuzey Amerika'nın birçok bölgesinde doğallaşmış ve geniş bir yayılım alanı oluşturmuştur. Taze fidanların düz ve yeşil kabuklarının aksine, yaşlı ağaçların kabuğu derin yarıklarla pürüzlü ve koyu grimsi kahverengi tonlarındadır. Küçük dalları ve özellikle sürgünleri, kıl şeklinde dikenli kulakçıklara sahiptir. Yalancı akasya, genellikle alt kısımlardan dallanarak, kapalı bir orman yapısı oluşturduğunda dallanma sadece üst kısımlarda devam eder. Yaprakları karşılıklı dizilmiş olup, 7-21 yaprakçıktan oluşan bileşik yapraklardan meydana gelir. Yaprakçıklar ince, elipsimsi, tüysüz olup, üst kısmı daha koyu yeşil, alt kısmı ise daha açık renklidir. Çiçekleri beyazdan sarıya kadar değişen renkte olup, 15-20 mm çapında ve 16-20 cm uzunluğundaki salkımlarda yer alır. Her baklada 4-8 arasında tohum bulunur ve baklalar 5-10 cm uzunluğunda, parlak, pürüzsüz ve ince yapılıdır (Uludağ, 2015).
Yalancı akasya, çevresel strese karşı yüksek uyum yeteneği ve geniş alan toleransı ile dikkat çeker ve deniz seviyesinden 1600 m kadar farklı yüksekliklerde yetişebilir. En iyi gelişimini, deniz seviyesinden 300 mm civarında yağış alan yerlerde gösterirken, 1000 m ve üzerindeki bölgelerde daha fazla yağışla daha verimli büyür. Bu ağaç türü, yazları sıcak, kışları ise sert olan kara iklimlerinde ve soğuk donlardan etkilenmeden yetişebilir. Işığa olan yüksek ihtiyacı ve hızlı büyüme eğilimi ile bilinir. Nehir kenarları ve sulak alanlarda en iyi gelişimini

gösteren yalancı akasya, kuraklığa karşı oldukça hassastır (Burner ve ark., 2005; Danso ve ark., 1995).
Robinia pseudoacacia L., Türkiye'ye Cumhuriyetin ilk yıllarında süs bitkisi olarak getirilmiş ve o zamandan beri yol kenarlarında, okul bahçelerinde, kışlalarda, tren istasyonlarında ve köy ağaçlandırmalarında değerlendirilmiştir. Bu sebeple, "Cumhuriyet Ağacı" olarak da bilinir. Ülkenin çeşitli bölgelerinde ise bu ağaç, "Diken Ağacı" ve "Salkım Ağacı" gibi farklı adlarla da anılmaktadır (Turna ve Turna, 2000; Kayacık, 1982).
İstenilen şekilde budanabilen bu tür kentsel alanlarda fazla sayıda tercih edilir. Bu türün üreme potansiyeli yüksek olmasına rağmen peyzaj alanlarında fazla kullanılması ekosistem değişikliğine neden olmakta ve yerel türlerin kullanılmasını kısıtlamaktadır. Egzotik ve istilacı türlerin kentsel olguyu negatif yöndeki etkilerini azaltmak için kullanıcılar ve peyzaj mimarlarının doğal türleri daha çok tercih etmeleri gerekmektedir. Iğdır Üniversitesi Şehit Bülent Yurtseven kampüsünde Robinia pseudoacacia L."Umbraculifera", Robinia hispida L., Robinia pseudoacacia L. yol ağaçlandırması ve sınırlandırma için kullanılmıştır. Akasyanın kampüsde sürekli istilacı olduğu özellikle çim alanlarında fazla sayıda çoğaldığı ama çimlerin düzenli şekilde biçilmesi sayesinde kontrol altına alındığı tespit edilmiştir.

Parthenocissus quinquefolia (L.) Planch.
Vitaceae familyasına ait olan virginia sarmaşığı, bazen ağaç asması, çalılık sarmaşığı, Amerikan sarmaşığı ve beş yapraklı sarmaşık olarak da anılır. Ağaçların tepelerine veya duvarlara 15 m veya daha fazla ulaşabilen yaprak döken odunsu bir sarmaşıktır. Tekli veya çoklu gövdeler ince, yuvarlak, açık kahverengidir ve belirgin merceklere sahiptir. Genç büyüme kırmızımsıdır. Sarmaşıklar, fincan benzeri, yapışkan uçlarla biten beş ila sekiz dallı dallar vasıtasıyla yüzeylere yapışır. Alternatif yapraklar beş (bazen üç veya dört) yaprakçıklı palmiye şeklinde bileşiktir. Yaprakçıklar mızrak şeklinde, mızraksı veya obovat, 3 ile 15 cm uzunluğunda ve 1,6 ila 8 cm genişliğinde olup kenarları tek veya çift tırtıklıdır. Yaprak sapları 15 ila 20 cm uzunluğundadır ve yaprakçıkların belirgin petiolleri vardır. Küçük, yeşilimsi beyaz, oyuncak sarımsı yeşil çiçekler, yaprakların altına yerleştirilmiş terminal simalar veya salkımlar halinde doğar. Meyveleri, tepesi biraz yassılaşmış, 4 ila 6 mm çapında, mavimsi siyah renkte ve olgunlaştığında belirgin bir çiçeklenme gösteren meyvelerdir. Meyveler genellikle iki ile üç tohum içerir (Francis, 2004). İyi bir şekilde kurulduktan sonra Virginia sarmaşığı hızla büyür. Süs ortamlarında kontrolden çıkmasını önlemek için genellikle budanması gerekir. Yakındaki çiçek tarlalarına ve yabani alanlara tohumlanabilir. Virginia sarmaşığı ahşap kaplamalı binalara tırmanmak için dikilmemelidir çünkü sökülmesi zordur ve nemi artırarak çürümeyi hızlandırır (Gilman, 1999). Iğdır Üniversitesi Şehit Bülent Yurtseven kampüsünde duvar kenarlarına dikilmiş duvarlardaki kötü görüntüyü kapatmak hedeflenmiştir.

SONUÇ VE TARTIŞMA

Kentsel alanlar biyolojik çeşitlilik açısından fazlasıyla zengin alanlardır. Bu alanların korunması, türlerin yaşam statülerinin korunup sürdürülebilirliğinin sağlanması amacıyla önem taşımaktadır. Bu bağlamda kentsel alanlarda biyoçeşitliliğin korunması için istilacı türlerin kontrol altında olması hatta bitkisel tasarım sırasında tercih edilmemelidir.
Çok sayıda tercih edilen yerli olmayan süs bitkisi istilacıdır veya potansiyel olarak istilacıdır. Bu bitkiler ekosistemimize ciddi zararlar verebilir. Ancak yeni ithalatın tamamen yasaklanması ve istilacı ve istilacı olma potansiyeli taşıyan tüm süs bitkilerinin kullanımının tamamen yasaklanması sosyal, politik ve ekonomik açıdan mümkün olmamaktadır. İstilacı süs bitkilerinin yayılmasını kontrol etmeye yönelik mevcut yöntemler etkisiz, teknik açıdan zor ve pahalı olabilmektedir. Ekonomik açıdan önemli süs bitkilerinin steril formlarının geliştirilmesi, istilacılığı cinsel üremeye bağlı olan egzotik süs bitkilerinin istilacı sorununu

çözmek için mükemmel bir alternatif sunabilir. Steril bitkiler, peyzaj veya süs amaçlı olarak yetiştirilebilir ve kullanılabilir; bu sayede bu bitkilerin cinsel olarak çoğalması ve istilacı hale gelmesi ihtimali neredeyse tamamen ortadan kaldırılır. Ayrıca, şu anda piyasada mevcut olan veya piyasaya sürülmesi muhtemel olan, ekonomik açıdan önemli süs bitkilerinin steril çeşitlerinin gen transferi aracılı üretimi için çok sayıda moleküler araç kullanılabilir.
İstilacı türlerin kapsamı ve etkisi iklim değişikliği ile daha da artacak ve yerli olmayan türler ile insan aracılı diğer stres faktörleri arasındaki sinerjiler daha sık görülecektir. Bu nedenle kentsel peyzaj alanlarında kullanılan bitkilerin istilacı olarak tanımlanıp tanımlanmadığı bilinmelidir. Bu konuda peyzaj mimarlarına ve süs bitkisi yestiştiricilerine önemli görevler düşmektedir. Ayrıca bu türler hernekadar tercih edilse dahi kullanım alanları ve kullanım yoğunluğu iyi planlanmalıdır. Yabancı süs bitkilerinin istilası, yerli türlerin yer değiştirmesi, habitatın değişmesi ve ekosistem işlevlerindeki değişiklikler dahil olmak üzere önemli ekolojik etkilere sahip olabilir. Bu konuyu ele almak, önleme, erken tespit, hızlı müdahale ve uzun vadeli yönetim stratejilerini içeren çok yönlü bir yaklaşımı gerektirir. İşte bazı etkili çözümler:

Önleme

Düzenleme ve Mevzuat: İstilacı süs bitkilerinin ithalatını ve satışını kısıtlayan yasaları uygulamak. Kamuoyunu Bilinçlendirme Kampanyaları: Halkı ve bahçecilik endüstrisini istilacı bitkilerin riskleri konusunda eğitin ve yerli veya istilacı olmayan türlerin kullanımını teşvik etmek. Bahçecilikte En İyi Uygulamalar: İstilacı türlerin yayılmasını önlemek için bahçıvanlar, peyzajcılar ve perakendeciler arasındaki en iyi uygulamaları teşvik etmek.

Erken Tespit ve Hızlı Müdahale (EDRR)

İzleme Programları: Fidanlıklarda, bahçelerde ve doğal alanlarda istilacı süs bitkilerinin varlığını izlemeye yönelik programlar oluşturmak. Vatandaş Bilimi: Gönüllülerin potansiyel istilacı türlerin görüldüğünü bildirme sürecine katılımını teşvik etmek. Hızlı Müdahale Ekipleri: Yeni istilalara daha ortaya çıkmadan önce hızlı bir şekilde müdahale edebilecek ve onları ortadan kaldırabilecek ekipler oluşturmak.

Mekanik Kontrol

Elle Kaldırma: Yeniden büyümeyi önlemek için istilacı bitkileri kökleri de dahil olmak üzere fiziksel olarak çıkarmak. Bu emek yoğun olabilir ancak küçük istilalar için etkili olabilir. Biçme ve Kesme: İstilacı bitkileri üreme ve yayılma yeteneklerini azaltmak için düzenli olarak biçmek veya kesmek.

Kimyasal Kontrol

Herbisitler: İstilacı bitki popülasyonlarını kontrol etmek için hedefe yönelik herbisit uygulamalarını kullanmak. Çevresel etkiyi en aza indirmek için herbisitlerin dikkatli kullanılması önemlidir. Entegre Zararlı Yönetimi (IPM): Daha sürdürülebilir bir yaklaşım için kimyasal tedavileri diğer kontrol yöntemleriyle birleştirmek.

Biyolojik Kontrol

Doğal Düşmanlar: Yerli türlere zarar vermeden özellikle istilacı bitkileri hedef alan doğal yırtıcıları, patojenleri veya otçulları tanıtmak. Bu yaklaşım, istenmeyen sonuçlardan kaçınmak için kapsamlı bir araştırma gerektirir. Biyokontrol Ajanları: Zamanla istilacı süs bitkilerinin popülasyonunu azaltabilecek biyokontrol ajanlarını geliştirmek ve serbest bırakmak.

Restorasyon ve Rehabilitasyon

Yerli Türlerle Yeniden Dikim: İstilacı bitkilerin kaldırılmasından sonra, doğal ekosistemi onarmak ve yeniden istilayı önlemek için alanı yerli türlerle yeniden dikmek. Habitat Restorasyonu: Gelecekteki istilalara karşı dayanıklılığı artırmak için bozulmuş habitatları onarmak.

Araştırma ve İzleme

Sürekli Araştırma: İstilacı süs bitkilerinin ekolojisini daha iyi anlamak ve daha etkili kontrol yöntemleri geliştirmek için araştırma yapmak. Uzun Vadeli İzleme: Yönetim çabalarının başarısını değerlendirmek ve stratejileri gerektiği gibi ayarlamak için uzun vadeli izleme uygulamak.
Toplumsal Katılım ve İşbirliği
Paydaş Katılımı: İstilacı bitkileri kontrol etme çabalarına yerel toplulukları, arazi sahiplerini, koruma gruplarını ve devlet kurumlarını dahil etmek. İşbirlikçi Çabalar: İstilacı süs bitkilerinin yönetimine yönelik kaynakları, bilgiyi ve stratejileri paylaşmak için farklı paydaşlar arasında işbirliğini teşvik etmek.
Ekonomik Teşvikler
Sübvansiyonlar ve Teşvikler: İstilacı bitkilerin kaldırılması ve peyzajda yerli veya istilacı olmayan alternatiflerin kullanılması için ekonomik teşvikler sağlamak. Pazar Temelli Yaklaşımlar: Yerli bitkiler için pazarlar geliştirmek ve bunların süs bahçeciliğinde kullanımını teşvik etmek. Bu çözümlerin uygulanması yerel, bölgesel ve ulusal düzeyde koordineli çabalar gerektirir. Yabancı süs bitkilerinin istilasını etkili bir şekilde yönetmek için stratejilerin sürekli değerlendirilmesi ve uyarlanması çok önemlidir.

KAYNAKLAR

Akça, Ş. B., & Gülgün Aslan, B. (2019). Kampüs Yaşamında Estetik ve Fonksiyonel Açıdan Süs Bitkilerinin Yeri ve Önemi; Çaycuma Kampüsü Örneği. Bartın Orman Fakültesi Dergisi, 21(2), 267-279. https://doi.org/10.24011/barofd.526537

Akbulut, S., & Karaköse, M. (2018). Some natural and exotic invasive plant species in Turkey. Science, Ecology and Engineering Research in the Globalizing World (I. Christov, E. Strauss, A.-A. Gad & I. Curebal, eds.). St. Kliment Ohridski University Press, Sofia, 194-203.

Aksoy N., 2015. Acer negundo L. S: 143-147. Türkiye İstilacı Bitkiler Kataloğu.

Atasoy, M. & Corbaci, O. (2018). The Invasive Alien Plants of Turkey A Checklist and Environmental Hazards. Journal of Applied Environmental and Biological Sciences. 8.1-8.

Burner, D. M., Pote, D. H., & Ares, A. (2005). Management effects on biomass and foliar nutritive value of Robinia pseudoacacia and Gleditsia triacanthos f. inermis in Arkansas, USA. Agroforestry Systems, 65, 207-214.

Cabı (2024). Acer Negundo L. https://www.cabi.org/isc/datasheet/8808, Erişim Tarihi: 25/03/2024.

Cabı (2024). Berberis thunbergii. https://www.cabi.org/isc/datasheet/8808, Erişim Tarihi: 21/03/2024.

Cabı (2024). Buddleja davidii. https://www.cabi.org/isc/datasheet/10314, Erişim Tarihi: 21/03/2024.

Callaway, R. M., & Aschehoug, E. T. (2000). Invasive plants versus their new and old neighbors: a mechanism for exotic invasion. Science, 290(5491), 521-523.

Çorbacı, Ö. L., Ekren, E., & Atasoy, M. (2022). Rize Kentsel Açık Yeşil Alanlarındaki İstilacı Bitki Türleri Üzerine Bir Araştırma. Journal of Anatolian Environmental and Animal Sciences, 7(2), 156-162. https://doi.org/10.35229/jaes.1085042

Danso, S.K.A., Zapata, F. and Awonaike, K.O. 1995. Measurement of biological N2 fixation in field-grown Robiniapseudoacacia L. Soil Biol. Biochem., 27: 415–419.

Francis, J. K. (2004). Parthenocissus quinquefolia (L.) Planch. Virginia creeper. Wildland Shrubs of the United States and Its Territories: Thamnic Descriptions: Volume, 532.

Gilman, E.F. 1999. Parthenocissus quinquefolia. Fact Sheet FPS-454. Cooperative Extension Service, University of Florida, Gainesville, FL. 3 p.

Hall, M. (2000). IPlants: Invasive Plants and the Nursery Industry (Doctoral dissertation, Brown University).

Karaer, F., Kutbay, H. G., & Terzioğlu, S. (2015). Invasive Plants Biodiversity of Turkey, Factors affecting and necessary Measures required. Turkish Journal of Weed Science, 18(1), 24-32.
Kayacık, H. 1982. Ormanve Park Ağaçlarının Özel Sistematiği Angiospermae (Kapalı tohumlular) III. Cilt. I.Ü. Orman Fakültesi Yayınlarından Yayın No. 821.
Kayacetin, F. (2020). Botanical characteristics, potential uses, and cultivation possibilities of mustards in Turkey: a review. Turkish Journal of Botany, 44(2), 101-127.
Kowarik, I., & Säumel, I. (2007). Biological flora of central Europe: Ailanthus altissima (Mill.) swingle. Perspectives in Plant Ecology, Evolution and Systematics, 8(4), 207-237.
National Park Service. 2004. Plant invaders of Mid-Atlantic natural areas > shrubs > multiflora rose.
Nedir, İ. T. Kentsel Peyzajda Kullanılan Bazı İstilacı Süs Bitkileri; Türkiye'den Örnekler. Scientific Developments, 174.
MacDougall, A. S., & Turkington, R. (2005). Are invasive species the drivers or passengers of change in degraded ecosystems? Ecology, 86(1), 42-55.
Morse, L. E. , Kartesz, J. T. and Kutner, L. S. 1995. " Native vascular plants " . In Our Living Resources: A Report to the Nation on the Distribution, Abundance, and Health of U.S. Plants, Animals and Ecosystems, Edited by: LaRoe, E. T. , Farris, G. S. , Puckett, C. E., Doran, P. D. and Ma, M. J. 205 – 209. Washington, DC : U.S. Department of the Interior, National Biological Service.
Önen, H. (2015). Türkiye istilacı bitkiler kataloğu, T.C. Gıda, Tarım ve Hayvancılık Bakanlığı, Tarımsal Araştırmalar ve Politikalar Genel Müdürlüğü, Bitki Sağlığı Araştırmaları Daire Başkanlığı, Ankara, 533s.
Özhatay N., Kültür Ş., Gürdal B. (2017). Check-list of Additional Taxa to the Supplement Flora of Turkey VIII. Journal of Faculty of Pharmacy of Istanbul University, 47(1): 30-44. https://doi.org/10.5152/IstanbulJPharm.2017.006
Petrova, A., Vladimírov-Hurban, V., & Georgiev, V. (2013). Invasive alien species of vascular plants in Bulgaria. Sofia, Bulgaria: Institue of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences.
Pımentel, D., LACH, L., Zunıga, R., & Morrıson, D. (1999). Costs of Nonindīgenous Species.
Pimentel, D., Lach, L., Zuniga, R. & Morrison, D. (2000). Environmental and economic costs of nonindigenous species in the United States. Bioscience, 50, 53-65.
Pulatkan, M., Yıldırım, N., & Şahin, E. K. (2018). Farklı hormon uygulamalarının Berberis thunbergii "Atropurpurea Nana" çeliklerinin köklenmesi üzerine etkisi. Turkish Journal of Forestry, 19(4), 386-390.
Reichard, S. H., & White, P. (2001). Horticulture as a pathway of invasive plant introductions in the United States: most invasive plants have been introduced for horticultural use by nurseries, botanical gardens, and individuals. BioScience, 51(2), 103-113.
Uludağ A., 2015. Ailanthus altissima L. S: 148-155. Türkiye İstilacı Bitkiler Kataloğu.
Uludağ A., Aksoy N., Yazlık A., Arslan Z. F., Yazmış E., Üremiş I., Cossu T.A., Groom Q., Pergl J., Pysek P., Brundu G. (2017). Alien Flora of Turkey: Checklist, Taxonomic Composition and Ecological Attributes. NeoBiota, 35: 61–85.
University of Florida IFAS Extension. 2004. State Weed Board takes action on invasive plant that can harm reforestation efforts: popular butterfly bush added to noxious weed list. National Park Service 2004. Plant invaders of Mid-Atlantic natural areas > shrubs > multiflora rose.
Tallent-Halsell, N. G., & Watt, M. S. (2009). The invasive Buddleja davidii (butterfly bush). The Botanical Review, 75, 292-325.

Turna, İ. veTurna, H. 2000. Yalancı Akasya (Robinia pseudoacacia L.) Orjinlerinde Fidan Kalite Sınıflarının Belirlenmesi. Artvin Çoruh Üniversitesi Orman Fakültesi Dergisi 1(1):18-26. ISSN: 2146-1880

Vila, M., Basnou, C., Pysek, P., Josefsson, M., Genovesı, P., Gollasch, S., Nentwıg, W., Olenın, S., Roques, A., Roy, D., Hulme P. & Partneres, D. (2010). How well do we understand the impacts of alien species on ecosystem services? A panEuropean cross-taxa assessment. Front. Ecol. Environ., 8, 135-144.

Yi Li, Zongming Cheng, William A. Smith, Donna R. Ellis, Yongqin Chen, Xuelian Zheng, Yan Pei, Keming Luo, Degang Zhao, Quanhong Yao, Hui Duan & Qi Li (2004) Invasive Ornamental Plants: Problems, Challenges, and Molecular Tools to Neutralize Their Invasiveness, Critical Reviews in Plant Sciences, 23:5, 381-389, DOI: 10.1080/07352680490505123

Wagner, V., Chytrý, M., Jiménez-Alfaro, B., Pergl, J., Hennekens, S., Biurrun, I., ... & Pyšek, P. (2017). Alien plant invasions in European woodlands. Diversity and distributions, 23(9), 969-981.

Wilcove, D.S., Rothstein, D., Dubow, J., Phillips, A. & Losos, E. (1998). Quantifying threats to imperiled species in the United States. Bioscience, 48, 607- 615.

HARNESSING ECOLOGICAL PRINCIPLES FOR SUSTAINABLE AGRICULTURE

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Abstract:
Ecological agriculture aims to harness the inherent strengths of natural ecosystems and integrate them into modified agroecosystems designed for food and fibre production. This approach emphasizes three overarching strategies: first, the cultivation of resilient plants equipped with natural solid defence mechanisms; second, the strategic imposition of stress on pests to control their populations; and third, the active promotion of beneficial organisms that support plant health and ecosystem balance. Achieving these goals involves comprehensive habitat management that optimizes environments above ground and within the soil. Many practices that align with these strategies—such as the widespread use of cover crops, which enrich the soil and enhance Biodiversity, and reduced tillage methods that preserve soil structure and health—are well established and documented. However, their limited adoption in some regions prompts further investigation into the barriers that farmers face. Ecological agriculture's challenges are especially pronounced in economically disadvantaged countries, particularly in the Global South, where structural inequalities—such as unequal access to land and resources—hinder progress. Urgent action is needed to engage national governments in a renewed commitment to equitable and sustainable agricultural development in these regions. This paper explores the complexities of ecological diversity and sustainability within the farming sector, advocating for enhancing natural Biodiversity while laying the groundwork for long-term environmental sustainability. The chosen methodology for this exploration includes a thorough document analysis, aiming to answer a pivotal question: How can the principles of ecology not only survive but thrive within agricultural practices?
Keywords: Ecological Agriculture, Sustainable Agriculture, Agroecosystems, Food Production, Biodiversity, Habitat Management, Resilient Plants, Pest Control, Beneficial Organisms, Soil Health, Cover Crops, Reduced Tillage, Global South, Structural Inequalities, Agricultural Development, Natural Ecosystems, Cross-Cultural Communication, International Learning, Educational Community.

Introduction: Human activities profoundly reshape the Earth's ecosystems, ushering in a new era of intricate social and ecological dynamics (Bennett et al., 2021). As these transformations unfold, it becomes increasingly clear that our well-being is intrinsically linked to the vitality of these ecosystems. Despite being aware of such dependence on nature, it frequently overlooks the invaluable ecosystem services that sustain our lives. (Bennett et al., 2021) Take agricultural landscapes[5], for example. It offers a rich tapestry of benefits beyond mere food production. These environments play a crucial role in flood and erosion control, serve as vital habitats for pollinators, sequester carbon to mitigate climate change, and provide stunning vistas that enhance the quality of life. It also creates recreational areas with significant cultural value, fostering community and land connections. However, in the relentless pursuit of cost-effective food sources, it has often failed to acknowledge these landscapes' essential services and the natural resources required to uphold them. [6]Agricultural lands are among the planet's

[5] Ecosystem services and the resilience of agricultural landscapes. Introduction. Paragraph 2nd.
[6] Ecosystem services and the resilience of agricultural landscapes. Introduction. Paragraph 3rd.

most prevalent and critical ecosystems, occupying approximately one-third of the Earth's surface and accounting for 40% of all potentially arable land. Managing food, feed, and fibre involves increasing agricultural yields and adopting sustainable practices, such as enhancing soil health. Unfortunately, this often leads to the expansion of farmland, heightened use of pesticides and fertilizers, and alterations to traditional crop varieties. These approaches have yielded dramatic outcomes. For instance, the [7]Green Revolution of the 1950s and 1960s saw a remarkable tripling of cereal production with only a 30% increase in cultivated land, driven by breakthroughs in crop genetics and refined agricultural practices. [8]This momentum continued into the 21st century, with global crop production surging by an additional 28% between 1985 and 2005. These global trends have played a pivotal role in improving human welfare, making food more affordable, alleviating hunger, enhancing food availability, and bolstering economic conditions in numerous regions. Over the past 50 to 75 years, agricultural systems have significantly bettered the lives of countless individuals, increasing caloric intake, providing essential proteins that enhance nutrition, and raising health standards and life expectancy in many areas of the world. Nearly half of the global population relies on agriculture as their primary source of livelihood, securing calories, nutrients, fibre, biofuels, and an array of other essential products (Bennett et al., 2021).

The principles of ecology are deeply intertwined with geographical factors, such as the specific requirements of agricultural land, water availability, and the presence of rivers, canals, and dams in proximity to farming areas. Additionally, human awareness and environmental sustainability—factors heavily influenced by consistent weather patterns—play critical roles in determining how effectively individuals can cultivate their lands for crops and plantations. Innovations in technology, social and economic empowerment initiatives, and establishing model villages are also vital for fostering sustainable agriculture in line with ecological principles. Harnessing these ecological requirements for agricultural success is not merely an exercise in environmental stewardship; it also requires a profound understanding of human values. How people interact with and treat the environment reflects their sense of humanism.

The synergy between environmental and human considerations is essential in cultivating a resilient agricultural landscape that thrives in harmony with nature. This growing awareness drives us to seek solutions that allow humanity to navigate the challenges of natural disasters and other calamities. While scientific exploration is crucial for addressing the complexities of environmental turmoil, human intellect and effort—the knowledge and labour of individuals—ultimately shape our agricultural landscapes and contribute to technological advancements. Humans have the potential to foster sustainable agriculture, yet they also possess the capacity to undermine it through detrimental practices. The responsibility lies in our actions. In this evolving landscape, merging science and human management can revolutionize agriculture by aligning it more closely with its natural capacities. This commitment to maintaining ecological principles for innovative agriculture can be rewarding, provided that all stakeholders effectively utilize environmental resources and proactively prepare their lands for a thriving, sustainable future.

Literature Review: Integrating ecological principles into sustainable agriculture has become more critical in recent years. This approach helps tackle food security and environmental issues. This review looks at key findings from different studies on ecological agriculture, focusing on strategies, challenges, and effects on farmers, particularly in poorer areas. Ecological agriculture aims to use nature's strengths to improve food production. According to Altieri (1999), it promotes Biodiversity, crop rotation, and the natural management of pests.

[7] Ecosystem services and the resilience of agricultural landscapes. Introduction. Paragraph 3rd.
[8] Ecosystem services and the resilience of agricultural landscapes. Introduction. Paragraph 3rd.

These practices help maintain healthy soil and create resilient farming systems that handle environmental challenges. Garibaldi et al. (2011) highlight the importance of growing plants naturally resistant to pests and diseases. This reduces the need for chemical inputs and benefits the environment. Supporting beneficial creatures like pollinators and natural pest predators is essential to keep ecosystems balanced (Gurr et al., 2016). Some key strategies in ecological agriculture include covering crops, which improve soil fertility and encourage Biodiversity (Clark et al., 2013). Cover crops help control weeds and prevent erosion, essential for sustainable land management. Reduced tillage practices keep soil structure intact, promote microbial life, and help retain water while lowering carbon emissions (Kassam et al., 2019). Organic pest management, which stresses pests without synthetic pesticides, is vital for maintaining healthy crops (Pimentel et al., 2016). Van Rijn et al. (2016) show successful cases of natural pest control. Many farmers, especially in the Global South, do not use ecological agriculture despite its benefits.
Studies show that inequalities in access to land, resources, and technology make it hard to adopt sustainable methods (Tittonell, 2014). Farmers in poorer regions often need more money or knowledge to switch to ecological practices (Pretty, 2008). Cultural views on farming can also be a barrier. Traditional methods might be deeply rooted in local communities, making it hard for new ecological practices to get accepted (Kassam et al., 2019). To address these challenges, national governments and policymakers need to help. Fair agricultural policies can give communities the resources and training they need to adopt sustainable practices. The Food and Agriculture Organization (FAO, 2017) states that policies supporting agroecology can enhance food sovereignty and assist small farmers in the Global South by offering funds and technical support. While ecological agriculture provides a good solution for sustainable food production and environmental protection, significant barriers prevent its widespread use in poorer regions. Overcoming these challenges requires teamwork among governments and communities and ongoing research into best practices. Boost Communities Biodiversity in agriculture can significantly support environmental sustainability and ensure food security for future generations.

Methodology: This article focuses on using ecological principles for sustainable agriculture. It provides an in-depth look at environmental farming's strengths, challenges, and opportunities. The methodology is organized into several steps to ensure a thorough understanding of the topic. First, I conducted a detailed review of existing research and literature on ecological agriculture, agroecology, and sustainable farming practices. We identified and gathered peer-reviewed articles, academic journals, and relevant case studies. This review included a variety of ecological farming efforts from different regions around the world to showcase a wide range of practices and results. To gain deeper insights, I also used qualitative research methods. This involved analyzing case studies that demonstrated successful applications of ecological principles in agriculture. By closely examining these examples, we aimed to learn about the strategies and methods that led to positive outcomes and the contexts in which these practices were successful. A key part of our research was identifying barriers to adopting ecological practices, especially in economically disadvantaged areas. This included looking at economic data, policy documents, and case studies to understand issues related to land access, resource distribution, and socio-economic factors affecting agricultural communities in the Global South. Recognizing these barriers was crucial for developing strategies to overcome them. I systematically synthesized the insights and findings from the literature review and qualitative analyses. This synthesis aimed to create a set of recommendations to improve the practice of ecological agriculture. These recommendations were designed to support Biodiversity, sustainability, and fair agricultural policies for diverse farming communities. This research provides actionable insights and practical guidance for stakeholders in agriculture. By highlighting the complexities and obstacles of ecological agriculture, we hope to inspire new strategies that benefit both ecosystems and farming communities. We aim to promote sustainable and socially just practices, contributing to the resilience and health of the agricultural sector and the environment. Through this detailed approach, we strive to help guide the transition to more sustainable farming practices that align with ecological principles.

Discussion: (Bennett et al., 2021) Ecological resilience is a system's ability to function similarly when it faces changes. Resilient systems (Bennett et al., 2021) can absorb shocks and maintain essential processes and functions. [9]In agriculture, resilience means balancing strength, flexibility, and the potential for change to continue providing critical services like food and ecosystem support. [10]Sustainability means ensuring we can continue to meet our needs now and in the future. Resilient and sustainable agriculture includes both ecological and social aspects. It acknowledges that agriculture's environment and social factors are interconnected, so agricultural resilience is considered (Bennett et al., 2021) [11]"social-ecological." Even when looking at ecosystems, the resilience of social systems is critical. It assesses agricultural resilience by examining how it can sustain [12]multiple ecosystem services and the natural and social resources that support them. To continue providing food and ecosystem support, agriculture must persist and adapt to changes in the world. Sometimes, it may need to transform to protect its vital functions amidst more significant shifts. [13]The traits that foster resilience—like persistence, adaptability, and transformation—are similar in social and natural systems. A set of seven principles has been created to guide efforts in strengthening resilience in social-ecological systems. The first three principles center on the system's social-ecological aspects, while the last four relate mainly to governance and understanding.

(Bennett et al., 2021) Seven principles maintain diversity through intercropping, creating diverse field margins, and preserving native habitats. These approaches ensure redundancy and varied functions within the system, making it less fragile. [14]Manage connectivity by balancing how connected landscapes and people are. [15]Facilitate species movement and agricultural trade to promote connections and independence at different levels. [16]Monitor changes and feedback by paying attention to long-term changes and attentive to system aspects, such as the connection between increased farming intensity and the need for more intensification. This understanding helps predict how systems react to disruptions. [17]Understand complex systems by recognizing farms, farming communities, and food trade systems as complex and adaptive. This understanding can shape our options and decisions.

[9]Ecosystem services and the resilience of agricultural landscapes. Resilience and Sustainability for Agriculture. Paragraph 1st.

[10]Ecosystem services and the resilience of agricultural landscapes. Resilience and Sustainability for Agriculture. Paragraph 1st.

[11]Ecosystem services and the resilience of agricultural landscapes. Resilience and Sustainability for Agriculture. Paragraph 1st.

[12]Ecosystem services and the resilience of agricultural landscapes. Resilience and Sustainability for Agriculture. Paragraph 2nd.

[13]Ecosystem services and the resilience of agricultural landscapes. Resilience and Sustainability for Agriculture. Paragraph 2nd.

[14]Ecosystem services and the resilience of agricultural landscapes. Resilience and Sustainability for Agriculture. Paragraph 2nd.

[15]Ecosystem services and the resilience of agricultural landscapes. Resilience and Sustainability for Agriculture. Paragraph 2nd.

[16]Ecosystem services and the resilience of agricultural landscapes. Resilience and Sustainability for Agriculture. Paragraph 2nd.

[17]Ecosystem services and the resilience of agricultural landscapes. Resilience and Sustainability for Agriculture. Paragraph 2nd.

[18]Encourage learning and experimentation by supporting farmers in learning and trying new methods. Adapting to constant changes in complex systems requires ongoing learning. Include all stakeholders by involving everyone, including farmers, in decision-making. [19]Diverse viewpoints can improve system understanding and enhance decision-making and governance. [20]Use multi-level governance by creating governance structures that connect different levels. This supports informed decision-making while reflecting the complex relationships within and between systems. When tailored for ecosystem services in agriculture, these principles highlight key aspects of a resilient social-ecological system (Bennett et al., 2021). While more research is needed to determine how many of these principles must be met to demonstrate agricultural systems' resilience, they guide our understanding of farming practices and trends that affect their strength. Agricultural resilience is evaluated by [21]rural mainstream societies that maintain or enhance nature, ensure a balanced and sustainable range of ecosystem services over time, and recognize those practices that do not succeed.

Conclusion: The journey toward sustainable agriculture, rooted in ecological principles, presents both a world of opportunity and a landscape of challenges. The strategies we can adopt—such as cultivating hardy and resilient plant varieties, managing pest populations through carefully designed environmental stressors, and nurturing beneficial organisms—have shown great promise in enhancing farming practices. However, the road to successfully implementing these techniques is fraught with significant hurdles, especially in economically disadvantaged areas with limited resources. The intricate interplay of structural inequalities and a lack of financial support creates substantial barriers to accessing these sustainable practices. For meaningful progress to occur, governments, organizations, and community stakeholders must join forces in a dedicated effort to create equitable access to ecological agriculture. By emphasizing collaboration, comprehensive education, and strategic investments in sustainable practices, we can bolster agricultural productivity and play a crucial role in biodiversity conservation. This, in turn, fosters healthier ecosystems that will benefit future generations. Embracing these principles and practices is vital for establishing a robust agricultural framework that serves the dual purpose of meeting human needs and protecting our planet's natural resources. It is a call to action for all of us to work together toward a more sustainable and resilient future.

References:

Bennett, E. M., Baird, J., Baulch, H., Chaplin-Kramer, R., Fraser, E., Loring, P., Morrison, P., Parrott, L., Sherren, K., Winkler, K. J., Cimon-Morin, J., Fortin, M.-J., Kurylyk, B. L., Lundholm, J., Poulin, M., Rieb, J. T., Gonzalez, A., Hickey, G. M., Humphries, M., & Bahadur KC, K. (2021). Ecosystem services and the resilience of agricultural landscapes. Advances in Ecological Research, pp. 64, 1–43. https://doi.org/10.1016/bs.aecr.2021.01.001

M., & Bahadur KC, K. (2021). Ecosystem services and the resilience of agricultural landscapes. Advances in Ecological Research, 64, 1–43. https://doi.org/10.1016/bs.aecr.2021.01.001

Altieri, M. A. (1999). The Ecological Role of Biodiversity in Agroecosystems. Agronomy for Sustainable Development, 19(2), 75-82.

[18]Ecosystem services and the resilience of agricultural landscapes. Resilience and Sustainability for Agriculture. Paragraph 2nd.

[19]Ecosystem services and the resilience of agricultural landscapes. Resilience and Sustainability for Agriculture. Paragraph 2nd.

[20]Ecosystem services and the resilience of agricultural landscapes. Resilience and Sustainability for Agriculture. Paragraph 2nd.

[21]Ecosystem services and the resilience of agricultural landscapes. Resilience and Sustainability for Agriculture. Paragraph 3rd.

Clark, A. J., et al. (2013). The Role of Cover Crops in Sustainable Agriculture. Sustainable Agriculture Research, 2(4), 53–64.

Food and Agriculture Organization (FAO). (2017). Agroecology for Food Security and Nutrition: Proceedings of the FAO International Symposium, 18-19 September 2014, Rome.

Garibaldi, L. A., et al. (2011). Stability of Pollination Services Decreases with Agricultural Intensification. Ecology Letters, 14(2), 189-200.

Gurr, G. M., et al. (2016). Biodiversity and Pest Management: A Toxicology Perspective. Ecotoxicology, 25(7), 1298-1306.

Kassam, A., et al. (2019). The Global Impact of Conservation Agriculture on Soil Health and Ecosystem Services. Land, 8(7), 107.

Pimentel, D., et al. (2016). Reducing Pesticide Use by Altering Pest Control Practices. Environmental management, 44(5), 910-922.

Pretty, J. (2008). Agricultural Sustainability: Concepts, Principles, and Evidence. Philosophical Transactions of the Royal Society B, 363(1491), 447-465.

Tittonell, P. (2014). Agroecology: Principles and Practices for Sustainable Food Systems. Food Security, 6(4), 631-643.

van Rijn, P. C. J., et al. (2016). Natural Pest Control: The Role of Biodiversity. Asian Journal of Ecotoxicology, 11(1), 15-2

COMPOSITION OF ESSENTIAL OILS OBTAINED FROM THE PLANT (Salvia virgata Jacq.) GROWN IN DIFFERENT ECOLOGIES

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ABSTRACT

Introduction and Purpose: There are approximately 900 species of the Salvia genus worldwide. There are 99 species of the Salvia L. genus in Turkey; 51 of these species are endemic. The local name of S. virgata in Turkey is "yılancık" or "fatmanaotu" and is used in the treatment of wounds and various skin diseases. In addition, the brew prepared using the aboveground parts of this species is used to prevent blood cancer. This study was carried out by growing the salvia virgata plant, which has economic importance in Turkey, in different regions. The volatile oil composition was determined.

Materials and Methods: The materials in this study were obtained from Ankara University Faculty of Agriculture.The trial was conducted in Balıkesir, Çanakkale, Kütahya regions in 2017-2019. Since 180 plants were needed in the trial area, seedlings were grown in greenhouse conditions and considering the failures after transplanting to the field, 216 plants were transplanted to the trial area. Rooted seedlings were transplanted to the field as of April 2017.

The seedlings were given life water immediately after transplanting to the field. Field trials were conducted according to the randomized block trial design with 3 replications. The planting distance in the trial was 50x50 cm and there were 3 rows in each plot. The plot size was 1.75x5.00 = 8.75 m2. 24 plants were planted in each row and 72 plants in each plot). When we examine the trial years and long-term climate data of the trials we conducted in different locations; when the long-term data are taken into account, the lowest precipitation was recorded in the Kütahya location and the highest precipitation was recorded in the Balıkesir location among the 3 locations where the trials were conducted.

Results: It is a study to evaluate the essential oils of Salvia virgata Jacq. species depending on ecological factors according to the two-year results of the essential oil composition. In the study conducted in three different regions; Carvacrol, β-Ylangene, Bicyclogermacrene, phytol were identified only in Kütahya, γ-Terpinene, α-Thujone, Linalool, Linalylacetate in Balıkesir, Viridiflorol compound was identified only in Çanakkale.The highest essential oil ratio was determined as 0.05% in Çanakkale. Considering that the essential oil components also differ according to ecological factors, it would be beneficial to conduct more studies on different Salvia species from different locations.

Key Words: Essential oil, Different Region, Volatile Components

GİRİŞ

Türkiye'de Salvia L. cinsinin 99 türü bulunmaktadır; Bu türlerin 51'i endemiktir. S. virgata'nın Türkiye'deki yerel adı "yılancık" veya "fatmanaotu" olup, yaraların ve çeşitli cilt hastalıklarının tedavisinde kullanılmaktadır. Ayrıca bu türün toprak üstü kısımları kullanılarak hazırlanan kaynatma da kan kanserini önlemek amacıyla kullanılmaktadır (Şenkal ve ark.,2019). Salvia virgata'nın toprak üstü kısmından farklı oluşum (çiçeklenme öncesi ve tam çiçeklenme) koşulları altında hidrodistilasyon yoluyla izole edilen uçucu yağın kimyasal bileşimi, Gaz Kromatografisi (GC) ve Gaz Kromatografisi-Kütle Spektrometresi (GC-MS) kullanılarak belirlendi. S. virgata'da yirmi dokuz bileşen tanımlandı uçucu yağların farklı intogenez koşulları altında yağların %98.36 - 99.18'ini temsil ettiği belirlendi. Yağın ana bileşenleri β-karyofilen (%24,58-42,54), karyofillen oksit (%10,25-19,88), sabinen (%8,64-19,58), 1-Octen-3-Ol (%7,54-8,59), terpinen- 4-ol (%4,25-6,64) ve a-tujen (%3,74-6,46) olduğu tespit edilmiştir (Alizadeh, 2013). İran'da yabani olarak yetişen Salvia syriaca L., Salvia virgata Jacq'ın uçucu yağlarının kimyasal bileşimi, GC ve GC-MS ile incelenmiştir. S. virgata için ana bileşenler olarak β-karyofillen (%46,6), germacrene B (%13,9), β-karyofilen (%13,2), spathulenol (%6,4) ve germacrene D (%5,7) içeren on beş bileşen tanımlanmıştır (Sefidkon ve ark.,1999). Salvia virgata'nın kurutulmuş yaprakları, sapları ve toprak üstü kısımlarının hidrodistilasyonuyla elde edilen uçucu yağların kimyasal bileşimi GC ve GC/MS kombinasyonuyla analiz edildi. Yaprak yağında ana bileşenler olarak β-karyofilen (%35,2), (Z)-β-farnesen (%10,1), karyofillen oksit (%6,1) ve α-pinen (%5,7) olmak üzere yirmi dört bileşen tanımlandı. Ana bileşenler olarak hekzadekanoik asit (%56) ve β-karyofilen (%7,6) içeren yirmi üç bileşik kök yağı için karakterize edildi (Baharfar ve ark.,2009). Bu çalışma Türkiye'de ekonomik öneme sahip olan salvia virgata bitkisinin farklı bölgelerde yetiştirilerek. Uçucu yağ kompozisyonu belirlenmeye çalışılmıştır. Bu çalışma ile bölge halkının ürün çeşitliliğini artırmak, ilaç ve gıda sektörüne katkı sağlamak hedeflenmiştir.

MATERYAL VE YÖNTEM

Bu araştırmada materyaller Ankara Üniversitesi Ziraat Fakültesinden temin edilmiştir. Deneme 2017-2019 yılında Balıkesir, Çanakkale, Kütahya bölgelerinde yürütülmüştür. Tarla denemeleri tesadüf blokları deneme desenine göre 3 tekerrürlü olarak yürütülmüş. Denemede dikim aralığı 50x50 cm olup her parselde 3 sıra yer almıştır. Parsel büyüklüğü 1,75x5,00=8,75 m^2 dir. Her sıraya 24 bitki her parselde 72 bitki bulunacak şekilde dikim yapılmıştır. Bitkiler ilk iki hafta her gün hortumla sulanmış. Tutmayan bitkilerin yerine yenileri şaşırtılarak her parselde en az 70 bitki olması sağlanmıştır. İkinci haftadan sonra haftada bir sulama yapılmıştır. Gözlemler ve ölçümler her parselde işaretlenen sağlıklı bitkiler içerisinde etiketlenen 9 adet bitkilerden elde edilen çiçek örneklerinde yapılmıştır. İlk yıl tek, ikinci yıl iki biçim yapılmış ve biçim zamanı olarak uçucu yağ oranının en yüksek olduğu çiçeklenme başlangıcı tercih edilmiştir. Denemelerin yürütüldüğü Balıkesir, Çanakkale, Kütahya lokasyonlarında deneme yerinin toprak tekstürü kumlu – tınlı, killi – tınlı, toprak rengi ise kahverengidir. Çanakkale ve Kütahya lokasyonlarında topraklar, kil oranı bakımında yüksek olması nedeniyle geçirgenliği az, ağır bünyeli topraklardır. Balıkesir lokasyonunda deneme yerinin toprak tekstürü kumlu – tınlıdır. Bu lokasyonun toprak yapısı geçirgen, su tutma kapasitesi, kireç oranı ise düşüktür. Organik madde bakımında fakir olduğu analizler sonucunda belirlenmiştir (Anonim. 2017). Farklı lokasyonlarda yürüttüğümüz denemelerin deneme yılları ve uzun yıllara ait iklim verilerini incelediğimizde; uzun yıllar verileri dikkate alındığında denemelerin yürütüldüğü 3 lokasyon içerisinde en düşük yağış Kütahya lokasyonunda en fazla yağış Balıkesir lokasyonunda kaydedilmiştir (Anonim. 2017-2019).

Uçucu Yağ Oranının Elde Edilmesi

Deneme uçucu yağ analizinin başlangıcında 20 g kuru materyal tartılarak 500 ml'lik balona alınmıştır. Üzerine 200 mL (örnek miktarına göre değişebilir, yaklaşık 10 kat) saf su eklenip çalkalanmıştır. İki saat süreyle hidrodistilasyon işlemine tabi tutularak uçucu yağ elde edilmiştir. Sistem soğuduktan sonra ve dereceli kısma toplanan uçucu yağ sulu fazdan ayrıldıktan sonra miktarı (mL) tespit edilmiştir. Tartımı alınan örnek miktarına (g) göre 100 g örnekteki uçucu yağ miktarı uçucu yağ oranı (%) olarak hesaplanmıştır (Skoula ve ark., 2000).

Uçucu Yağ Bileşenlerinin GC-MS ile Elde edilmesi

Örneklerin, uçucu yağ bileşen analizi GC-MS cihazı ile kapiler kolon kullanılarak gerçekleştirilmiştir. Örnekler analiz edilmek üzere 1:100 oranında hekzan ile seyreltilmiştir. Analizde taşıyıcı gaz olarak 0.8 ml/dk akış hızında helyum kullanılmış, örnekler cihaza 1 µl olarak 40:1split oranı ile enjekte edilmiştir. Enjektör sıcaklığı 250°C, kolon sıcaklık programı 60°C (10 dakika), 60°C'den 220°C'ye 4°C/dakika ve 220°C (10 dakika) olacak şekilde ayarlanmıştır. Bu sıcaklık programı doğrultusunda toplam analiz süresi 60 dakika sürmüştür. Kütle detektörü için tarama aralığı (m/z) 35-450 atomik kütle ünitesi ve elektron bombardımanı iyonizasyonu 70 eV kullanılmıştır. Uçucu yağın bileşenlerinin teşhisinde ise WILEY, NIST ve OIL ADAMS kütüphanelerinin verileri esas alınmıştır. Sonuçların bileşen yüzdeleri FID dedektör kullanılarak, bileşenlerin teşhisi ise MS dedektör kullanılarak yapılmıştır (Özek ve ark., 2010).

BULGULAR VE TARTIŞMA

Kütahya-Çanakkale, Balıkesir bölgelerinde elde edilen uçucu yağ oranı sırasıyla %0.03-0.03, %0.05 olarak bulunmuştur. Uçucu yağ oranı ve bileşenleri belirlemek için tüm parsellerden ölçüm alınmıştır. En yüksek uçucu yağ oranı Balıkesir bölgesinde elde edilmiştir. Üç bölgede de farklı bileşenler elde edilmiştir. Uçucu yağ oranı konusunda yapılan çalışmalarda; İran'ın kuzeyindeki Mazandaran Eyaletindeki Chalus'tan (Gachsar) toplandı. Bu bitkilerin yapraklarından ve çiçeklerinden elde edilen suyla damıtılmış esansiyel yağlar, GC ve GC/MS ile analiz edildi. S. virgata'nın yaprak ve çiçeklerinden elde edilen yağlar %0,15 ve %0,19 olup, uçucu yağların sırasıyla 19 ve 30 bileşiğ tanımlanmıştır. Yaprak yağının ana bileşenleri fitol (%29,1), β-karyofillen (%19,2), karyofillen oksit (%17,0) ve hekzadekanoik asit (%8,2) idi. Çiçek yağının ana bileşenleri β-karyofilen (%21,1), germakren-D (%13,2), bisiklogermakren (%7,0), α-humulen (%6,7) ve β-pinen (%6,7) idi (Sarbanha ve ark., 2011). Tam çiçeklenme sırasında hasat edilen S. virgata'nın toprak üstü kısımlarındaki esansiyel yağ içeriği %0,01 idi. Esansiyel yağın temel bileşenleri pentakozan (%20,09), karyofillen oksit (%6,90), fitol (%6,83), spatulenol (%6,09) ve nonakozan (%5,15) idi (Şenkal ve ark., 2019). S.virgata esansiyel yağı karyofillen oksit (%30,23), β-karyofililendir (%22,63), sabinen (%11,82) (Golparvar ve ark., 2017). Morteza-Semnani ve diğerleri tarafından toplanan başka bir raporda, S.virgata bileşikleri, karyofililen oksit (%34,4), spathulenol (%25,6), doco ile-sanol (%11,7), tetradekanol (%9,3) ve geranil aseton (%5,6) olarak tespit edilmiştir (Morteza-Semnani ve ark., 2005). Yaprak yağında ana bileşenler olarak β-karyofilen (%35,2), (Z)-β-farnesen (%10,1), karyofillen oksit (%6,1) ve α-pinen (%5,7) olmak üzere yirmi dört bileşen tanımlandı. Ana bileşenler olarak hekzadekanoik asit (%56) ve β-karyofilen (%7,6) içeren yirmi üç bileşik kök yağı için karakterize edildi (Baharfar ve ark., 2009).

Tablo 1. Salvia virgata Jacq. türünün uçucu yağının (çiçek) iki yıllık ortalamanın bileşen miktarının (%) değişimi

No	Bileşen adı	Balıkesir bölgesi	Çanakkale bölgesi	Kütahya bölgesi
1	α-Thujene	0,83		
	β-Ylangene			0.58
2	Sabinene	2,02		1.16
	Carvacrol			4.45
3	γ-Terpinene	1,01		
4	α-Thujone	0,59		
5	α-Cubebene	0,64		0.62
6	α-Copaene	2,02		1.99
7	Linalool	0,7		
8	Linalyl acetate	0,66		
9	β-Copaene	0,72		0.79
10	β-Caryophyllene	48,12	29,46	39.48
11	α-Humulene	2,82	2,67	2.56
12	γ-Muurolene	3,83	4,37	3.93
13	Germacrene D	9,79	9,95	14.48
14	β-Bisabolene	1,18	1,53	2.86
15	δ-Cadinene	3,61	5,17	3.89
16	γ-Cadinene	1,56	2,22	1.69
	Viridiflorol		1,8	
17	Caryophyllene oxide	13,25	26,9	6.94
18	Humulene epoxide-ll	0,72	1,73	
19	Spathulenol	0,82		2.87
20	14-Hydroxy-β-Caryophyllene	1,38	4,14	0.99
21	Bicyclogermacrene			1.42
22	phytol			2.61
	Toplam	96.27	89.94	93.31

Salvia'da genotiplerin tanımlanmasının, morfolojik benzerlik ve Salvia türlerinde doğal melezlemenin yaygın oluşu nedeniyle karmaşık olduğunu bildirmişlerdir. Tür ve genotipe özgü DNA işaretlerinin bitki tanımlama, üreme ve koruma programları için çok yararlı olduğunu yağ verimlerinin bitkinin DNA'sı ile ilişkili olduğunu belirtmişlerdir (Karaca ve ark., 2008). Salvia virgata Jacq. toprak üstü organlarından elde edilen uçucu yağın analizinde toplam yağın Balıkesir'de %96.27,Çanakkale'de %89.94, Kütahya'da %93.31 kısmını oluşturmuştur. Salvia virgata Jacq. türüne ait çiçeklerde elde edilen uçucu yağ oranı bileşenlerin değerleri iki yıl sonucu elde edilen örneklerin ortalaması ile belirlenmiştir. Salvia virgata Jacq türünün uçucu yağ bileşenlerin değerleri ayrı ayrı olacak şekilde Tablo 1'de gösterilmiştir. Salvia virgata Jacq türünün bitki kısımlarına göre uçucu yağ bileşenleri belli ölçüde değişiklik göstermektedir. Salvia virgata Jacq türünde ana bileşeni β-Caryophyllene olarak gerçekleşmiştir. İki yılın ortalamalarına göre üç bölgede elde edilen Caryophylleneoxide oranı, yapılan diğer çalışmalarla karşılaştırıldığında daha yüksek bulunmuştur.

SONUÇ

Üç farklı bölgede yapılan çalışmada; Carvacrol, β-Ylangene, Bicyclogermacrene, phytol bu bileşikler yalnız kütahyada, γ-Terpinene, α-Thujone, Linalool, Linalylacetate, Balıkesirde, Viridiflorol bileşiği yalnız Çanakkale'de tanımlanmıştır. Uçucu yağ oranı en yüksek Çanakkale'de %0.05 olarak tespit edilmiştir. Ekolojik faktörlere göre uçucu yağ bileşenlerinin de farklılık gösterdiği düşünüldüğünde farklı lokasyonlarından farklı Salvia türleri üzerinde daha fazla çalışmaların yürütülmesi faydalı olacaktır.

KAYNAKÇA

Alizadeh, A. (2013). Essential oil constituents, antioxidant and antimicrobial activities of Salvia virgata Jacq. from Iran. Journal of Essential Oil Bearing Plants, 16(2), 172-182.

Anonim 2017. Toprak Analizi Sonuçları. Kütahya Ziraat Odası Başkanlığı, Kütahya.

Anonim 2017-2019. İklim Verileri. Kütay Meteoroloji İl Müdürlüğü, Kütahya.

Baharfar, R., Tajbakhsh, M., Azimi, R., Khalilzadeh, M. A., & Eslami, B. (2009). Chemical constituents of essential oils from the leaves, stems and aerial parts of Salvia virgata Jacq. from Iran. Journal of Essential Oil Research, 21(5), 448-450.

Golparvar, A. R., Hadipanah, A., Gheisari, M. M., Naderi, D., Rahmaniyan, S., & Khorrami, M. (2017). Chemical composition and antimicrobial activity of essential oil of Salvia officinalis L. and Salvia virgata Jacq. Journal of Medicinal Herbs,, 8(2), 71-78.

Karaca M., Ince A. G., Ay S. T., Turgut K., Onus A. N., 2008. Pcr-Rflp and Damd-Pcr Genotyping for Salvia Species. Journal of The Science of Food and Agriculture, 88 (14): 2508-2516.

Morteza-Semnani K., Saeeidi M., Changizi ve S. M. (2005). Vosoughi,Gerekliyağ bileşimi Salvia virgata Jacq. İran'dan. J. Essent. Yağ Yatağı Bitkiler,8, 330–333.

Özek T., Tabanca N., Demirci F., David E., Wedgeand K., Başer H.C., 2010. Enantiomeric Distribution of Some Linalool Containing Essential oils and Their Biological Activities. Rec. Nat. Prod. 4 (4): 180-192.

Sarbanha, S., Masoomi, F., Kamalinejad, M., & Yassa, N. (2011). Chemical composition and antioxidant activity of Salvia virgata Jacq. and S. verticillata L. volatile Oils from Iran. Planta Medica, 77(12), PE19.

Skoula M, Abbes JE, Johnson CB, 2000. Geneticvariation of volatil esandrosmarinicacidin populations of Salvia fruticosa Mill., growing in Crete. Journal of Biochemical Systematics and Ecology, 28:551-561.

Sefidkon, F., & Mirza, M. (1999). Chemical composition of the essential oils of two Salvia species from Iran, Salvia virgata Jacq. and Salvia syriaca L. Flavour and Fragrance Journal, 14(1), 45-46.

Şenkal, B. C., Uskutoğlu, T., Cesur, C., Özavcı, V., & Doğan, H. (2019). Determination of essential oil components, mineral matter, and heavy metal content of Salvia virgata Jacq. grown in culture conditions. Turkish Journal of Agriculture and Forestry, 43(4), 395-404.

Tepe, B. (2008). Antioxidant potentials and rosmarinic acid levels of the methanolic extracts of Salvia virgata (Jacq), Salvia staminea (Montbret & Aucher ex Bentham) and Salvia verbenaca (L.) from Turkey. Bioresource Technology, 99(6), 1584-1588.

AREAS OF USE OF SOME MEDICINAL AND AROMATIC PLANTS FOUND IN THE FLORA OF MURAT MOUNTAIN (KUTAHYA)

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ABSTRACT

Introduction and Purpose: Murat Mountain, located in the Inner Western Anatolian Section of the Aegean Region, has been studied in terms of floristics. Murat Mountain is 130 km away from Kütahya province. It is 30 km away from Gediz district. Murat Mountain, located within the borders of Kütahya and Uşak provinces and with its highest point being 2309 m, extends in the northwest-southeast direction. The research area, which is under the influence of Mediterranean, Black Sea and Central Anatolian climates, has a rich flora due to this feature. Many plants continue to be collected from nature unconsciously for the purpose of using in domestic consumption or selling. As a result, many plant species that were previously rich in the flora of Murat Mountain have either become difficult to find or are facing extinction today. The sole purpose of this study is to draw attention to Murat Mountain and to ensure that the necessary precautions are taken as soon as possible.

Materials and Methods: In this study, some plant samples belonging to the Murat Mountain flora of Gediz (Kütahya) district were discussed. Face-to-face interviews were conducted with people over 60 years of age (25 people) living in the Gökler town, Çukurören, Gümüşlü, and Gümele villages around Murat Mountain, and a total of 15 medicinal and aromatic plant taxa were identified, the areas of use of which were determined. In addition, after receiving the opinions of 4 herbalists in the Gediz district of Kütahya province, information was obtained about the local usage patterns of the plants. The identification and diagnosis of the plants were made by me. The medicinal effects of the plants and the recipes in their use are the information used by the local people. In the findings section, the Turkish name of the plant, its family, Latin name and the used part of the plant are stated.

Results: Let's not forget that our humanity is valuable. Medicinal plants, which are frequently used by the public in the treatment of various diseases and whose positive effects cannot be ignored, should be consumed consciously. It is important to use plant species that have been analyzed, have known content, and are securely supplied, consciously in the alternative treatment of diseases so that public health is not negatively affected. There are other plants in addition to the plants we have identified on Murat Mountain. However, most of these plants have not been addressed so that they are not harmed. For this reason, the characteristics of the research areas have not been fully specified. Many plant species that used to be common in the Murat Mountain flora are now either extinct or on the verge of extinction. In order to prevent this, it is among the duties of authorized persons or institutions and organizations to take the necessary precautions and keep biodiversity at the highest level and to ensure that the natural ecosystem is protected on.

Key Words: Murat Mountain Flora, Use of Plants, Medicinal Plants

GİRİŞ

Ege Bölgesi'nin İç Batı Anadolu Bölümü'nde bulunan Murat Dağı floristik yönden araştırılmıştır. Murat Dağının Kütahya iline uzaklığı 130 km. Gediz ilçesine uzaklığı ise 30 km. dir. Kütahya ve Uşak illeri sınırları içinde yer alan ve en yüksek noktası 2309 m. olan Murat Dağı kuzeybatı-güneydoğu yönünde uzanır. Akdeniz, Karadeniz ve İç Anadolu iklimleri etkisi altında bulunan araştırma bölgesi, bu özelliği nedeniyle zengin bir floraya sahiptir. 1976-1978 ve 1980 yıllarında bölgeye yapılan on beş gezi sonunda Murat Dağı ve yakın çevresinde 814 taksona ait 1765 örnek toplanmıştır (Çırpıcı, 1981). Türkiye florasının yayımlanmış ilk altı cildinde (Davis 1965 – 1978) endemik türlerinin oranı % 19-39 arasında değişmektedir; bu oran ortalama olarak %31'dir. Yine bu altı cilde dayanarak IUCD (1980) tarafında yayınlanan listeye göre, Türkiye 1780 endemik türü barındırmaktadır. Bu durum göz önünde bulundurularak Türkiye florasındaki endemik tür oranının %30'un üstünde olduğu ileri sürülmektedir. Murat Dağı florası %11, Türkiye florasının %31 neredeyse yarısını oluşturmaktadır (Çırpıcı, 1981).Türkiye, coğrafi konumu, jeolojik yapısı, iklimi ve üç farklı fitocoğrafi bölgenin (Avrupa–Sibirya, İran-Turan, Akdeniz) karşılaştıkları bir yerde bulunması dolayısıyla çok çeşitli bitki örtüsü barındırmaktadır. Yine aynı nedenlerle Türkiye'de endemik türlerin sayısı oldukça yüksektir. Türkiye aynı zamanda birçok türün gen merkezini de oluşturmaktadır. Bu nedenle endemik türler bakımından oldukça zengindir. Çalışma sonunda Murat Dağı'nda yetiştiği saptanan 853 taksondan 94'ü Türkiye için endemiktir. Buna göre Murat Dağı'ndaki endemik türler oranı %11'dir (Çırpıcı, 1981). Murat Dağı, Türkiye'de mevcut 3 farklı fitocoğrafik bölgenin karşılaştığı bir yerde bulunmaktadır. Yapılan araştırmalarda saptanan türlerden 77'si Avrupa-Sibirya, 69'u Akdeniz, 67'si İran-Turan elementidir. Bu duruma göre her üç fitocoğrafik araştırma bölümünde yaklaşık aynı oranlarda temsil olunmaktadır (Çırpıcı, 1989a). Özellikle ilaç ve tıbbi bitkilerin sayısında görülen hızlı artış, modern tıbbın, yapay ilaçlar yerine doğal kaynakların kullanılmasının faydalarını kabullenmesinden sonra görülmüştür. Bugün gerek dünyada ve gerekse ülkemizde ilaç ve baharat bitkileri, doğal floradan toplanarak kullanılmakta veya pazarlanmaktadır. Sürekli olarak yapılan bu yoğun toplama sonucu bitkilerin doğal floradaki nesli giderek azalmaktadır, bazıları kaybolmaktadır ve her yıl bu bitkilerin birçoğu da kaybolmaktadır. Özellikle kök, rizom, yumru veya çiçekleri drog olarak kullanılan bitkilerde durum kendini daha çok hissettirmektedir. Çünkü bitkiler ya tamamen sökülerek yok edilmekte ya da tohum bağlamadan önce toplandıkları için nesillerini devam ettirememektedirler. Bu durum Avrupa ülkelerinde erken hissedilmiş ve bitki toplayıcılarına eğitici bilgi verilmiştir (Koç,1999). Murat Dağı'nın en yüksek noktası 2309 m ile Kartal Tepe'dir. Bunun dışında Elmalı (2288 m), Öküzkaya (2213 m), Çatmalı mezar (1990 m), Karakötek (1986 m), Kazıkbatmaz (1857 m), Kesiksöğüt (1737 m) önemli tepelerdir. Kuzeybatısında İkizce (1450 m), Söbealan (1450 m), Sarıçiçek (1800 m); kuzeyde Çukurören yukarısında Sığırkuyruğu (1600 m); kuzeydoğu yamaçlarda Kesiksöğüt (1600 m) ve güneyde Gürlek Köyü yukarısında Çukuroluk (1650 m) önemli yaylalarıdır. Gölyeri (1750 m); yazın bataklık haline dönüşen bir sirk gölü, Kuzugöl ise elips şeklinde glasyal kökenli önemli bir göldür (Çırpıcı, 1989b). Çalışma alanında kuvaterner yaşlı çakıl, kum, silt ve kil çapındaki çökellerden oluşan dere ve dere yataklarında görülen alüvyon ile yamaçlarda iyi çimentolu çakıl taşlarından meydana gelmiş taraçalara da sık rastlanmaktadır (Tekin, 2002). Biyolojik çeşitlilik bakımından ülkemiz oldukça zengindir. Bu çeşitliliğin asıl sebebi şöyle sıralanabilir; iklim, topoğrafik, jeolojik ve jeomorfolojik farklılıklar; deniz, göl, akarsu gibi değişik su ortamlarının oluşu, 0-5000 m'ler arasında değişen yükseklik farkları Anadolu diagonalinin doğusu ve batısı arasında ekolojik farkların bulunması ve bütün bu ekolojik çeşitliliğin floraya yansımasıdır (Avcı, 2005). Ülkemizde ise, bu şekilde bir toplama ile doğal floranın yok edildiği çok geç fark edilmiş olmasına rağmen henüz ciddi önlemler alınmış değildir (Koç, 1999). Dolayısıyla iç tüketimde kullanmak veya satmak amacıyla birçok bitkinin doğadan bilinçsiz bir şekilde toplanmasına devam edilmektedir. Bunun sonucu olarak, Murat Dağı'nın florasında önceleri zengin bir şekilde bulunan birçok bitki türü günümüzde ya zor bulunur hale gelmiştir ya da nesli tükenme durumuyla karşı karşıyadır. Bu çalışmanın tek amacı Murat Dağı'na dikkat çekmek ve bunun için gerekli önlemlerin bir an önce alınmasını sağlamaktır. Murat Dağı zengin bitki florasının yanında, termal kayak merkezi, termal kaplıca suları ile de ön plana çıkmaktadır.

MATERYAL VE YÖNTEM

Bu çalışmada Gediz (Kütahya) ilçesi Murat Dağı florasına ait bazı bitki örnekleri ele alınmıştır. Murat dağı çevresinde bulunan Gökler beldesi, Çukurören, Gümüşlü, ve Gümele köylerinde yaşayan 60 yaş üstü kişiler (25 kişi) ile yüz yüze görüşülmüş, kullanım alanları belirlenen toplam 15 tıbbi ve aromatik bitki taksonu tespit edilmiştir. Ayrıca Kütahya ili Gediz ilçesinde bulunan 4 aktarın da görüşleri alındıktan sonra bitkilerin yöresel kulanım şekilleri hakkında bilgi edinilmiştir. Bitkilerin tespit ve teşhisi tarafımdan yapılmıştır. Bitkilerin tıbbi etkileri ve kullanımındaki tarifler yöre halkının kullanmış olduğu bilgilerdir. Bulgular kısmında bitkinin Türkçe adı, Familyası, Latince adı, Bitkinin Özellikleri, Tıbbi Etkileri ve bitkinin kullanılan kısmı belirtilmiştir.

BULGULAR TARTIŞMA VE SONUÇ

Araştırma alanındaki 15 bitkinin kullanım alanları tespit edilmiştir. Yörede tespit edilen bu bitkilerin, ilçe ve köylerdeki insanlar tarafından yaygın şekilde kullanıldığı gözlemlenmiştir. Kütahya ili Murat Dağı doğal florasında bulunan ve ekonomik değeri olan tıbbi ve aromatik bitkilerin kullanımı;

1- Türkçe adı: Civan perçemi
Familyası: Compositae
Latince adı: Achillea nobilus L.
Bitkinin Özellikleri: Murat Dağı'nın en önemli bitkilerindendir. Yörede ayvadana adıyla bilinir. Murat Dağı bünyesinde bulunan köylerdeki her evde civanperçemi bulmak mümkündür. Acı bir tadı vardır. 20–50 cm boylarında, çiçekleri beyazdır. Ormanlık alanın yol kenarlarında, sulak olmayan düz alanlarda çok bulunur.
Tıbbi Etkileri: Yörede mide, bağırsak ve gazı giderici olarak çok kullanılmaktadır. Soğuk algınlığında, soğuktan oluşan karın ağrılarında, bronş ve astımda kullanılır.
Kullanımı: Bir dal civanperçemin çiçeği kaynamış bir su bardağında 5-10 dakika demlendikten sonra içilir.
2-Türkçe adı: Altınbaş Otu
Familyası: Asteraceae
Latince adı: Salidago Virgousea
Bitkinin Özellikleri: Altınbaş otu Murat Dağı'na özgü bitki türlerindendir.1500–1700 m. yükseklikte yetişir. Kayaların kuzeye bakan yüzeylerinde bulunur. Üstü yeşil, alt kısmı kahverengi yaprakları olan 5–15 cm boyunda bir bitkidir. Yapraklarının kenarları testere görünümündedir.
Tıbbi Etkileri: Yöresel olarak böbrek ağrılarında, böbrek taşı düşürmede kullanırlar.
Kullanımı: İki bardak kaynayan suya kurutulmuş yapraklardan 1 yemek kaşığı atılır 5 dakika kadar demletilir. Sabah ve akşam aç karınla birer su bardağı içilir.
3- Türkçe adı: Aslan pençesi
Familyası: Rosaceae
Latince adı: Alchemilla Vulgaris
Bitkinin Özellikleri: 1000 m yükseklikte, çayırlık alanlarda sıkça rastlanır. 20–40 cm boylanır, sarı renkte çiçek açar yaprakları dişlidir. Bitkinin yaprakları ve çiçekleri kullanılır.
Tıbbi Etkileri: Kadın hastalıklarında etkilidir.

Kullanımı: Sabah-akşam demleyerek bir su bardağı içiyorlar.
4- Türkçe adı: Ayı Gülü
Familyası: Paeoniaceae
Latince adı: Paeonia turcica L
Bitkinin Özellikleri: Murat Dağı'nın kendine özgü bitkilerindendir. 1600–2000 m. yüksekliklerde yetişir. Dağ Gülü de denir. Çiçekleri daha çok kırmızı açan, güzel kokusu olan, 40–70 cm arası boylanan bir bitkidir. Çiçekleri ve kökleri kullanılır.
Tıbbi Etkileri: Ayı gülünün çiçekleri kadın hastalıklarında etkilidir.
Kullanımı: Gölgede kurutulmuş çiçekleri demleyerek sabah-akşam aç karınla bir su bardağı içilir.
5- Türkçe adı: Çoban çantası
Familyası: Brassicaceae
Latince adı: Capsella bursa-pastoris (L.) Medik
Bitkinin Özellikleri: Murat Dağı'nın 1000 m'den düşük rakımlarda yetişir. Beyaz çiçekler açar yaprakları küçük kalp biçiminde, 20–40 cm boylanan bir bitkidir.
Tıbbi Etkileri: Böbrek kumu iltihabında ve dış kanamalarda etkilidir.
Kullanımı: Çobançantasının çiçekleri tam açmadan toplanmalıdır. Gölgede kurutulmuş bitkinin tamamı kullanılır.
6- Türkçe adı: Çuha Çiçeği
Familyası: Primulaceae
Latince adı: Primula vulgaris
Bitkinin Özellikleri: Çuha Çiçeği Murat Dağı'nın nazlı çiçeğidir. İki çeşidi vardır. Biri sarı çiçek açan, yaprakları marul yaprağına benzeyen 20 cm kadar boy atabilen bir türdür. Diğeri ise gerçek çuha çiçeği olup Murat Dağı'nın önemli bitkilerindendir. Sivri yapraklı olan 40 cm boylanan mor çiçekleri olan bir türdür. Bu türe 1500-2000 m arasında bulunur. Sarıçiçek açan türüne sulak yerlerde, diğer türüne ise her yerde rastlanır. Çuha çiçeğinin kökü, yaprağı, çiçeği kullanılır. Yöremizde ise süs bitkisi olarak saksılarda yerini almıştır.
Tıbbi Etkileri: Çuha çiçeği iştah açıcı, balgam söktürücü, bronşit ve astımda etkilidir. Uykusuzluğa iyi gelir.
Kullanımı: Kökler ve çiçekler infüzyon yöntemleriyle hazırlanır. Sabah-akşam birer su bardağı içilir.
7- Türkçe adı: Ebe gümeci
Familyası: Malvaceae
Latince adı: Malva sylvestris L.
Bitkinin Özellikleri: Ebegümecinin bodur türünü her yaylada görebiliriz. Bodur olmayan türünü dağ içi köylerin yakın alanlarında görebiliriz. Bitkinin çiçekleri ve yaprakları kullanılır. Yörede geniş ebegümeci yapraklarından dolma yapılır. Taze yapraklar salata olarak kullanılır.
Tıbbi Etkileri: Solunum ve sindirim sistemi rahatsızlıklarında, öksürük kesici, balgam söktürücü, boğaz ağrısı, ağız içi iltihaplarında, çıban ağrılarını dindirmede kullanılır.
Kullanımı: iki su bardağı kaynamış suya 2 yemek kaşığı çiçek atılır 10 dakika demletilir süzülür Sabah-akşam birer su bardağı içilir.
8- Türkçe adı: Hüsnü Yusuf
Familyası: Caryophyllaceae
Latince adı: Dianthus arpadiaanus
Bitkinin Özellikleri: Yöresel adı dağ karanfilidir. Ormanın açık alanlarında oldukça çoktur. Bir süs bitkisidir. Tıbbi olarak çiçekleri kullanılır.
Tıbbi Etkileri: Soğuk algınlıklarında, idrar söktürücü olarak kullanılır.
Kullanımı: Çiçeklerinden demlenerek elde edilen çay sabah-akşam içilir.
9- Türkçe adı: Isırgan

Familyası: Urticaceae
Latince adı: Urtica dioica L.
Bitkinin Özellikleri: Isırgan otu Murat Dağı bitki örtüsünde önemli yer tutar. Murat Dağın çoğu derelerinde, açık alanlarında rastlanır. Yakıcı bir bitkidir. Birkaç çeşidi vardır. 20 ile 80 cm arasında boy atar. Bitkinin bütün kısımları şifa olarak kullanılır. Taze yapraklarından yemek ve börek yapılır.
Tıbbi Etkileri: Vücut şişliklerinde, öksürük, solunum yolları, kansızlık tedavisinde, romatizmal hastalıklarda, kanser başlangıç safhalarında, saç dökülmelerinde kullanılır.
Kullanımı: Sayılan rahatsızlıkların çoğunda yapraklar demlenir sabah-öğle-akşam birer su bardağı içilir. Kanser tedavisinde yaprak çayı yanında tohumları balla karıştırılır yenilir. Saç dökülmesinde ise elde edilen çay ile saçlar yıkanır.
10- Türkçe adı: Bodur Mahmut Otu
Familyası: Labiatae
Latince adı: Teucrium flavum L. subsp. hellenicum Rech.fil.
Bitkinin Özellikleri: Murat dağında yetişen bir türümüzdür. 20 cm kadar boylanır toprak üstü kısımları kullanılır. Orman içi taşlık yerlerde bulunur. Kurutulmuş yaprak ve çiçekleri kullanılır.
Tıbbi Etkileri: Mide ve bağırsak sancılarında, iştahsızlıkta, yüksek ateşte iyileştirici özelliği vardır.
Kullanımı: İki bardak kaynamış suya bir yemek kaşığı bitki herbası atılarak demlenir. Günde 3–4 defa birer fincan içilir.
11- Türkçe adı: Mürver
Familyası: Adoxaceae
Latince adı: Sambucus nigra L.
Bitkinin Özellikleri: Murat Dağının 1300 m yüksekliklerinde görülür. İki çeşidi vardır, yer mürveri ve ağaç mürveri olarak. Yer mürveri 1 m boy yapan, kötü kokulu, beyaz çiçek açan şifada kullanılmayan çeşididir. Şifada mürver ağacının çiçekleri ve meyveleri kullanılır.
Tıbbi Etkileri: İdrar söktürücü, soğuk algınlığına ve kabızlığa iyi gelir.
Kullanımı: Şifası genelde çiçeğindedir. Sabah-akşam çiçekleri demlenerek çayı içilir.
12- Türkçe adı: Salep
Familyası: Orchidaceae
Latince adı: Orchis
Bitkinin Özellikleri: Murat Dağı'nın kıymetli bitkilerindendir. İki türü görülmektedir. Biri çayırlık yerlerde iri yumru yapan bir türdür. Değerli bir tür değildir. Nedeni yumrular kurutulduğunda buruşma yapar. Diğer tür ise seyrek çamlıklarda yetişen türdür. Şifada kullanılan bu türün yumrularıdır. Ağustos ayında toplanır. Açık havada kurutulur.
Tıbbi Etkileri: Öksürük, Balgam ve çocuk ishallerini önlemede etkilidir.
Kullanımı: Yumrular toz haline getirilir. 10 gr salep tozu 1 su bardağı süte katılır kaynatılır. İshallerde ise su ile kaynatılır.
13- Türkçe adı: Yakı Otu
Familyası: Onagraceae
Latince adı: Epilobium angustifolium L.
Bitkinin Özellikleri: Murat Dağı'nın 100–1500 metre yükseklikleri arasında görülür. Kırmızı renkte çiçekler açar. 20–100 cm arası boylanır. Yaprak, kök ve çiçekleri kullanılır.
Tıbbi Etkileri: Prostatta, astım, bronşitte ve ishal kesmede etkilidir.
Kullanımı: Bitkinin herbası demlenir, Sabah–akşam birer su bardağı içilir. İshal kesici olarak çayı soğuk içilir.
14- Türkçe adı: Dağ çayı
Familyası: Labiatae
Latince adı: Sideritis libanotica Labill.

Bitkinin Özellikleri: Murat dağının çamlık diplerinde, çamlık alanlara yakın açık alanlarda yetişir.
Tıbbi Etkileri: Soğuk algınlığında, iştah açıcı, mide ağrılarını azaltıcı ve ağrı kesici olarak kullanılmaktadır.
Kullanımı: Yaprak, sürgün ve çiçekleri demleyerek kullanılır.
15- Türkçe adı: Misk adaçayı
Familyası: Labiatae
Latince adı: Salvia sclarea L.
Bitkinin Özellikleri: Murat dağının yol kenarlarında açık alanlarda yetişir.
Tıbbi Etkileri: Soğuk algınlığı, boğaz ağrıları, mide üşütmeleri, öksürük kesici ve ağız yaralarına karşı kullanılmaktadır
Kullanımı: Yaprak, sürgün ve çiçekleri demleyerek kullanılıyor.

Bu çalışmada, Kütahya ili Murat Dağı florasında bulunan ve ekonomik değeri yüksek olan tıbbi ve aromatik bitkilerin neler olduğu ve nasıl kullanıldıkları, literatür taramaları ve inceleme gezileri yapılarak belirlenmiştir. Yöre halkının ekonomik durumunun yetersiz olması, köylerin şehir merkezinden uzakta olması, zaman zaman ilaçların yan etkilerinin görülmesi gibi etkenler bitkilerin daha sık kullanılmasına yol açmıştır (Koç, 1999). Gıda olarak kullanılan bitkiler; çiğ olarak, haşlayarak veya haşlayıp süzüldükten sonra içine bulgur, pirinç katılarak, yumurtalı veya yumurtasız ya da sarımsaklı yoğurt ilave edilerek tüketilebilmektedir (Şimşek ve ark., 2002). Murat dağındaki endemiklerin yön değerlendirmesine göre 115 lokaliteden 73'ünün (%63,5) kuzey sektörde toplandığı bunlardan da %35,7'sinin Kuzeybatı yönünde yer aldığı görülmüştür. Endemiklerin yön tercihlerindeki ikinci etkin yön %27,8 ile güney yönler olarak ortaya çıkarken, bu sektörde de %14,8'lik oranla Güneybatı yönünde yoğunlaşma olmuştur. İstatistiksel verilere göre ara yönler dışında Doğu yönünde hiç lokasyon belirlenemezken, %8,7 lokaliteyle temsil edilen Batı yönü, Kuzey ve Güney yönlerine göre oldukça zayıf kalmıştır. Murat dağının Kütahya il sınırlarının kuzey kesimlerinde yer alan endemik örneklerinden %43,4'ü Kuzeybatı yönünde bulunurken, Uşak il sınırının güney kesimlerindeki örneklerin %43,8 oranında Güneybatı yönünde yer almıştır (Erinç, 1996; Atalay, 2008; Atalay, 2011). Endemik türlerin yön eğilimlerinde, ait oldukları fitocoğrafya bölge koşullarının oluştuğu lokasyonları tercih ettiği anlaşılmaktadır. Endemikler içerisindeki payı fazla olan iran-Turan fitocoğrafya bölgesi elementleri, ağırlıklı olarak karasal iklim koşullarının etkili olduğu kuzey sektör %65 ile başta olmak üzere bütün yönlere dağılmıştır. Sahada yıl boyunca etkili olan hava hareketlerinin etkisiyle Avrupa-Sibirya elementleri ve kozmopolit türlerin büyük bir kısmı serin ve nemli rüzgârlara açık Kuzey ve Kuzeybatı yönlerinde, sıcaklık ve ışık istekleri yüksek Akdeniz elementleri ise sahaya tektonik oluklar vasıtasıyla Akdeniz iklimi etkisinin sokulduğu Kuzeybatı ve Güneybatı yönlerinde bulunuyorlar (Keser, 2013). Gerçekten de etken maddelerine bakıldığı zaman, geçmişte insanların bitkileri doğru alanlarda kullandıkları görülmektedir. Çalışma alanımız olan Kütahya ili Gediz ilçesinde bulunan ve tıbbi amaçlı kullanımı olan bitkiler, daha çok mide ve solunum yolu rahatsızlıklarında kullanılmaktadır
(Yıldırımlı, 2004). Murat dağı endemiklerinin %47,8'inin horizonların tam olarak gelişmiş olduğu olgun toprak örtüsü üzerinde yer aldığı, bunun %60'ının da kahverengi orman toprakları üzerinde olduğu görülmüştür. Endemiklerin birlikte bulunduğu vejetasyon türleri ise Murat dağında baskın tür olan karaçam ile meşe türlerinin oluşturduğu ormanlar (%63,7), çayır ve steplerdir (%36,3). Endemiklerin sahadaki dağılışında, belli bir toprak ve vejetasyon seçiciliğinden ziyade yükselti, bakı ve eğim gibi topoğrafik faktörlerle anakaya türü belirleyici olmuştur (Keser, 2013). Ülkemizdeki ve yöremizdeki bitkilerin kayıt altına alınması ve arazi çalışmalarının yapılması gerekiyor. Böylece tıbbi ve aromatik bitkilerin

sayıları, yoğunlukları, biyolojik özellikleri ve ekolojik isteklerine uygun yetiştirme teknikleri ortaya konmuş olacaktır (Doğanoğlu ve ark., 2006). Özellikle ciddi hastalıkların tanısında ve tedavisinde yanılgıya düşmemek için kontrolsüz ve bilinçsiz bir şekilde tıbbi bitki kullanımına gidilmemelidir (Özer ve ark., 2001). Analizi yapılmış, içeriği belli olan, güvenilir bir şekilde temin edilen bitki türlerinin hastalıkların alternatif tedavisinde bilinçli bir şekilde kullanılması halk sağlığının olumsuz etkilenmemesi için önem arz etmektedir. Murat dağında tespit etmiş olduğumuz bitkilerin dışında başka bitkilerde mevcuttur. Ama bu bitkiler zarar görmesin diye çoğunluğu ele alınmamıştır. Bu sebepten dolayı araştırma yerlerinin özelikleri tam olarak belirtilmemiştir. Murat dağı florasında eskiden yaygın bir şekilde bulunan birçok bitki türü günümüzde ya nesli tükenmiş ya da tükenmek üzeredir. Bunun önüne geçmek için gerekli önlemlerin ve biyolojik çeşitliliğin en yüksek seviyede tutmak ve doğal ekosistemin yerinde korunmasını sağlamak yetkili kişiler ya da kurum ve kuruluşların görevleri arasındadır.

KAYNAKÇA

Atalay, İ., 2008. Ekosistem Ekolojisi ve Coğrafyası(Cilt I, II), izmir: Meta Basım ve Matbaacılık.

Atalay, İ., 2011. Türkiye Coğrafyası ve Jeopolitiği (8. Baskı),izmir: Meta Basım ve Matbaacılık.

Avcı M., 2005, Çeşitlilik ve endemizim açısından Türkiye'nin bitki örtüsü, Coğrafya Dergisi, Sayı:13, ISSN No: 1305-2128, İstanbul, 28-48.

Çırpıcı, A., 1981. Murat Dağı (Kütahya - Uşak)'nın Florası Üzerine Araştırmalar, Doçentlik Tezi, İstanbul: İstanbul Üniversitesi Botanik ve Genetik Kürsüsü.

Çırpıcı, A., 1989a. Murat Dağı (Kütahya - Uşak)'nın Florası, Doğa T. U. Botanik Dergisi, S. 2, s. 157-222.

Çırpıcı A., 1989b, Murat Dağı Florası, Ege Üniversitesi İzmir.

Doğanoğlu, Ö., Gezer, A., Yücedağ, C., 2006. Göller Bölgesi-Yenişarbademli Yöresi'nin Önemli Bazı Tıbbi ve Aromatik Bitki Taksonları Üzerine Araştırmalar. Süleyman Demirel Üniversitesi Fen Bilimleri Enstitüsü Dergisi, 10(1), 66-73.

Erinç, S., 1996. Klimatoloji ve Metodları (4. Baskı), Ġstanbul: Alfa Basım Yayım Dağıtım.

https://muratdagi.gediz.bel.tr/kayak-merkezi-319.html.14.04.2021.

Keser, N., 2013. Murat Dağı'nda Endemizme Etki Eden Topografik Faktörler (İç Batı Anadolu). Electronic Turkish Studies, 8(12).

Koç, H., 1999. İlaç ve Baharat Bitkileri- I -Gaziosmanpaşa üni. Yayınları No:40. Ders kitapları serisi No:18. Tokat.

Özer, Z., Tursun, N., Önen, H., 2001. Yabancı Otlarla Sağlıklı Yaşam (Gıda ve Tedavi). Yayınları. 133s. Ankara.

Şimşek, I., Aytekin, F., Yeşilada, E., Yıldırımlı, Ş., 2002. Anadolu'da Halk Arasında Bitkilerin Kullanılış Amaçları Üzerinde Etnobotanik Bir Çalışma Bitkisel İlaç Hammaddeleri Toplantısı, Bildiriler, 29-31 Mayıs, Eskişehir, Eds. K.H.C. Başer ve N. Kırımer Web'de yayın tarihi: Haziran 2004 ISBN 975-94077-2-8

Yıldırımlı, Ş., 2004. Etnobotanik ve Türk Etnobotaniği. Kebikeç. Alp Matbaası. Ankara. 17: 175-193.

THE ROLE OF NANOTECHNOLOGY IN HERBICIDE DEVELOPMENT: MECHANISMS, FORMULATIONS, AND ECOLOGICAL IMPACTS

HERBİSİT GELİŞTİRMEDE NANOTEKNOLOJİNİN ROLÜ: MEKANİZMALAR, FORMÜLASYONLAR VE EKOLOJİK ETKİLER

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ÖZET

Tarımsal üretim alanlarında sorun teşkil eden yabancı otların kontrolü amacıyla kullanılan geleneksel herbisitlerin getirdiği ve giderek artan sorunlardan (herbisitlere karşı direnç, çevre kirliliği ve azalan etki gibi) dolayı bu konularda çalışan insanları alternatif çözümleri araştırmaya yöneltmiştir. Nanoteknolojik yöntemler kullanarak herbisitlerin iletimini, kararlılığını ve etkinliğini artıran nanoherbisitler, yabancı ot yönetiminde umut vadeden bir yeniliği temsil etmektedir. Bu çalışma ile eldeki mevcut bilgiler doğrultusunda, nanoherbisitlerin etki mekanizmaları, formülasyon şekilleri ve etkileri konusunda genel ve kapsamlı bir bakış ortaya konulmuştur. Nano-herbisitler, tarımda bitki koruma alanında kullanılan yenilikçi bir teknolojidir. Bu teknoloji, herbisitlerin daha etkin, çevre dostu ve düşük dozajlarla kullanımını sağlarken, hedef alana yönelik kontrollü salınım imkânı sunmaktadır. Nano-herbisitler, herbisitlerin etkili maddelerini nano-parçacıklar içerisinde kapsülleyerek çevreye zarar verme riskini azaltmakta ve etkinliğini artırmaktadır. Bununla birlikte, nano-herbisitlerin uzun vadeli çevresel etkileri ve insan sağlığı üzerindeki potansiyel riskleri henüz tam olarak belirlenmemiştir. Bu nedenle, bu ürünlerin geniş çaplı kullanımı öncesinde kapsamlı araştırmalara ihtiyaç duyulmaktadır. Kapsülleme, nanoemülsiyonlar ve katı lipit nanopartikülleri dahil olmak üzere temel nano formülasyon stratejileri, herbisit salınımını kontrol etme ve hedeflenen yabancı ot kontrolünü iyileştirme yetenekleriyle ilişkili olarak tartışılmaktadır. Bunula birlikte, çalışmada nanoherbisitlerin azaltılmış çevre kirliliği, artırılmış herbisit etkinliği ve en aza indirilmiş hedef dışı etkiler gibi potansiyel faydaları vurgulanmaktadır. Bunun yanında, nanoherbisitlerin çevresel etkileri, toksisitesi, biyolojik olarak parçalanabilirliği ve düzenleyici endişeleriyle ilgili zorluklar da ele alınmıştır.

Anahtar Kelimeler: Nanoteknoloji, Herbisit geliştirme, Yabancı otlar, Formülasyonlar, Ekolojik etkiler.

ABSTRACT

The increasing problems (such as herbicide resistance, environmental pollution and reduced efficacy) caused by traditional herbicides used to control weeds that pose a problem in agricultural production areas have led people working on these issues to look for alternative solutions. Nanoherbicides, which use nanotechnology to improve the transfer, stability and efficacy of herbicides, are a promising innovation in weed management. This study has provided a general and comprehensive overview of the mechanisms of action, formulations and effects of nanoherbicides in accordance with the available information. Nanoherbicides are an innovative technology that is used in the agricultural sector for plant protection. This technology enables more effective, environmentally friendly and lower-dose use of herbicides, while offering the possibility of controlled release to the target area. Nanoherbicides reduce the risk of environmental damage and increase their effectiveness by encapsulating the active ingredients of herbicides in nanoparticles. However, we do not yet have a complete understanding of the long-term environmental effects of nanoherbicides and their potential risks to human health. A great deal of research is therefore needed before these products can be used on a large scale. Major nanoformulation strategies including encapsulation, nanoemulsions and solid lipid nanoparticles are discussed in relation to their ability to control herbicide release and improve targeted weed control. However, the study highlights the potential benefits of nanoherbicides such as reduced environmental impact, improved herbicide efficacy and minimised off-target effects. In addition, the challenges associated with the environmental impact, toxicity, biodegradability and regulatory concerns of nanoherbicides will also be addressed.

Keywords: Nanotechnology, Herbicide Development, Weeds, Formulations, Ecological Impacts.

GİRİŞ

Herbisitler, çiftçilerin besin, su ve ışık için mahsullerle rekabet eden yabancı otları kontrol etmelerini sağlayarak modern tarımda önemli bir rol oynar. Etkili yabancı ot yönetimi, mahsul verimliliğini korumak ve gıda güvenliğini sağlamak için esastır, çünkü kontrolsüz yabancı otlar mısır, pirinç ve buğday gibi büyük mahsullerde verimi %40'a kadar azaltabilir (Oerke, 2006). Herbisitler, toprak erozyonunu ve işçilik maliyetlerini azaltmaya yardımcı olarak geleneksel ve sıfır toprak işlemeli tarım sistemlerinin ayrılmaz bir parçasıdır. Ancak, geleneksel herbisitlerin yaygın ve tekrarlanan kullanımı, herbisit direnci, çevre kirliliği ve hedef dışı organizmalara zarar verme gibi çeşitli çevresel ve tarımsal zorluklara yol açmıştır (Powles and Yu, 2010).

Son yıllarda, nanoteknoloji, özellikle nanoherbisitlerin geliştirilmesi yoluyla, bitki korumadaki bu sınırlamaları ele almak için umut verici bir araç olarak ortaya çıkmıştır. Nanoherbisitler, aktif bileşenlerin iletimini ve etkinliğini artırmak için nanopartiküller kullanan herbisit formülasyonlarıdır. Nanoherbisitler, herbisit bileşiklerini nanopartiküllere kapsülleyerek veya bağlayarak, geleneksel formülasyonlara göre birkaç potansiyel avantaj sunar. Bunlar arasında iyileştirilmiş kararlılık, kontrollü ve yavaş salınımlı özellikler, artırılmış biyoyararlanım ve azaltılmış hedef dışı etkiler bulunur (Kah *et al*., 2013). Nanopartiküller ayrıca bitki dokuları tarafından herbisit emilimini iyileştirebilir, etkinliği artırırken potansiyel olarak gerekli uygulama oranlarını düşürebilir (Ghormade *et al*., 2011).

Dahası, nanoherbisitlerin kullanımı, yabancı ot kontrolünün çevresel ayak izini en aza indirerek sürdürülebilir tarıma katkıda bulunabilir. Nano bazlı dağıtım sistemleri, ihtiyaç duyulan aktif bileşen miktarını azaltma ve herbisitlerin çevreye sızmasını, akmasını ve birikmesini sınırlama potansiyeline sahiptir. Ek olarak, daha fazla yabancı ot türünün yaygın olarak kullanılan herbisitlere direnç geliştirmesiyle önemli bir küresel sorun haline gelen herbisite dirençli yabancı otların büyüyen sorununa olası bir çözüm sunarlar (Heap, 2014). Ancak, vaatlerine rağmen, nanoherbisitler aynı zamanda çevresel ve insan sağlığı etkileri konusunda endişelere de yol açmaktadır. Nanopartiküllerin toprak ve su ekosistemlerindeki uzun vadeli etkileri ve insan maruziyeti riskleri üzerine yapılan araştırmalar sınırlı kalmaya devam etmektedir (De Oliveira *et al*., 2014). Nano-herbisitler, tarımda bitki koruma alanında son yıllarda dikkat çeken yenilikçi bir teknolojidir. Geleneksel herbisitlerin bazı dezavantajlarını aşmak amacıyla geliştirilmiş bu nano-formülasyonlar, etkinlik, çevre dostu özellikler ve düşük dozajda kullanım imkânı sunmaktadır. Nano-teknolojinin sağladığı kontrollü salınım, hedefe yönelim ve uzun süreli etki özellikleri, nano-herbisitlerin popülaritesini artırmaktadır.

Bu literatür incelemesinin amaçları, nanoherbisitlerin kapsamlı bir analizini sunmak, potansiyel faydalarını ve risklerini incelemek ve bilgi boşluklarını ve daha fazla araştırma için alanları belirlemektir. Bu inceleme, nanoherbisit teknolojisinin mevcut durumunu inceleyecek, çeşitli nano formülasyon türlerini, etki mekanizmalarını, çevresel ve ekonomik etkilerini ve kullanımlarını çevreleyen düzenleyici zorlukları ayrıntılı olarak açıklayacaktır. Mevcut literatürü sentezleyerek, bu inceleme nanoherbisitlerin sürdürülebilir yabancı ot yönetiminde oynayabileceği rolün net bir şekilde anlaşılmasını sağlamayı ve gelecekteki araştırmalar için yönler ana hatlarını çizmeyi amaçlamaktadır.

Tarımda Nanoteknolojiye Genel Bakış

Benzersiz özelliklere sahip yapılar oluşturmak için moleküler ve atomik seviyelerdeki malzemeleri manipüle etme bilimi olan nanoteknoloji, tarımda önemli ilgi görmüştür. Genellikle 1 ila 100 nanometre arasında değişen boyutlardaki parçacıklar olarak tanımlanan nanopartiküller (NP'ler), yüksek yüzey alanı-hacim oranı ve kuantum etkileri nedeniyle toplu benzerlerinden farklı olan yeni fiziksel ve kimyasal özellikler sergiler (Rai and Ingle, 2012). Bu benzersiz özellikler, nanopartikülleri tarımsal uygulamalarda özellikle etkili hale getirir, çünkü herbisitler, gübreler ve pestisitler dahil olmak üzere tarımsal kimyasalların kararlılığını, çözünürlüğünü ve biyoyararlanımını artırabilirler (Kah *et al.,* 2013).

Tarımda Nanoteknolojinin Uygulamaları

Tarımda nanoteknoloji, bitki korumayı, besin dağıtımını ve toprak sağlığını iyileştirebilir. Bitki koruma için nano formülasyonlar, herbisitler, böcek ilaçları ve fungusitlerin aktif bileşenlerin hassas bir şekilde etki bölgesineiletilmesini sağlayarak çevresel etkiyi en aza indirirken etkinliği en üst düzeye çıkarır. Nanoteknolojinin sağladığı kontrollü salınım sistemleri, tarımsal kimyasalların zamanla kademeli olarak salınmasını sağlar, bu da tedavilerin ömrünü uzatır ve sık tekrar uygulama ihtiyacını azaltır (Gogos *et al*., 2012). Dahası, bu nano formülasyonlar, sıcaklık, pH veya nemdeki değişiklikler gibi belirli çevresel tetikleyicilere yanıt olarak içeriklerini salacak şekilde tasarlanabilir ve aktif bileşenlerin hedeflenen, talep üzerine iletilmesini sağlar (Ghormade *et al*., 2011). Nanoteknoloji ayrıca, besinleri mahsullere kademeli olarak sağlayan kontrollü salınımlı nano formülasyonlarda gübreler sunarak besin kullanım verimliliğini artırabilir, böylece besin akışını azaltır ve alımı artırır. Örneğin, nano kapsüllü gübreler, çevre kirliliğini en aza indirmek ve mahsul verimini artırmak için kritik öneme sahip olan azot kullanım verimliliğini artırmada potansiyel göstermiştir (De Rosa *et al*., 2010).

Bitki Korumada Kullanılan Nanopartikül Türleri

Bitki korumada çeşitli nanopartikül türleri kullanılır ve her biri herbisit iletimi ve etkinliği için belirli faydalar sunar:

Polimerik Nanopartiküller: Bunlar genellikle poli(laktik-ko-glikolik asit) (PLGA) veya kitosan gibi polimerlerden yapılan biyolojik olarak parçalanabilir partiküllerdir. Polimerik nanopartiküller, herbisit aktif bileşenlerini kapsülleyebilen kontrollü ve sürekli salınım sağlayan bir matris sağlar. Özellikle hidrofobik bileşikleri iletmek, bunların stabilitesini artırmak ve çevrede erken bozulmayı önlemek için faydalıdırlar (Pereira *et al.,* 2014).

Lipit Bazlı Nanopartiküller: Katı lipit nanopartikülleri (SLN'ler) ve nanoyapılı lipit taşıyıcıları (NLC'ler) gibi lipit nanopartiküller de tarımsal formülasyonlarda yaygın olarak kullanılır. Bu nanopartiküller, hidrofobik aktif bileşenleri etkili bir şekilde kapsülleyebilen doğal veya sentetik lipitlerden oluşur. Biyouyumlulukları ve aktif bileşiklerin biyoyararlanımını iyileştirme yetenekleri nedeniyle, lipit bazlı nanopartiküller sürdürülebilir ve güvenli tarımsal kimyasal uygulamalar için umut verici olarak kabul edilir (Ali *et al.,* 2014).

Metal ve Metal Oksit Nanopartiküller: Çinko oksit (ZnO), titanyum dioksit (TiO_2) ve gümüş (Ag) nanopartiküller gibi metal oksit nanopartiküller, antimikrobiyal ve pestisit özellikleri nedeniyle etkilidir. Bu partiküller, yabancı otlarda, patojenlerde ve böceklerde hücre zarlarını bozarak direnç gelişimini önlemeye yardımcı olabilecek alternatif bir etki şekli sağlayabilir. Ek olarak, bazı metal nanopartiküller diğer tarımsal kimyasallar için taşıyıcı görevi görerek bitki dokuları tarafından penetrasyonu ve alımı artırır (Dimkpa and Bindraban, 2018).

Silika Nanopartiküller: Silika nanopartiküller, geniş yüzey alanları, ayarlanabilir gözenek boyutları ve biyouyumlulukları nedeniyle çok yönlüdür. Bu partiküller tarımsal kimyasalları adsorbe edebilir ve taşıyabilir ve gözenekli yapıları kontrollü salınım sağlar. Mezogözenekli silika nanopartiküller (MSN'ler), bitkilerdeki hedef bölgelere aktif bileşiklerin çözünürlüğünü ve iletimini iyileştirme yetenekleri göz önüne alındığında, herbisitler için taşıyıcı olarak özellikle popülerdir (Chhipa, 2017).

Geleneksel Yöntemlere Göre Nano-Formülasyonların Avantajları

Nano-formülasyonlar, geleneksel tarım kimyasallarına göre çeşitli avantajlar sunar. Nanopartiküllerin küçük boyutu ve yüksek yüzey alanı, aktif bileşenlerin çözünürlüğünü, kararlılığını ve penetrasyonunu artırarak, bunları daha düşük dozlarda daha etkili hale getirir (Kah *et al*., 2013). Etkinlikteki bu artış, uygulanan tarım kimyasallarının miktarını azaltabilir, potansiyel olarak maliyetleri düşürebilir ve çevre kirliliğini en aza indirebilir. Örneğin, nanopartiküller bitki dokularına daha büyük partiküllerden daha kolay nüfuz edebilir, bu da herbisitlerin ve diğer tarım kimyasallarının iletimini ve etkinliğini artırır (Servin *et al*., 2015).

Nanoherbisitlerin Etki Mekanizmaları ve Avantajları

Nanoherbisitler, kontrollü salınım, hedefli dağıtım ve gelişmiş biyoyararlanım gibi benzersiz etki mekanizmaları nedeniyle geleneksel herbisitlere göre önemli bir ilerlemeyi temsil eder. Bu mekanizmalar, herbisit formülasyonlarının kararlılığını, etkinliğini ve çevresel güvenliğini iyileştirmek için nanopartiküllerin özelliklerini kullanır. Nanoherbisitler, aktif bileşenlerin salınımını kontrol ederek ve hedefleyerek potansiyel olarak uygulama oranlarını azaltabilir, çevre kirliliğini en aza indirebilir ve yabancı otlarda herbisit direncini yönetmek için yeni bir yaklaşım sunabilir (Kah *et al.,* 2013).

Kontrollü Salınım Mekanizmaları

Nanoherbisitlerin temel faydalarından biri kontrollü salınım özellikleridir. Geleneksel herbisitler genellikle uygulamadan sonra aktif bileşenlerini hızla dağıtır ve bu da çevre kirliliğine ve azaltılmış etkinliğe katkıda bulunan sızma, akış ve buharlaşma gibi sorunlara yol açar (Gogos *et al*., 2012). Ancak nanoherbisitler, aktif bileşenlerini zamanla yavaş ve istikrarlı bir şekilde salacak şekilde tasarlanabilir, böylece herbisidal etki uzatılır ve uygulama sıklığı en aza indirilir. Kontrollü salınım, aktif bileşenleri kademeli olarak veya belirli çevresel tetikleyicilere yanıt olarak salacak şekilde tasarlanmış polimerik nanopartiküller veya mezogözenekli silika parçacıkları gibi malzemeler içinde kapsülleme yoluyla elde edilir (Pereira *et al*., 2014). Bu yaklaşım, herbisitin tarlada uzun ömürlülüğünü ve etkinliğini artırırken istenmeyen dağılma riskini en aza indirir.

Kontrollü salınım, çevre kirliliğini azaltmanın yanı sıra, hassas büyüme aşamalarındaki yabancı otları hedeflemek için çok önemli olan hassas dozajlamayı da mümkün kılar. Nanoherbisitler, çevrede sürekli bir varlık sürdürerek yabancı otları daha uzun bir süre boyunca etkili bir şekilde kontrol edebilir ve ortaya çıkan yabancı ot fidelerinin sürekli olarak herbisite maruz kalmasını sağlayabilir. Bu sürekli etki, sık tekrar uygulama ihtiyacını azaltarak hem işçilik hem de malzeme maliyetlerini düşürebilir (Perez-de-Luque and Rubiales, 2009).

Hedeflenen Dağıtım ve Geliştirilmiş Biyoyararlanım

Nanopartiküller, aktif bileşenin yabancı ottaki hedef bölgeye ulaşma derecesi ve hızı anlamına gelen herbisitlerin biyoyararlanımını iyileştirmek için uyarlanabilir. Nanoherbisitler, geleneksel formülasyonlardan daha etkili bir şekilde bitki dokularına nüfuz eden nanopartiküller kullanarak hedeflenen dağıtımı gerçekleştirebilir. Örneğin, belirli nanopartiküller bitkinin kütikülünü ve hücre duvarlarını atlayarak yabancı ot dokuları tarafından daha etkili bir şekilde herbisit emilimi ve alımına olanak tanır (Ghormade *et al.,* 2011). Bu özellik, meristemler veya kökler gibi belirli büyüme bölgelerine ulaşmak için yabancı ot içinde taşınması gereken sistemik herbisitler için özellikle faydalıdır. Hedeflenen dağıtım, ihtiyaç duyulan herbisit miktarını azaltır ve hedef dışı etkileri en aza indirir, bu da çevredeki mahsulleri, toprak organizmalarını ve diğer hedef dışı türleri korumaya yardımcı olabilir (Kah and Hofmann, 2014). Örneğin, polimerik ve lipit bazlı nanopartiküller genellikle hidrofobik herbisitleri kapsüllemek, çözünürlüklerini ve biyoyararlanımlarını artırmak için kullanılır. Katı lipit nanopartikülleri (SLN'ler) ve nanoyapılı lipit taşıyıcıları (NLC'ler) gibi lipit bazlı nano taşıyıcılar, lipit bileşimleri nedeniyle hücre zarlarıyla birleşerek aktif bileşenin bitki hücrelerine girmesini kolaylaştırır. Hücre zarlarıyla birleşme yeteneği, nanoherbisitlerin aktif bileşikleri daha doğrudan ve etkili bir şekilde yabancı otlara iletmesini sağlar (Ali *et al.,* 2014). Ek olarak, gümüş veya çinko oksit gibi metal ve metal oksit nanopartikülleri, yabancı otları ve belirli patojenleri aynı anda hedefleyebilen herbisit ve antimikrobiyal etkilerin ikili bir etkisini sunarak doğal antimikrobiyal özellikler sergiler (Servin *et al.,* 2015).

Geleneksel Herbisitlere Kıyasla Gelişmiş Etkinlik

Nanoherbisitler, biyoyararlanım, kararlılık ve çevresel etki açısından geleneksel herbisitlere göre çeşitli iyileştirmeler sunar. Geleneksel herbisitler genellikle UV radyasyonu, sıcaklık ve mikrobiyal aktivite gibi çevresel faktörler tarafından bozulur ve bu da etkinliğin azalmasına ve daha yüksek uygulama oranlarına ihtiyaç duyulmasına neden olur (Perez-de-Luque and Rubiales, 2009). Öte yandan nanoherbisitler, nanopartiküller aktif bileşenleri çevresel bozulmadan koruyabildiği için gelişmiş kararlılık sağlar. Bu koruma, nanoherbisitlerin daha uzun süreler boyunca etkililiğini korumasını sağlayarak onları daha etkili ve çevresel kayba daha az duyarlı hale getirir (Kah *et al.,* 2013).

Nanoherbisitler, aktif bileşiklerin biyoyararlanımını artırarak, geleneksel formülasyonlara kıyasla aynı veya daha yüksek etkinliğe ulaşmak için daha düşük dozlara olanak tanır. Örneğin, araştırmalar nano kapsüllü herbisitlerin hedef yabancı otları etkili bir şekilde kontrol etmek için daha düşük dozajlar gerektirdiğini ve bunun da tarımsal kimyasal uygulamalarının genel çevresel yükünü azaltmaya yardımcı olduğunu göstermiştir (Dimkpa and Bindraban, 2018).

Nanoherbisitlerin Formülasyonu ve Türleri

Nanoherbisitlerin formülasyonu, aktif bileşenlerin daha iyi iletilmesini ve kontrollü salınımını sağlayan gelişmiş nanoteknolojik teknikleri içerir. Kapsülleme, aktif bileşenlerin polimerik veya lipit bazlı bir kabuk içinde kapsüllendiği en yaygın tekniklerden biridir. Kapsülleme, herbisitin uzun süreli salınımına izin vererek çevresel bozulmaya karşı koruma sağlar. Emülsiyonlar ve nanoemülsiyonlar, herbisitin küçük damlacıklarının bir yağ-su emülsiyonu içinde stabilize edildiği ve herbisitin stabilitesini ve emilimini artırdığı diğer popüler yöntemlerdir (Pereira *et al*., 2014; Kah and Hofmann, 2014).

Formülasyona göre, nanoherbisitler birkaç türe ayrılabilir:

Nanokapsüller: Bunlar, aktif bileşenin bir nanotaşıyıcı kabuk içinde kapatıldığı küçük kapsüllerdir. Nanokapsüller kademeli salınıma izin verir ve kontrollü herbisit dağılımı sunarak hedef dışı etkileri en aza indirir (Ghormade *et al*., 2011).

Nanojeller: Bu hidrofilik polimer ağları suda şişer ve büyük miktarda herbisit tutabilir. Nanojeller kontrollü salınımı kolaylaştırır ve özellikle sulu ortamlarda faydalıdır (Nair *et al.*, 2010).

Katı Lipit Nanopartikülleri (SLN'ler): Bu nanopartiküller katı lipitlerden oluşur ve lipofilik herbisitlerin stabilitesini ve biyoyararlanımını artırabilir. SLN'ler biyolojik olarak parçalanabilir ve herbisitin bitki dokularına nüfuz etmesini iyileştirebilir (Ali *et al*., 2014).

Bu nano-formülasyon tiplerinin her biri farklı avantajlar sunar. Örneğin, nanokapsüller belirli bölgeleri hedef alabilir ve herbisit israfını azaltabilirken, nanojeller kontrollü salınım sağlar ve özellikle sürekli toprak uygulaması için faydalıdır. Bu arada katı lipit nanopartikülleri, hızlı bozunmaya meyilli herbisitler için geliştirilmiş stabilite sunarak, daha uzun raf ömrü ve sahada etkinlik sağlar (Gogos *et al*., 2012; Servin et a., 2015).

Nanoherbisitlerin Çevresel ve Ekolojik Etkileri

Nanoherbisitler, sık uygulama ihtiyacını azaltarak ve akıntı ve sızmayı sınırlayarak potansiyel çevresel faydalar sunar. Geleneksel herbisitlerle karşılaştırıldığında, nano formülasyonlar kontrollü ve hedefli salınım sağlayarak çevre kirliliğini en aza indirebilir ve bu da hedef dışı alanlara ulaşan herbisit miktarını azaltır (Kah *et al*., 2013). Ancak nanoherbisitlerin toprak, su ve ekosistemlerdeki kaderi, nanopartiküller toprak bileşenleri ve mikrobiyal topluluklarla benzersiz etkileşimler gösterebildiğinden, aktif bir araştırma alanı olmaya devam etmektedir.

Nanoherbisit toksisitesi üzerine yapılan çalışmalar hem potansiyel faydaları hem de riskleri göstermektedir. Bazı nanoherbisitler toksik olmayan yan ürünlere dönüşürken, diğerleri çevrede birikerek kalıcılıkları ve biyolojik birikimleri konusunda endişelere yol açabilir. Örneğin, metal oksit nanopartikülleri üzerine yapılan araştırmalar, herbisitler olarak etkili olabilmelerine rağmen, topraktaki kalıcılıklarının toprak mikrobiyal aktivitesini ve besin döngülerini etkileyebileceğini göstermiştir (Dimkpa and Bindraban, 2018). Biyolojik olarak parçalanabilirlik kritik bir husustur, çünkü doğal polimerlere dayalı olanlar gibi biyolojik olarak parçalanabilir nanopartiküller, uzun vadeli çevresel riskleri en aza indiren daha güvenli alternatifler sunabilir (Pereira *et al.*, 2014).

Ekonomik ve Tarımsal Faydalar

Nanoherbisitler, herbisit verimliliğini artırarak ve uygulama sıklığını azaltarak potansiyel ekonomik faydalar sunar. Kontrollü salınımlı formülasyonlar, tekrarlanan uygulamalara olan ihtiyacı azaltarak çiftçiler için işgücü ve işletme maliyetlerini düşürür (De Rosa *et al.*, 2010). Ek olarak, nanoherbisitler daha hassas ve tutarlı yabancı ot kontrolü sağlayarak ürün verimini ve üretkenliğini artırabilir. Çalışmalar, nano formülasyonların herbisit etkinliğini artırdığını, gereken genel aktif bileşen miktarını azalttığını ve uzun vadede maliyetleri potansiyel olarak düşürdüğünü göstermiştir (Gogos *et al.*, 2012).

Nanoherbisitlerle İlişkili Zorluklar ve Riskler

Potansiyellerine rağmen nanoherbisitler çeşitli sağlık ve çevre riskleriyle karşı karşıyadır. Nanopartiküller küçük boyutları nedeniyle biyolojik zarlara nüfuz ederek insanlar, hayvanlar ve hedef dışı organizmalar için potansiyel sağlık riskleri oluşturabilir (Ghormade *et al.*, 2011). Nanoherbisitleri değerlendirmek ve düzenlemek için şu anda standartlaştırılmış bir çerçeve olmadığından düzenleyici sorunlar da bir zorluk olmaya devam etmektedir. Bu standartlaştırma eksikliği onay sürecini karmaşıklaştırmakta ve uzun vadeli güvenlik konusunda endişelere yol açmaktadır (Kah and Hofmann, 2014). Kamuoyu algısı bir diğer engeldir; bazı tüketiciler çevresel etki ve gıda güvenliği konusundaki endişeleri nedeniyle tarımda nanoteknolojiyi kabul etmekte tereddüt edebilir. Ayrıca, nanoherbisitlerin ekosistemlerdeki uzun vadeli etkilerinin, özellikle toprak sağlığı ve biyoçeşitlilik üzerindeki etkilerinin anlaşılmasında bilgi boşlukları vardır (Servin *et al.*, 2015).

Nano-Herbisitlerin Avantajları ve Etki Mekanizmaları

Nano-herbisitler, bitki koruma ürünlerinin daha etkili ve sürdürülebilir kullanılmasını sağlar. Bu tür herbisitler, herbisitlerin etkin maddesini kapsüller veya nano-parçacıklar içine hapsederek, herbisitin sadece hedef alana ulaşmasını sağlayabilir. Bu özellik, diğer bitkilere ve çevreye zarar verme riskini azaltırken, herbisitin etkinliğini artırır (Ghormade *et al.*, 2011).

Nano-parçacıklar, bitki yaprakları ve kökleri tarafından daha kolay absorbe edilebileceğinden, herbisitlerin biyoyararlanımı artar. Ayrıca, bu tür formülasyonlar, herbisitin çevrede daha uzun süre kalmasına ve etkinliğini kaybetmeden daha düşük dozajlarda kullanılmasına olanak tanır (Kah *et al.*, 2013).

Çevresel ve Ekonomik Faydaları

Geleneksel herbisit uygulamaları çevre kirliliğine ve hedef dışı organizmalara zarar verebilirken, nano-herbisitler bu sorunları azaltmada önemli rol oynayabilir. Örneğin, nano-formülasyonlar sayesinde herbisitler yavaş salınım yapar ve çevrede daha az birikme eğilimi gösterir. Bu da, özellikle su kaynaklarına herbisit bulaşmasını azaltarak çevresel etkiyi minimuma indirir (De Oliveira *et al.*, 2014).

Ekonomik açıdan nano-herbisitler, daha az herbisit kullanımıyla maliyetleri düşürebilir. Ayrıca, kontrollü salınım özelliği sayesinde herbisitler daha az sayıda uygulama ile etkili olabilir, bu da işçilik maliyetlerini azaltabilir (Ditta, 2012).

Nano-Herbisitlerin Sınırlamaları ve Riskleri

Nano-herbisitlerin potansiyel avantajlarına rağmen, henüz tam anlamıyla risk profilleri ortaya konmamıştır. Nano-parçacıkların uzun vadeli çevresel etkileri ve insan sağlığı üzerindeki olası riskleri konusunda daha fazla araştırmaya ihtiyaç vardır. Özellikle, nano-parçacıkların biyobirikimi ve çevresel toksisitesi, bu ürünlerin tarımda yaygın kullanımı öncesinde dikkate alınmalıdır (Khot *et al*., 2012).

SONUÇ ve ÖNERİLER

Nanoteknoloji, yabancı otların herbisitlere karşı oluşturdukarı direnç, çevre kirliliği ve geleneksel formülasyonlarla ilişkili azaltılmış etkinlik gibi kritik zorlukları ele alarak herbisitlerin geliştirilmesinde umut verici bir çözüm olarak ortaya çıkmıştır. Kapsülleme, nanoemülsiyonlar ve katı lipit nanopartiküller gibi tekniklerle tasarlanan nanoherbisitler, aktif bileşenlerin kararlılığını, aktif maddenin etki bölgesine ulaşmasını ve kontrollü salınımını artırarak artan verimlilik, düşük olumsuz çevresel etki ve en aza indirilmiş hedef dışı etkiler gibi önemli avantajlar sunmaktadır. Bu avantajlarla birlikte, özellikle nanopartiküllerin uzun vadeli ekolojik ve insan sağlığı etkileri, çevrede kalıcılıkları, potansiyel toksisiteleri ve kapsamlı bir düzenleyici yasal çerçevenin olmaması konusundaki zorluklar devam etmektedir.

Nanoherbisitlerin sürdürülebilir gelişimini ve üreticiler tarafından benimsenmesini sağlamak için çeşitli tedbirler önerilmektedir. Nanopartiküllerin çevresel akibetini, toksisitesini ve biyolojik olarak parçalanabilirliğini değerlendirmek için kapsamlı risk değerlendirmeleri gerekmektedir. Standartlaştırılmış düzenleyici yasal çerçevelerin oluşturulması, bu teknolojilerin benimsenmesi ve izlenmesi için net yönergeler sağlayacaktır. Uzun vadeli çevresel çalışmalar, ekosistemlerdeki nanopartiküllerin kalıcılığını ve biyolojik birikimi araştırmalı ve biyoçeşitlilik, toprak sağlığı ve su kalitesi üzerindeki etkilerine odaklanmalıdır.

Nanoherbisitlerin faydaları ve riskleri hakkında kamuoyunun farkındalığını artırma çabaları, bunların kabul edilmesi ve sorumlu bir şekilde kullanılması için önemlidir. Bu teknolojileri tüm çiftçiler, özellikle de küçük ölçekli tarım sistemlerindekiler için erişilebilir kılmak amacıyla maliyet etkin üretim yöntemleri geliştirilmelidir. Araştırmalar ayrıca, etkinliği korurken potansiyel riskleri en aza indirmek için çevreye zararsız ve biyolojik olarak parçalanabilir nanopartiküllerin üretilmesine odaklanmalıdır. Sonuç olarak, nanoherbisitler, aktif maddelerin etkinliklerini artırmak ve tarımsal ekosistemlerin uzun vadeli sürdürülebilirliğine katkıda bulunmak için hassas çiftçilik ve entegre yabancı ot yönetim sistemleri gibi sürdürülebilir tarım uygulamalarına entegre edilmelidir. Bu yönleri ele alarak, nanoherbisitler tarımsal uygulamaları ilerletmede ve çevresel sürdürülebilirliği sağlamada önemli bir rol oynayabilecektir.

KAYNAKLAR

Ali, A., Zafar, H., Zia, M., Ul Haq, I., Phull, A. R., Ali, J. S., & Hussain, A. (2014). *Synthesis, characterization, applications, and challenges of iron oxide nanoparticles.* Nanotechnology, Science and Applications, 7, 49-67.

Chhipa, H. (2017). *Nanofertilizers and nanopesticides for agriculture*. Environmental Chemistry Letters, 15(1), 15-22.

De Oliveira, J. L., Campos, E. V., Bakshi, M., & Fraceto, L. F. (2014). *Application of nanotechnology for the encapsulation of botanical insecticides for sustainable agriculture: Prospects and promises.* Biotechnology Advances, 32(8), 1550-1561.

De Rosa, M. C., Monreal, C., Schnitzer, M., Walsh, R., & Sultan, Y. (2010). *Nanotechnology in fertilizers.* Nature Nanotechnology, 5, 91-96.

Dimkpa, C. O., & Bindraban, P. S. (2018). *Nanofertilizers: New products for the industry?* Journal of Agricultural and Food Chemistry, 66(26), 6462-6473.

Ghormade, V., Deshpande, M. V., & Paknikar, K. M. (2011). *Perspectives for nano-biotechnology enabled protection and nutrition of plants.* Biotechnology Advances, 29(6), 792-803.

Gogos, A., Knauer, K., & Bucheli, T. D. (2012). *Nanomaterials in plant protection and fertilization: Current state, foreseen applications, and research priorities*. Journal of Agricultural and Food Chemistry, 60(39), 9781-9792.

Pereira, A. E., Grillo, R., Mello, N. F., Rosa, A. H., & Fraceto, L. F. (2014). *Application of poly (epsilon-caprolactone) nanoparticles containing atrazine herbicide as an alternative technique to control weeds and reduce damage to the environment.* Journal of hazardous materials, 268, 207-215.

Heap, I. (2014). *Global perspective of herbicide-resistant weeds.* Pest Management Science, 70(9), 1306-1315.

Kah, M., & Hofmann, T. (2014). *Nanopesticide research: Current trends and future priorities*. Environment International, 63, 224-235.

Kah, M., Beulke, S., Tiede, K., & Hofmann, T. (2013). *Nanopesticides: state of knowledge, environmental fate, and exposure modeling.* Critical Reviews in Environmental Science and Technology, 43(16), 1823-1867.

Khot, L. R., Sankaran, S., Maja, J. M., Ehsani, R., & Schuster, E. W. (2012). *Applications of nanomaterials in agricultural production and crop protection: A review.* Crop Protection, 35, 64-70.

Oerke, E. C. (2006). *Crop losses to pests.* The Journal of Agricultural Science, 144(1), 31-43.

Pérez-de-Luque, A., & Rubiales, D. (2009). *Nanotechnology for parasitic plant control.* Pest Management Science: formerly Pesticide Science, 65(5), 540-545.

Powles, S. B., & Yu, Q. (2010). *Evolution in action: Plants resistant to herbicides.* Annual Review of Plant Biology, 61, 317-347.

Rai, M., & Ingle, A. P. (2012). *Role of nanotechnology in agriculture with special reference to management of insect pests*. Applied Microbiology and Biotechnology, 94(2), 287-293.

Servin, A., Elmer, W., Mukherjee, A., De la Torre-Roche, R., Hamdi, H., White, J. C., & Bindraban, P. (2015). *A review of the use of engineered nanomaterials to suppress plant disease and enhance crop yield*. Journal of Nanoparticle Research, 17(2), 1-21.

Ditta, A. (2012). *How helpful is nanotechnology in agriculture?.* Advances in Natural Sciences: Nanoscience and Nanotechnology, 3(3), 033002.

PROPOLİSDEN KATMA DEĞERLİ ÜRÜNLER VE İLGİLİ BİLEŞİKLER

VALUE-ADDED PRODUCTS AND RELATED COMPOUNDS FROM PROPOLIS

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ÖZET

Giriş ve Amaç: Bu çalışmanın amacı Türk propolisinden elde edilen çözücü özütlerinin kimyasal bileşimini, antioksidan ve antimikrobiyal aktivitelerini araştırmaktır. Propolis bazlı doğal bileşikler farmakoloji, kozmetik, tarım kimyasalları ve gıda alanlarında yaygın olarak kullanılmaktadır. Doğal ürünler kanser, nörodejeneratif bozukluklar ve geniş spektrumlu terapötik özelliklerde etkilidir. Propolis, arı ürünlerine ait tıbbi bir bitkisel üründür. Anti-inflamatuar, antikonvülsan, antioksidan, anti-emetik, anksiyolitik ve antipsikotik ajan gibi terapötik ve biyolojik aktivitelere sahiptir ve bu nedenle sırasıyla nöroinflamasyon, epilepsi, oksidatif hasar, kusma ve mide bulantısı, anksiyete ve şizofreni tedavisi için potansiyel bir ilaçtır. Propolisin ana bileşenleri kafeik asitler gibi bileşiklerdir, kafeik asit fenetil esteri propolisten toplanan temel aromatik bileşenlerden biridir. İçinde %10'a kadar flavonoid ve fenolik özütler temsil edebilen propolis. Bazı önemli yan etkileri olan terapötik özellikleri bir arada bulunduran başlıca aktif bitki kökenli fenolikler içerir. Propolis gibi arı ürünleri onlarca yıldır bilinmiyordu.

Gereç ve Yöntemler: Türkiye, propolisin ekonomi ve çevre açısından bir ürün olarak önemini belirlemek için Çankırı Merkezden propolis temin edildi. Propolis üretimi ve yetiştiriciliği yapan çiftçiden temin edilen propolis, kolon kromatografisi ve TLC ile ayırma işlemlerinden sonra saflaştırıldı. Saflaştırılan fenolik bileşikler NMR ve diğer spektroskopik yöntemler ile karakterize edildi.

Bulgular: Propolisin yapısında yaklaşık %55 oranında reçineli bileşikler, %30 oranında balmumu, %10 oranında aromatic bileşikler ve %5 oranında arı poleninin bulunmaktadır. Propoliste mevcut olan 350'den fazla fenolik bileşiklerden miktarı fazla olanlar saflaştırıldı.

Tartışma ve Sonuç: Propolisten ayrıştırılan ve tanımlanan biyoaktif fitokimyasallar flavonlar ve flavonoidler, alkoller, terpenler ve terpenoidler, aldehitler, aromatik asitler ve esterleri, kalkonlar, alifatik asitler ve esterleri, ketonlar, amino asitler ve hidrokarbonlardır. Propolisin katma değeri yüksek tarımsal ürünlere dönüştürülmesiyle yerel halka ekonomik katkı sağlanabilir.

Anahtar Kelimeler: Arı ürünleri; scCO2; uçucu parçalar; aktiviteler

ABSTRACT

Introduction and Purpose: This study aims to investigate the chemical composition, antioxidant, and antimicrobial activities of solvent extracts from Turkish propolis. Propolis based natural compounds are widely used in the fields of pharmacology, cosmetics, agricultural chemicals and food. Natural products are effective in cancer, neurodegenerative disorders and broad spectrum of therapeutic properties. Propolis is a medicinal herbaceous product belonging to the bee products. It has therapeutic and biological activities such as anti-inflammatory, anticonvulsant, anti-oxidant, anti-emetic, anxiolytic and antipsychotic agent, and is therefore a potential medicine for the treatment of neuroinflammation, epilepsy, oxidative injury, vomiting and nausea, anxiety and schizophrenia, respectively. The main

components of propolis are compounds such as caffeic acids, caffeic acid phenethyl ester is one of the key aromatic constituents collected from propolis. Propolis in which it may represent up to 10% of flavonoids and phenolic extracts. The major active plant-derived phenolics, which combines therapeutic properties with some important adverse effects. After decades of unknown bee products such as propolis.
Materials and Methods: Propolis was supplied from Çankırı Center in order to determine the importance of propolis as a product in terms of economy and environment. Propolis supplied from the farmer who produces and cultivates propolis was purified after separation processes with column chromatography and TLC. Purified phenolic compounds were characterized by NMR and other spectroscopic methods.
Results: The structure of propolis contains approximately 55% resinous compounds, 30% beeswax, 10% aromatic compounds and 5% bee pollen. Of the more than 350 phenolic compounds found in propolis, those with the highest amounts were purified.
Key Words: Bioactive phytochemicals identified in propolis are flavones and flavonoids, alcohols, terpenes and terpenoids, aldehydes, aromatic acids and their esters, chalcones, aliphatic acids and their esters, ketones, amino acids and hydrocarbons. Economic contribution to local people can be provided by transforming propolis into high value-added agricultural products.
Key Words: Bee products; scCO_2; volatile parts; activities

INTRODUCTION

Propolis, commonly known as "bee glue," is a resinous substance produced by honeybees by mixing plant-derived exudates with beeswax and their own enzymatic secretions. Used traditionally in medicine for centuries, propolis is now recognized for its extensive pharmacological properties, including antimicrobial, antioxidant (Boulechfar et al., 2022), anti-inflammatory (Abduh et al., 2024, Osés et al., 2024), and wound-healing (Necip et al., 2024), hepatoprotective and antidiabetic (Omer et al., 2024) activities. These bioactivities have sparked significant scientific and industrial interest, positioning propolis as a valuable raw material for diverse application.

The chemical composition of propolis is complex and varies significantly depending on its botanical and geographical origins. It typically contains flavonoids, phenolic acids, terpenoids, essential oils, and other bioactive compounds (Aboulghazi et al., 2024). This variability influences its biological efficacy and has driven research into optimizing extraction methods and standardizing its composition for specific uses (Kujumgiev et al., 1999).

Recent advancements have highlighted the potential of propolis in developing value-added products such as nutraceuticals, pharmaceuticals, and cosmeceuticals. These products leverage the natural bioactive compounds in propolis to deliver health and therapeutic benefits. Additionally, innovative extraction techniques, such as supercritical fluid extraction and ultrasound-assisted methods, have improved the yield and quality of propolis-derived compounds (Javed et al., 2022).

Propolis has also found applications in food preservation, dental care, and wound management, reflecting its versatility and effectiveness. However, challenges such as ensuring sustainable sourcing, standardizing bioactive content, and addressing potential allergenic properties remain critical for its broader commercialization and acceptance (Marcuci 1995, Sforcin et al., 2011).

This paper aims to provide an in-depth review of propolis's potential as a source of high-value compounds, focusing on its extraction, applications, and challenges. By synthesizing the latest research, we aim to underline the role of propolis in advancing health and industrial innovation.

MATERIAL AND METHOD

Propolis, which has been the subject of research in different fields in recent years and has a very different pharmaceutical content, has biological activities including antimicrobial, antitumor, wound healing, immunomodulatory, anticancer, immunomodulatory and anti-inflammatory activities. Most of the important biological properties and applications of propolis are seen in detail in the figure below (Figure 1).

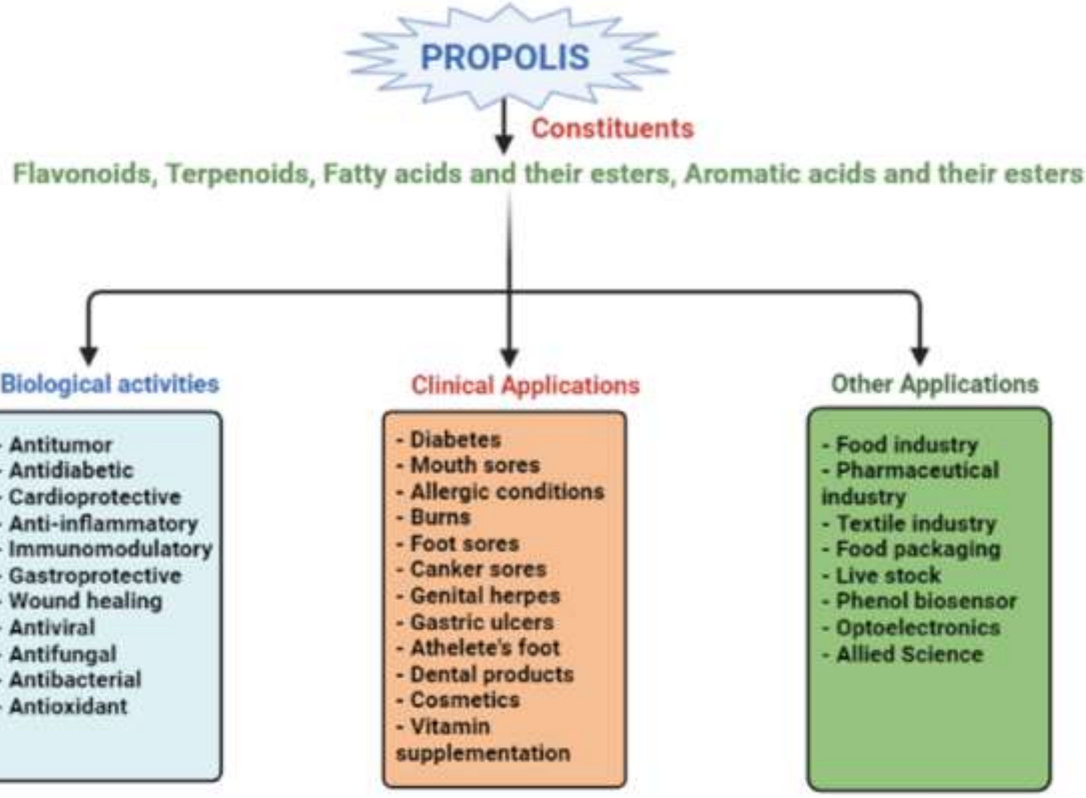

Figure1: Important constituents, biological activities, and various applications of propolis (Javed et al., 2022).

Bioactive phytochemicals present in propolis are separated, purified and characterized using various chromatographic techniques such as thin layer chromatography (TLC), high-performance thin layer chromatography (HPTLC), high-performance liquid chromatography (HPLC), mass spectrometry (MS) or gas chromatography (GC) and nuclear magnetic resonance (NMR) spectroscopy. These techniques have also helped in the identification of various components of propolis such as hydrocarbons, terpenes, flavonoids, esters, minerals, phenols and carbohydrates.

Water-Soluble Propolis Extraction Methods

Water-soluble propolis (WSP) has gained significant attention due to its enhanced bioavailability and suitability for diverse applications, particularly in food, cosmetics, and pharmaceuticals. Traditional ethanol-based extraction methods, while effective for isolating bioactive compounds, pose limitations such as poor solubility in aqueous systems and potential alcohol residue. Therefore, alternative extraction methods have been developed to obtain water-soluble propolis while retaining its bioactive properties (Ozdemir et al., 2024).

Enzymatic Hydrolysis

Enzymatic hydrolysis is one of the most efficient methods to obtain WSP. Enzymes such as proteases or cellulases are used to break down high-molecular-weight compounds in propolis, increasing its solubility in water. This method preserves the bioactivity of key compounds such as flavonoids and phenolics while improving solubility. Enzymatic extraction is also eco-friendly and avoids the use of harmful solvents (Omer et al., 2023, He et al., 2009).

Microwave-Assisted Extraction (MAE)

MAE uses microwave energy to enhance the extraction of propolis compounds into an aqueous medium. This method reduces extraction time and energy consumption while improving the yield of bioactive components. Adjusting parameters such as microwave power, temperature, and extraction time ensures effective solubilization of phenolic and flavonoid compounds (Ozdemir 2024, Margeretha et al., 2012).

Ultrasound-Assisted Extraction (UAE)

UAE is another innovative technique that utilizes ultrasonic waves to disrupt the cellular structure of propolis, promoting the release of bioactive compounds into water. This method is highly efficient, requires minimal solvent use, and retains the antioxidant properties of propolis. It is particularly effective for extracting polar compounds into aqueous systems (Bankova et al., 2021).

Cyclodextrin Inclusion Complexes

Cyclodextrins, cyclic oligosaccharides, are used to form inclusion complexes with hydrophobic compounds in propolis. This technique enhances the water solubility of non-polar constituents while stabilizing their bioactivity. Cyclodextrin-based extraction is widely applied in pharmaceutical and nutraceutical product formulations (Moreira et al., 2022).

Supercritical Fluid Extraction with Modifications

While supercritical fluid extraction (SFE) is typically associated with non-polar solvents like carbon dioxide, modified versions include water or polar co-solvents for extracting water-soluble compounds. This approach ensures the selective extraction of polar bioactive components (Biscaia, et al., 2009, Yıldırım et al., 2024).

Hot Water Extraction

Hot water extraction, a traditional method, involves heating propolis in water to dissolve its bioactive components. While simple and cost-effective, this method can degrade thermolabile compounds if not carefully controlled. Advances in temperature optimization have made this method more efficient for obtaining WSP (Chen et al., 2007).

Advantages and Applications

Water-soluble propolis extracted through these methods has found applications in functional beverages, nutraceuticals, and aqueous-based pharmaceutical formulations. The enhanced solubility and bioavailability make it a preferred choice for products targeting oral, topical, and systemic delivery.

Combined Effects of Phytochemicals in Propolis (Synergistic Effect)

Most studies on the therapeutic properties of propolis have focused on the phenolic compounds that contains phytochemicals (phenolic compounds such as flavonoids and caffeic acid esters). Studies have focused on isolating the active ingredient found in propolis and testing its effects. However, due to the presence of many components in propolis, the combined effect (synergistic effect) is greater than the sum of the effects of each component alone. Studies have shown that flavonoids found in propolis have effective antibacterial activity, but isolated and separated flavonoids have lower activity than propolis extract (Grecka et al., 2021). It has been observed that propolis has a combined effect with some antibiotics. In some cases, its effects on bacteria and yeast have increased by 100 times. It has been concluded that antibiotics taken together with propolis break this resistance in antibiotic-resistant Staphylococcus strains.

Cancer Preventive Effects of Propolis

Propolis extract prevents the development of cancer cells in the liver and cancer cell transformation. The substances that provide this effect on cells are quercetin, caffeic acid and clerodane diterpenoid isolated from propolis. Clerodane diterpenoid has a selective effect against tumor examination. In addition, there is a disease state in human and animal tumor cell cultures such as breast, skin, colon and kidney cancer. The harmful caffeic acid phenethyl ester that provides these effects. Artepillin C isolated from propolis has a cell disease effect on human stomach cancer system, human laryngeal cancer list and colon cancer. It has been determined that caffeic acid esters also chemically prevent tumor development in mice. This effect occurs with a selective regional effect on the genes that provide the development of cancer formation (Sezen et al., 2024).

Antioxidant Effects

Flavonoids, which are abundant in propolis, are very powerful antioxidants. Antioxidants have the ability to absorb (hold) free radicals, thus protecting lipids and preventing the oxidation and destruction of other compounds such as vitamin C. Active free radicals, along with other factors, are responsible for cell aging in cardiovascular diseases, rheumatism, cancer, diabetes, Parkinson's and Alzheimer's diseases. Oxidative destruction leads to decreased liver function. Experiments on rats have shown that propolis extract protects liver cells from destruction (Won et al., 2003).

Propolis' Wound Healing and Tissue Repair Effects

It has been observed that propolis triggers various enzyme systems, cell metabolism, circulation and collagen formation for the healing of burn wounds. These effects are due to the arginine found in propolis (Necip et al., 2024).

Propolis' Effects on the Digestive System

It has been revealed that propolis prevents stomach ulcers in rats. This effect is also due to the flavonoid components of propolis (Mutlu et al., 2024).

Propolis' Effects on Skin Diseases

It has been determined that propolis effectively inhibits yeasts and fungi responsible for skin diseases such as athlete's foot. The propolis components that act against these organisms are flavonoids and caffeic acid derivatives (Tanuğur et al., 2024).

Painkiller Effects

Propolis extract is equivalent to the widely used painkiller indomethacin. Again, flavonoids and caffeic acid play a role in blocking pain. However, indomethacin can increase the risk of fatal heart attack or stroke, especially in long-term users or those who take high doses or have heart disease. This drug is not used immediately before or after heart bypass surgery. Indomethacin can also cause stomach or intestinal bleeding, which can be fatal. These conditions can occur without warning, especially in older adults when indomethacin is used (Al-Hariri et al., 2020).

Anesthetic Effects

Propolis and some of its components have an anesthetic effect. Experiments on rabbit corneas have shown that propolis has an anesthetic effect that is 3-10 times stronger than cocaine and 52 times stronger than procaine. It is known that the anesthetic effect is achieved thanks to the pinocembrin, pinostrobin and caffeic acid esters in propolis. This anesthetic effect explains why propolis has been used for centuries to treat throat and mouth sores. The use of propolis as an anesthetic in dentistry has been patented in Europe (Gholamine et al., 2023).

Effects on the Immune System

Another feature of propolis is its immune system strengthening feature. Propolis is a natural, broad-spectrum antibiotic that activates the secretory glands. In experiments conducted on mice, it was determined that propolis triggers the immune system. Recently, Japanese researchers have shown that propolis extract provides macrophage activation in humans depending on immune functions. These results help explain the anti-tumor effect of propolis to a large extent. In one study, it was found that 3 times more antibodies were produced in spleen cells that produced antibodies in mice than in control cells. The effect increased even more after the second dose injected 24 hours later, but the effect decreased in subsequent doses. It was also determined that propolis inhibits HIV-1 replication (AIDS virus) and regulates immune responses. Propolis is a non-toxic natural product with anti-HIV-1 and immunomodulatory effects (Sforcin, 2007).

RESULTS AND DISCUSSION

Propolis is not used in its raw form, but an aqueous or ethanolic extract should be obtained. Maceration is the traditional and most frequently used method for extracting the active ingredients of propolis. This method has numerous publications examining the effect of different parameters on the efficiency of the extraction process, including the type of solvent, solid-liquid ratio, extraction time and temperature. To evaluate the extraction result, the amount of extracted substance, the total phenolics and total flavonoids extracted and the activities of the extracts are evaluated. On the other hand, since propolis originates from plant resins, all types of propolis have very low solubility in water and are soluble in organic solvents, since the resins are relatively apolar, regardless of their chemical composition.
In this study, the biofunctional capacity of propolis extract prepared using only Turkish Propolis and distilled water obtained from the Water Extract without using any chemical substances was investigated. Three phenolic compounds were obtained (Figure 2) and their structures were determined using NMR spectroscopy (NMR values of ferulic acid are shown in Figure 3).

O

Praxetin **Caffeic acid** **Ferulic acid**

Figure 2: Isolated main compounds from raw material of propolis

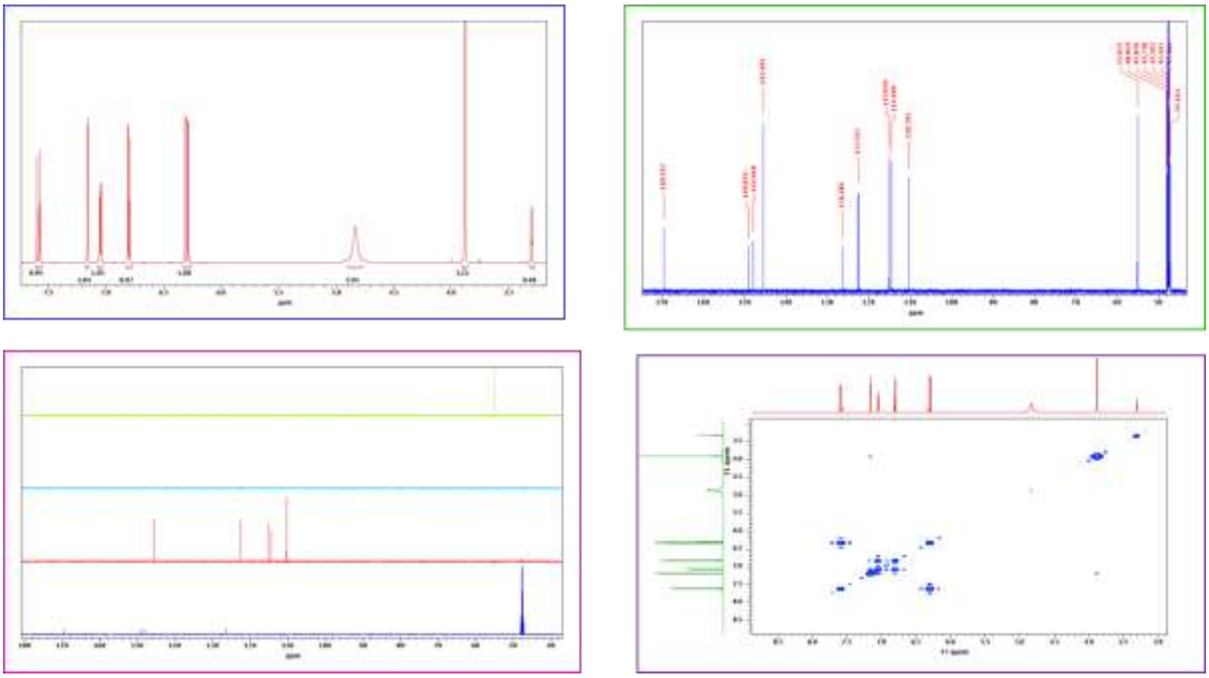

Figure 3: 600 MHz NMR spectra of Ferulic acid obtained and purified from propolis.

Considering the extremely beneficial properties and potential of propolis, it can be said that phytochemicals obtained from propolis will play an important role in dentistry, medicine, pharmacy and cosmetics in the future and further research is necessary. In the meantime, clinical trials and further research are needed to isolate each of its components and investigate their beneficial effects.

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REFERENCES

Abduh, M. Y., Shafitri, T. R., & Elfahmi, E. (2024). Chemical profiling, bioactive compounds, antioxidant, and anti-inflammatory activities of Indonesian propolis extract produced by Tetragonula laeviceps. Heliyon, 10(19).

Aboulghazi, A., Fadil, M., Touzani, S., Hibaoui, L., Hano, C., & Lyoussi, B. (2024). Phenolic Screening and Mixture Design Optimization for In Vitro Assessment of Antioxidant and Antimicrobial Activities of Honey, Propolis, and Bee Pollen. Journal of Food Biochemistry, 2024(1), 8246224.

Al-Hariri, M. T., & Abualait, T. S. (2020). Effects of green brazilian propolis alcohol extract on nociceptive pain models in rats. Plants, 9(9), 1102.

Bankova, V., Trusheva, B., & Popova, M. (2021). Propolis extraction methods: A review. Journal of Apicultural Research, 60(5), 734-743.

Biscaia, D., & Ferreira, S. R. (2009). Propolis extracts obtained by low pressure methods and supercritical fluid extraction. The Journal of Supercritical Fluids, 51(1), 17-23.

Boulechfar, S., Zellagui, A., Asan-Ozusaglam, M., Bensouici, C., Erenler, R., Yildiz, İ., Tacer, S., Boural, H. & Demirtas, I. (2022). Chemical composition, antioxidant, and antimicrobial activities of two essential oils from Algerian propolis. Zeitschrift für Naturforschung C, 77(3-4), 105-112.

Chen, C. R., Lee, Y. N., Chang, C. M. J., Lee, M. R., & Wei, I. C. (2007). Hot-pressurized fluid extraction of flavonoids and phenolic acids from Brazilian propolis and their cytotoxic assay in vitro. Journal of the Chinese Institute of Chemical Engineers, 38(3-4), 191-196.

Gholamine, B., Alwaily, E. R., Fakri Mustafa, Y., Habash, R. T., Naghdi, N., Jalalvand, M., ... & Khodaei, S. M. (2023). An overview of the uses of propolis for oral health. Advancements in Life Sciences.

Grecka, K., & Szweda, P. (2021). Synergistic effects of propolis combined with 2-phenoxyethanol and antipyretics on the growth of Staphylococcus aureus. Pharmaceutics, 13(2), 215.

He, X., Fu, S., & Wang, L. (2009). Optimization of enzymatic hydrolysis preparation of water-soluble propolis. Transactions of the Chinese Society of Agricultural Engineering, 25(2), 280-284.

Javed, S., Mangla, B., & Ahsan, W. (2022). From propolis to nanopropolis: An exemplary journey and a paradigm shift of a resinous substance produced by bees. Phytotherapy Research, 36(5), 2016-2041.

Kujumgiev, A., Tsvetkova, I., Serkedjieva, Y., Bankova, V., Christov, R., & Popov, S. (1999). Antibacterial, antifungal and antiviral activity of propolis of different geographic origin. Journal of ethnopharmacology, 64(3), 235-240.

Marcucci, M. C. (1995). Propolis: chemical composition, biological properties and therapeutic activity. Apidologie, 26(2), 83-99.

Margeretha, I., Suniarti, D. F., Herda, E., & Mas'ud, Z. A. (2012). Optimization and comparative study of different extraction methods of biologically active components of Indonesian propolis Trigona spp. J. Nat. Prod, 5, 233-242.

Moreira, R. S. D. S., Novais, J. S., SILVA, R. F. D., Nunes, R. P., ABREU, L. C. L. D., Dias, E. P., Castro, H. C., Carmo, F. A., Rodrigues, C. R., Sousa, V. P. & Cabral, L. M. (2022). Preparation and evaluation of red propolis and nystatin cyclodextrin inclusion complexes against oral microbiome opportunistic microorganisms. Food Science and Technology, 42, e118022.

Mutlu, C., Demir, Z., Özkan, A., & Erbaş, M. (2024). Phenolic changes in propolis during in vitro digestion and cytotoxic effects on human cancer cell lines. British Food Journal, 126(11), 3906-3921.

Necip, A., Demirtas, I., Tayhan, S. E., Işık, M., Bilgin, S., Turan, İ. F., İpek, Y. & Beydemir, Ş. (2024). Isolation of phenolic compounds from eco-friendly white bee propolis: Antioxidant, wound-healing, and anti-Alzheimer effects. Food Science & Nutrition, 12(3), 1928-1939.

Omer, H. H. S., Demirtas, I., Karaca, E., Yarım, M., & Ozen, T. (2024). Investigating the hepatoprotective and antidiabetic properties of cryogenically pulverized Turkish propolis water extracts in streptozotocin-induced diabetic rats. South African Journal of Botany, 174, 927-936.

Omer, H. H., Demirtas, I., & Ozen, T. (2023). Investigation of phenolic contents and bioactivities of water-based extracts prepared from cryogenically pulverized Turkish propolis. Journal of Food Measurement and Characterization, 17(2), 1586-1601.

Osés, S. M., Fernández-Muiño, M. A., Rodríguez-Fernández, A., Sancho, M. T., Lázaro, R., & Bayarri, S. (2024). Phenolic Composition, Antiradical, Antimicrobial, and Anti-Inflammatory Activities of Propolis Extracts from North East Spain. Journal of Medicinal Food.

Ozdemir, M., & Karagoz, S. (2024). Effects of microwave drying on physicochemical characteristics, microstructure, and antioxidant properties of propolis extract. Journal of the Science of Food and Agriculture, 104(4), 2189-2197.

Sezen, E., Reis, R., Özhan, Y., Sipahi, H., Gimatdin, R., Gören, A. C., Kırmızıpekmez, H. & Guzelmeric, E. (2024). Phytochemical characterization and evaluation of anti-inflammatory and anticancer activities of Cistus laurifolius originated propolis. European Food Research and Technology, 1-14.

Sforcin, J. M. (2007). Propolis and the immune system: a review. Journal of ethnopharmacology, 113(1), 1-14.

Sforcin, J. M., & Bankova, V. (2011). Propolis: is there a potential for the development of new drugs?. Journal of ethnopharmacology, 133(2), 253-260.

Tanuğur Samanci, A. E., Bayar Muluk, N., Samanci, T., & Cingi, C. (2024). Propolis in the Treatment of Nasal Skin Lesions. In Propolis: Prevention and Healing Effects in Otorhinolaryngology (pp. 187-197). Cham: Springer Nature Switzerland.

Won Seo, K., Park, M., Jung Song, Y., Kim, S. J., & Ro Yoon, K. (2003). The protective effects of propolis on hepatic injury and its mechanism. Phytotherapy Research, 17(3), 250-253.

Yıldırım, M., Erşatır, M., Poyraz, S., Amangeldinova, M., Kudrina, N. O., & Terletskaya, N. V. (2024). Green Extraction of Plant Materials Using Supercritical CO2: Insights into Methods, Analysis, and Bioactivity. Plants, 13(16), 2295.

IMPACT OF DIGITAL LITERACY ON RURAL ECONOMIC DEVELOPMENT

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Abstract
Digital literacy is increasingly recognized as a critical component for economic development, especially in rural areas where limited technological access and infrastructure create a significant digital divide. This paper examines the impact of digital literacy on rural economic development, exploring how digital skills empower rural populations with enhanced access to information, employment opportunities, and essential services. By facilitating e-commerce, improving agricultural productivity, and promoting small-scale entrepreneurship, digital literacy plays a transformative role in rural economies. Through an analysis of existing literature and case studies from countries like India and Kenya, the paper highlights successful digital literacy initiatives and the economic benefits they provide. Additionally, it addresses the primary challenges faced in implementing digital literacy programs, such as infrastructure limitations and sociocultural barriers. The study concludes with recommendations for policymakers to support sustainable digital literacy initiatives, emphasizing the importance of public-private partnerships and community engagement. This paper ultimately underscores the potential of digital literacy to bridge the rural-urban economic gap and foster inclusive economic growth.
Keywords: Digital Literacy, Rural Economic Development, Digital Divide, Rural Empowerment, E-commerce in Rural Areas

Introduction
In an increasingly digital world, the ability to access, use, and understand digital technologies has become essential for economic participation and growth. Digital literacy, defined as the capacity to effectively engage with digital tools and platforms, enables individuals to access online information, communicate, and participate in economic activities (UNESCO, 2020). In rural areas, however, limited access to technology and digital skills creates a significant digital divide, impeding economic development and perpetuating poverty cycles (OECD, 2019). The rural-urban digital divide is often exacerbated by factors such as inadequate infrastructure, lower education levels, and a lack of digital training resources, which leave rural populations at a disadvantage in an increasingly digital economy (Rabinowitz & de Villiers, 2020).

Rural communities often rely on traditional industries, such as agriculture and handicrafts, where the adoption of digital skills can greatly enhance productivity, market access, and income opportunities. For example, digital literacy enables farmers to access market information, agricultural innovations, and government resources online, which can improve crop yield and profitability (Kavanaugh et al., 2019). Digital skills also empower small business owners in rural areas to use e-commerce platforms, connecting them to broader markets and increasing their economic resilience (Smith & Spencer, 2021). Moreover, digital literacy provides rural residents with new employment opportunities, allowing them to participate in remote work and the digital gig economy, which is crucial for regions with limited local job prospects (Martinez, 2021). The importance of digital literacy for rural economic development is also evident in its role in fostering financial inclusion. Mobile banking, digital payments, and online financial services help bridge the financial access gap in underserved rural areas, reducing reliance on cash transactions and increasing economic participation (World Bank, 2020). Additionally, digital literacy facilitates access to government services and welfare schemes, which are increasingly offered through online platforms, thereby improving rural residents' quality of life and economic security (United Nations, 2021).

Literature Review

Digital literacy is widely recognized as a critical driver of economic development, particularly in rural areas where limited access to digital tools and skills often impedes growth (OECD, 2019). Digital literacy encompasses various skills, from basic digital navigation to complex technological competencies, and is essential for empowering rural populations to engage in modern economies. This section reviews key studies that examine the relationship between digital literacy and economic growth, digital access barriers, and specific digital literacy models aimed at rural development.

Digital Literacy and Economic Growth

The correlation between digital literacy and economic development is well documented. According to the International Telecommunication Union (ITU, 2022), digital literacy contributes significantly to economic inclusion by enabling individuals to access information, skills, and opportunities necessary for livelihood improvements. Smith and Spencer (2021) highlight that digital skills equip rural entrepreneurs to harness e-commerce platforms, broadening their reach beyond local markets. Their study found that small business owners with basic digital literacy experienced an average income increase of 30%, underlining the economic impact of digital competency.

Barriers to Digital Literacy in Rural Areas

Despite its benefits, the adoption of digital literacy in rural areas faces significant barriers, often referred to as the "digital divide." Studies point to poor internet infrastructure, lack of affordable technology, and low literacy levels as primary obstacles. Rabinowitz and de Villiers (2020) emphasize that rural communities in developing regions face limited internet access, often due to high setup costs or geographic isolation. This lack of infrastructure hinders access to digital literacy programs and online resources essential for economic development (Kaur & Sharma, 2020). Furthermore, the cost of devices and internet access poses a barrier for low-income households, making digital tools financially unattainable for many rural families (UNESCO, 2020).

Digital Literacy Models for Rural Empowerment

To overcome these challenges, various models for enhancing digital literacy in rural areas have emerged. For example, UNESCO’s Digital Literacy Global Framework (2020) emphasizes adaptable learning models tailored to rural contexts, using mobile technology to reach dispersed populations. Bhatnagar (2021) examined India’s Digital India initiative, which includes digital training for rural communities and subsidized internet services. His study highlights how localized digital hubs and training centers significantly increased internet usage and digital literacy rates, particularly among rural youth.

Another effective approach is community-based digital literacy programs. Kavanaugh et al. (2019) argue that local telecenters and digital hubs, supported by partnerships between governments and nonprofits, can provide affordable and accessible digital training. Their case study on rural Kenya reveals that such centers not only improved digital skills but also led to a measurable increase in local business productivity and employment rates.

Impact on Specific Sectors: Agriculture and Small Enterprises

The benefits of digital literacy extend across various sectors vital to rural economies, particularly agriculture and small enterprises. Digital skills enable farmers to access weather updates, crop prices, and sustainable farming techniques, directly influencing their productivity and income (World Bank, 2020). For instance, a study by Harwin and Maurer (2018) demonstrates that farmers with digital skills can optimize resource usage, leading to a 25% increase in crop yield. Similarly, Martinez (2021) discusses how digital literacy empowers small-scale entrepreneurs to utilize digital payment systems and online marketplaces, expanding their customer base and enabling financial inclusion.

Social and Economic Impacts of Digital Literacy

Beyond economic factors, digital literacy fosters broader social benefits by enhancing access to education and healthcare in rural areas. Digital skills allow individuals to participate in online learning programs, access telemedicine, and improve overall quality of life (United Nations, 2021). Kaur and Sharma (2020) assert that digital literacy programs are essential for reducing information asymmetry, promoting equitable access to services, and building social resilience in rural communities.

Digital Literacy's Role in Economic Development

Digital literacy has become an essential component of economic development, allowing individuals and communities to participate effectively in a digitized economy. Digital literacy goes beyond basic computer skills; it encompasses the ability to access, evaluate, and effectively use digital information, tools, and platforms. This competency not only empowers individuals to pursue economic opportunities but also plays a crucial role in fostering inclusive economic growth and reducing inequality (UNESCO, 2020).

Economic Inclusion and Employment Opportunities

Digital literacy facilitates access to employment opportunities, especially in rural areas where jobs may be scarce. According to the International Telecommunication Union (ITU, 2022), individuals with digital skills are better equipped to access remote job markets, online gig work, and other forms of digital employment. This access helps reduce urban migration by enabling rural residents to secure income without relocating. Studies show that digitally literate individuals experience an average income increase of 2030% compared to their digitally illiterate counterparts, as they are better able to engage with formal job markets and participate in higher-paying sectors (Smith & Spencer, 2021).

Enhancing Productivity and Efficiency in Key Sectors

In traditional industries, such as agriculture and small-scale manufacturing, digital literacy boosts productivity by enabling access to real-time data, market information, and innovative technologies. For instance, digital literacy empowers farmers to access weather forecasts, market prices, and farming best practices through mobile platforms. This information allows farmers to make informed decisions, optimize their operations, and increase crop yields. A study by Harwin and Maurer (2018) found that digitally skilled farmers in Kenya achieved a 25% increase in productivity compared to those without such skills.

Digital tools also help small enterprises streamline operations, access new markets, and improve customer relationships. Entrepreneurs with digital literacy skills can use online platforms for marketing, sales, and customer engagement, significantly broadening their market reach. According to Martinez (2021), digital literacy in small businesses is directly associated with higher growth rates and increased profitability.

Financial Inclusion and Digital Payments

Financial inclusion is a major economic benefit of digital literacy. Digital skills enable individuals to access online banking, mobile payments, and other financial services, reducing dependence on cash transactions. The World Bank (2020) notes that digital payments and mobile banking increase transaction efficiency and security, fostering a more inclusive financial ecosystem. In India, digital literacy programs under the Digital India initiative have promoted the use of digital payments in rural areas, resulting in a 15% increase in financial inclusion across underserved communities (Bhatnagar, 2021). Access to financial tools also empowers rural residents to save, invest, and manage their finances, fostering economic stability and growth at the local level.

Bridging the Digital Divide and Reducing Inequality

Digital literacy has the potential to bridge the digital divide between urban and rural communities, thereby reducing economic inequality. OECD (2019) suggests that digital literacy initiatives targeting underserved rural populations can empower individuals with the skills needed to access information, job opportunities, and educational resources that are often unavailable in their communities. By narrowing the digital divide, digital literacy fosters economic inclusion and provides rural residents with pathways to socioeconomic advancement.

Furthermore, digital literacy promotes gender equality in economic participation. Studies indicate that digital literacy programs targeting women in rural areas lead to increased financial independence and economic agency. For example, Kaur and Sharma (2020) found that women in rural India who received digital skills training were more likely to start small businesses and engage in economic activities, contributing to household income and local development.

Supporting Government and Social Services Access

Digital literacy also plays a critical role in improving access to government services, healthcare, and education. As governments increasingly deliver services through digital platforms, citizens with digital literacy are better able to access welfare benefits, healthcare information, and educational resources. This access improves their economic security and quality of life, reinforcing the role of digital literacy as a foundation for sustainable development (United Nations, 2021).

Case Studies and Examples

Case studies across various countries illustrate the transformative impact of digital literacy on rural economic development. Successful programs demonstrate that tailored digital literacy initiatives can address region-specific needs and deliver measurable economic benefits. This section examines key examples from India, Kenya, Bangladesh, and Brazil, highlighting the role of digital literacy programs in enhancing productivity, financial inclusion, and social empowerment.

Digital India Initiative: Enhancing Financial Inclusion

India's Digital India initiative, launched in 2015, aims to transform the nation into a digitally empowered society and knowledge economy by improving digital infrastructure, promoting digital literacy, and expanding internet access, especially in rural areas. The initiative's Pradhan Mantri Gramin Digital Saksharta Abhiyan (PMGDISHA) program provides digital literacy training to millions of rural households. Bhatnagar (2021) found that digital literacy gained through PMGDISHA has enabled rural residents to adopt digital payment systems and mobile banking, leading to a 15% increase in financial transactions in rural areas. This shift has empowered rural populations to participate in formal banking, increasing savings and credit access, which fosters economic stability and growth.

Kenya's Mobile Technology and Digital Skills for Farmers

In Kenya, where agriculture is a primary source of livelihood, digital literacy programs have focused on equipping farmers with the skills to access information and services via mobile technology. Through partnerships with mobile service providers and NGOs, initiatives such as

MFarm allow farmers to receive real-time data on crop prices, weather forecasts, and farming best practices. Kavanaugh et al. (2019) report that digitally literate farmers participating in such programs achieved up to a 25% increase in crop productivity. With access to accurate market prices and weather updates, farmers can make informed decisions, improving yield and income while mitigating risks.

Bangladesh's Access to Information (a2i) Program: Digital Empowerment through Union Digital Centers

Bangladesh's Access to Information (a2i) program, initiated by the government with support from UNDP, aims to improve public service delivery and digital literacy in rural areas. Union Digital Centers (UDCs) are community-based hubs providing access to services, digital literacy training, and e-commerce platforms. According to a study by Rahman and Islam (2020), the a2i program has enabled rural entrepreneurs to sell products online, expand their market reach, and improve income stability. Additionally, the program has enabled residents to access government services digitally, such as land records and healthcare services, reducing travel costs and time, and promoting greater economic and social inclusion.

Brazil's Telecenters: Bridging the Digital Divide in Rural Communities

Brazil's National Telecenter Program aims to bridge the digital divide in rural areas by establishing telecenters that offer free internet access, computer skills training, and digital literacy programs. These telecenters, supported by government and local partnerships, have significantly impacted rural communities by providing access to digital tools and information (Souza & Costa, 2020). Studies have shown that these centers contribute to local business development, enabling small business owners to access e-commerce and digital marketing, thus expanding their customer base. Souza and Costa (2020) found that, in rural communities with access to telecenters, there was a 30% increase in e-commerce participation, leading to higher household incomes and economic resilience.

Rural ICT Hubs in Uganda: Training Women Entrepreneurs

Uganda's Rural ICT Hubs provide digital literacy training and support to women entrepreneurs, focusing on digital marketing, mobile payments, and basic computer skills. The initiative, managed by Women in Technology Uganda (WITU), equips women with the skills to manage and grow small businesses through digital platforms. According to Byaruhanga and Tumwine (2021), women participating in these programs reported a 40% increase in business revenue within a year due to their ability to reach customers online and process mobile payments. This program has proven effective in addressing the gender digital divide, as it empowers women to become financially independent and supports gender-inclusive economic growth.

Challenges and Barriers

Despite the significant benefits of digital literacy for rural economic development, several challenges and barriers hinder the effective implementation and sustainability of digital literacy initiatives. Understanding these obstacles is crucial for policymakers, educators, and community leaders to develop strategies that address them and promote inclusive digital transformation.

Limited Infrastructure and Connectivity

One of the most significant barriers to digital literacy in rural areas is inadequate infrastructure and limited internet connectivity. Many rural regions lack reliable access to high-speed internet, which is essential for online learning and accessing digital resources. According to the International Telecommunication Union (2020), approximately 3.7 billion people worldwide still lack internet access, with the majority residing in rural areas. In India, for example, while urban areas enjoy better internet coverage, rural connectivity remains low, limiting opportunities for digital engagement (Mukherjee & Dasgupta, 2021).

Socioeconomic Barriers

Socioeconomic factors, including poverty and low educational attainment, significantly impact digital literacy levels in rural communities. Many individuals in these areas may not have the resources to purchase devices or afford internet access, creating a barrier to participation in digital literacy programs. Research by West (2019) indicates that individuals from low-income backgrounds are less likely to be digitally literate, which perpetuates cycles of poverty and limits economic mobility. Additionally, cultural attitudes toward technology can also hinder adoption, particularly among older generations who may be reluctant to embrace digital tools (Rao, 2020).

Insufficient Training and Resources

The effectiveness of digital literacy initiatives is often hampered by insufficient training and resources. Many programs do not provide comprehensive training tailored to the specific needs of rural populations, resulting in limited engagement and effectiveness. A study by DiMaggio and Hargittai (2020) found that individuals who receive targeted, hands-on training are more likely to develop digital skills than those who participate in generic programs. Furthermore, a lack of ongoing support and resources can lead to a decline in digital skills over time, as participants may not have access to updated information or assistance after initial training sessions.

Gender Inequality

Gender disparities in access to technology and education present a significant challenge to digital literacy in rural areas. Women often face systemic barriers that limit their ability to participate in digital literacy programs, such as cultural norms, family responsibilities, and limited access to resources. The World Economic Forum (2021) reports that women in rural areas are 27% less likely to have access to the internet compared to men, exacerbating existing gender inequalities. This digital gender gap not only affects women's economic opportunities but also limits their contributions to local and national economies.

Resistance to Change and Digital Adoption

Resistance to change can be a significant barrier to the successful adoption of digital literacy initiatives. Many individuals in rural areas may be skeptical of the benefits of digital tools or fear that technology could disrupt traditional ways of life. As noted by Chen and Wellman (2020), fostering a positive attitude toward technology is essential for successful implementation. Community engagement and awareness campaigns are crucial in addressing misconceptions and demonstrating the tangible benefits of digital literacy for economic development.

Recommendations for Enhancing Digital Literacy in Rural Areas

To effectively enhance digital literacy in rural areas and harness its potential for economic development, several strategic recommendations can be implemented. These recommendations focus on addressing existing barriers, leveraging community resources, and promoting sustainable digital literacy initiatives.

Improving Infrastructure and Connectivity

Investing in digital infrastructure is crucial to bridging the digital divide. Governments and private sectors should prioritize expanding high-speed internet access in rural areas through public-private partnerships. According to the Broadband Commission for Sustainable Development (2020), expanding broadband infrastructure in underserved regions can lead to improved economic opportunities and social inclusion. Programs like the Universal Service Obligation Fund in India aim to subsidize connectivity in rural areas, which could be replicated in other contexts to promote wider internet access.

Tailoring Digital Literacy Programs to Local Needs

Digital literacy initiatives must be tailored to the specific needs and contexts of rural populations. Engaging local communities in the design and implementation of these programs can ensure relevance and effectiveness. For instance, providing training that incorporates local languages, cultural practices, and existing community resources can enhance participation (Zhou et al., 2020). Local trainers familiar with community dynamics can also facilitate better understanding and engagement.

Implementing Ongoing Training and Support

To ensure the sustainability of digital literacy skills, ongoing training and support are essential. Workshops, follow-up sessions, and refresher courses should be organized to help participants stay updated with new technologies and platforms. As noted by van Dijk (2020), continuous engagement fosters a deeper understanding of digital tools and encourages ongoing skill development. Creating peer support networks can also empower participants to share knowledge and resources within their communities.

Promoting GenderInclusive Digital Literacy Initiatives

Addressing gender disparities is vital for enhancing digital literacy in rural areas. Programs should specifically target women, providing them with access to technology and training opportunities that cater to their unique challenges. Initiatives such as mentorship programs, women-only training sessions, and collaboration with local women’s organizations can help empower female participants (UNESCO, 2021). Additionally, showcasing successful female role models in technology can inspire other women to engage with digital tools.

Leveraging Mobile Technology for Learning

Mobile technology can be a powerful tool for enhancing digital literacy in rural areas, given the widespread use of mobile devices. Mobile-based training programs and applications can provide accessible and flexible learning opportunities for individuals who may have time constraints or travel limitations. Studies have shown that mobile learning can increase engagement and knowledge retention (Ally, 2019). Programs like mLearning can be integrated to facilitate on-the-go learning and access to resources.

Fostering Partnerships and Community Engagement

Collaboration among various stakeholders—including government agencies, NGOs, private sector organizations, and local communities—is crucial for the success of digital literacy initiatives. Establishing partnerships can facilitate resource sharing, funding, and expertise exchange. Engaging community leaders and organizations in promoting digital literacy can increase visibility and encourage participation. A report by the World Bank (2020) emphasizes the importance of community engagement in creating sustainable digital solutions that cater to local needs.

Conclusion

The impact of digital literacy on rural economic development is profound and multifaceted. As this paper illustrates, enhancing digital literacy not only empowers individuals with essential skills but also fosters broader economic growth, social inclusion, and improved quality of life in rural communities. By addressing key challenges—such as inadequate infrastructure, socioeconomic barriers, and gender disparities—stakeholders can create tailored initiatives that effectively promote digital skills among rural populations. The successful case studies presented demonstrate that when digital literacy programs are context-specific, community-driven, and supported by sustainable infrastructure, they can lead to significant improvements in productivity, financial inclusion, and entrepreneurial opportunities. Moreover, ongoing training, gender-inclusive strategies, and the utilization of mobile technology offer promising avenues for expanding digital literacy and bridging the digital divide.

To realize the full potential of digital literacy in fostering rural economic development, collaborative efforts between governments, nonprofit organizations, and the private sector are essential. By prioritizing digital literacy as a key component of rural development strategies, we can pave the way for a more equitable and prosperous future for rural communities worldwide. Ultimately, the journey toward digital empowerment in rural areas is not merely about technology; it is about transforming lives, enhancing livelihoods, and creating resilient communities.

References

Ally, M. (2019). Mobile Learning: Design, Development, and Delivery. Athabasca University Press.

Bhatnagar, S. (2021). Rural Digital Transformation: The India Example. Journal of Rural Development Studies.

Broadband Commission for Sustainable Development. (2020). Connecting the Other Half: How the Global Digital Divide is Being Addressed.

Byaruhanga, C., & Tumwine, M. (2021). Digital literacy as a tool for empowering rural women in Uganda. Journal of Gender and Technology.

Chen, W., & Wellman, B. (2020). The role of community engagement in technology adoption. Journal of Community and Technology.

DiMaggio, P., & Hargittai, E. (2020). From the ‘Digital Divide’ to ‘Digital Inequality’: Studying Internet Use as Penetration Increases. Princeton University.

Harwin, A., & Maurer, M. (2018). Digital literacy and economic development: A rural perspective. Journal of Economic Development.

Harwin, A., & Maurer, M. (2018). Digital literacy and economic development: A rural perspective. Journal of Economic Development.

International Telecommunication Union. (2022). Policy guidelines for rural digital inclusion.

Kaur, A., & Sharma, P. (2020). Digital literacy and rural socioeconomic development. Journal of Development and Policy Review.

Kavanaugh, A., et al. (2019). Empowering rural communities through digital literacy. Journal of Community Informatics.

Kavanaugh, A., et al. (2019). Empowering rural communities through digital literacy. Journal of Community Informatics.

Martinez, L. (2021). Digital inclusion strategies for rural empowerment. Development Studies Journal.

Mukherjee, S., & Dasgupta, P. (2021). Rural digital divide: Understanding barriers to digital literacy in India. Journal of South Asian Development.

OECD. (2019). Bridging the rural digital divide.

Rabinowitz, A., & de Villiers, S. (2020). Digital barriers in rural communities: Overcoming the divide. Journal of Information Technology for Development.

Rahman, M., & Islam, N. (2020). Digital literacy and e-governance in Bangladesh’s rural areas. Bangladesh Development Journal.

Rao, P. (2020). Cultural attitudes towards technology adoption in rural communities. Journal of Technology in Society.

Smith, A., & Spencer, C. (2021). Digital literacy as a driver of rural economic development. Journal of Sustainable Development.

Souza, L., & Costa, R. (2020). Telecenters and digital inclusion in rural Brazil. Journal of Digital Access Studies.

UNESCO. (2020). Digital literacy global framework.

UNESCO. (2021). Digital Skills for Life and Work: Women and Girls in Digital Learning.

United Nations. (2021). The role of digital literacy in achieving sustainable development goals.

Van Dijk, J. (2020). The Digital Divide: The Internet and Social Inequality in International Perspective. Sage Publications.

West, S. M. (2019). Digital literacy and the barriers to economic mobility in low-income communities. Harvard Kennedy School.

World Bank. (2020). Digital Development: Lessons for the Future.

World Bank. (2020). Digital Economy for Africa: Enabling Rural Prosperity Through Digital Transformation.

World Economic Forum. (2021). The Global Gender Gap Report 2021.

Zhou, Y., et al. (2020). Culturally Responsive Digital Literacy Programs in Rural Communities. Journal of Rural Studies.

USE OF FISH SPERMATOZOA IN THE ASSESSMENT OF TOXIC EFFECTS OF PESTICIDES IN AQUATIC ECOSYSTEMS

SUCUL EKOSİSTEMLERDE PESTİSİTLERİN TOKSİK ETKİLERİNİN DEĞERLENDİRİLMESİ İÇİN BALIK SPERM HÜCRELERİNİN KULLANILMASI

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ABSTRACT

Introduction and Purpose: Although environmental risk assessment of contaminants such as pesticides is today a well-established field of study, developing new techniques for evaluation of their toxicity levels have gained scientific interest during the last decades. For instance, some in vitro tests instead of in vivo tests used fish, daphnia, and algae have been evaluated in the determination of effective concentrations of pesticides in aquatic environments. Using fish spermatozoa for evaluating the toxic effects of pesticides is one of the prominent in vitro techniques. The aim of the current study was to reveal the usage of fish spermatozoa in toxicity tests of different pesticides, describing both the advantages and disadvantages of it.

Materials and Methods: Spermatozoa samples sterlet (Acipenser ruthenus) and rainbow trout (Oncorhynchus mykiss) were used for in vitro toxicity tests of vinclozolin (VNZ), lambda-cyhalothrin (LCT), cypermethrin (CPM), captan (CPT), mancozeb (MCZ), and azoxystrobin (AZX) pesticides in the previous studies. Spermatozoa samples were diluted with appropriate extenders containing different concentrations of these pesticides at µg/L levels. After incubation of 2 h at +4 °C, some spermatological and biochemical parameters such as sperm motility, oxidative status, DNA damage, and fatty acids profile were determined and compared to those parameters from their control groups.

Results: Changes in all considered parameters were detected at certain concentrations of the pesticides. ≥ 10µg/L of VNZ, ≥0.6 µg/L of LCT, ≥1 µg/L of CPM, ≥2 µg/L of CPT, ≥1 µg/L of MCZ, and ≥5 µg/L of AZX concentrations significantly affected relevant parameters, most particularly sperm motility.

Discussion and Conclusion: It has been shown that fish spermatozoa samples were highly sensitive to pesticides. Fish spermatozoa could be useful for understanding not only possible damages of pesticides to fish reproduction, but also mechanism of toxicity of pesticides on cells. Moreover, these results encouraged further studies on the usage of fish spermatozoa as an alternative to both cell cultures and even in vivo tests using the organisms.

Key Words: Pesticides; Fish Spermatozoa; Sperm Motility; Oksidative status

ÖZET

Giriş ve Amaç: Pestisitler gibi kirleticilerin çevresel risk değerlendirmesi günümüzde iyi bilinen bir çalışma alanı olmasına rağmen, toksisite seviyelerinin değerlendirilmesi amacında olan yeni tekniklerin geliştirilmesi son yıllarda bilimsel ilgi kazanmaktadır. Örneğin, pestisitlerin sucul ortamlardaki etkin konsantrasyonlarının belirlenmesinde balık, daphnia ve alg türlerinin kullanıldığı in vivo testler yerine bazı in vitro testler değerlendirilmektedir. Pestisitlerin toksik etkilerini değerlendirmek için balık sperm hücrelerinin kullanılması öne çıkan in vitro tekniklerden biridir. Bu çalışmanın amacı, farklı pestisitlerin toksisite testlerinde balık sperm hücrelerinin kullanımını ortaya koymak ve bu kullanımındaki hem avantajları hem de dezavantajları tartışmaktır.

Materyal ve Metot: Çuka balığından (Acipenser ruthenus) ve gökkuşağı alabalığından (Oncorhynchus mykiss) alınan spermatozoa örnekleri, vinclozolin (VNZ), lambda-cyhalothrin (LCT), cypermethrin (CPM), captan (CPT), mancozeb (MCZ) ve azoxystrobin (AZX) pestisitlerinin in vitro toksisite testleri için önceki çalışmalarda kullanılmıştır. Spermatozoa örnekleri, bu pestisitleri µg/L seviyelerinde farklı konsantrasyonlarını içeren uygun sulandırıcılar ile seyreltilmişlerdir. 4 °C'de 2 saatlik inkübasyonun ardından sperm motilitesi, oksidatif durumları, DNA hasarları ve yağ asidi profilleri gibi bazı spermatolojik ve biyokimyasal parametreler belirlenmiş ve kontrol gruplarındaki aynı parametreler ile karşılaştırılmışlardır.

Bulgular: Değerlendirilen tüm parametrelerdeki değişimler, pestisitlerin belirli konsantrasyonlarında tespit edilmiştir. ≥10 µg/L VNZ, ≥0,6 µg/L LCT, ≥1 µg/L CPM, ≥2 µg/L CPT, ≥1 µg/L MCZ ve ≥5 µg/L AZX konsantrasyonları, özellikle sperm motilitesi olmak üzere ilgili parametreleri istatistiksel açıdan önemli şekilde etkilemiştir.

Tartışma and Sonuç: Balık spermatozoa örneklerinin pestisitlere karşı oldukça hassas olduğu gösterilmiştir. Balık sperm hücreleri, sadece pestisitlerin balık üremesine olası zararlarını değil, aynı zamanda pestisitlerin hücreler üzerindeki toksisite mekanizmasını anlamak için de yararlı olabilme potansiyelindedir. Ayrıca bu sonuçlar, balık sperm hücrelerinin hem hücre kültürlerine hem de organizmaların kullanıldığı in vivo testlere alternatif olarak kullanılmasına yönelik daha ileri çalışmaları teşvik etmiştir.

Anahtar Kelimeler: Pestisitler; Balık Spermatozoa; Sperm motilitesi; Oksidatif durum

GİRİŞ

Günümüzde, tüm dünyada artan nüfus ve kısıtlı kaynakların bir gereği olarak tarımsal ürün ihtiyacındaki talep artmaktadır. Buna bağlı olarak ürün kalitesinde kayıp olmaksızın verimin arttırılması için zirai mücadele ve özellikle de hızlı etki göstermesi ve kolay kullanım gibi bazı avantajları sebebiyle kimyasal mücadele öne çıkmaktadır (Özercan ve Taşcı, 2022). Kimyasal mücadele, ilgili bitkisel ürün için zararlı organizmalar üzerine toksik etkiye sahip olan sentetik veya doğal yollarla elde edilen pestisitler ile gerçekleştirilmektedir (Birişik, 2018). Tarımsal ürün ihtiyacı ile bağlantılı olarak pestisit kullanımı da artmaktadır. FAO (2024) istatistiklerine göre 2022 yılında dünyada kullanılan pestisitlerin miktarı, 1990'da kullanılan miktarın iki katından fazlaya ulaşarak 3,5 milyon tonu aşmıştır. Bununla beraber, Türkiye'de pestisit kullanımının 2023 yılında 50.000 ton üzerinde olduğu bilinmektedir. Türkiye'de en çok kullanılan pestisit grupları, sırasıyla fungusitler, herbisitler, insektisitler, akarisitler, rodentisitler ve mollussisitler olarak sıralanmaktadır (T.C. Tarım ve Orman Bakanlığı, 2024).

Pestisitler, özellikle gereğinden fazla kullanıldıklarında, uygulandıkları tarımsal ekosistem dışında çok farklı yollar ile sucul ve diğer ekosistemlere taşınabilmektedirler. Pestisitler, akarsular ve sulak alanlar gibi farklı sucul ekosistemlere ulaştığında, bu ortamlarda doğal olarak yaşayan ve bu pestisitler açısından hedef olmayan sucul türlerde olumsuz etkilere neden olabilmektedirler (Tudi vd., 2021). Bu durum pestisitlerin çevreye olan etkilerinin değerlendirilmesinin önemini vurgulamaktadır. OECD (Ekonomik İşbirliği ve Kalkınma Örgütü), Avrupa Komisyonu (EC) ve Amerika Birleşik Devletleri Çevre Koruma Ajansı (USEPA) gibi farklı uluslararası kuruluşlar ve ülkelerin ulusal kuruluşları çevresel kirleticilerin etkilerinin değerlendirmesine yönelik kılavuzlar ve metotlar oluşturmuşlardır. Pestisitlerin akut ve kronik etkilerinin değerlendirilmesinde önemli yollardan biri sucul ekosistemde yaşayan balık, daphnia ve alg türlerinin kullanıldığı in vivo testlerin kullanılmasıdır. Bu testler özellikle doz-tepki arasındaki ilişkiyi tanımlamaya yönelik, LC_{50} (kullanılan organizmalarının toplamının %50'sinin ölümüne neden olan konsantrasyon) ve NOEC (gözlemlenmeyen etki konsantrasyonu) gibi farklı değerlerin belirlenmesini sağlamaktadır (Ragas, 2011). Ayrıca, ölümcül dozdan daha düşük dozlardaki toksik maddelerin farklı etkileri in vivo testler yardımıyla saptanabilmektedir. Söz konusu in vivo testlere bir alternatif olarak bazı in vitro testler de değerlendirilmektedir. Örneğin, pestisitlerin toksik etkilerinin değerlendirmesi için balık sperm hücrelerinin kullanılması öne çıkan in vitro tekniklerden biridir.

Birçok balık türünde spermatozoa testislerde hareketsizdirler. Spermatozoa dış ortama bırakılıp, ortamdaki su (tatlı su veya deniz suyu) ile karıştıklarında hareket (motilite) kazanırlar. Bu motilite kazanımından önce sağım yolu (karın masaj) ile alınan spermatozoa seminal plazma içeriğine benzer bir fizyolojik çözeltide (suni seminal plazma, sulandırıcı) hareket kazanmadan muhafaza edilebilmektedir (Alavi ve Cosson, 2005). Bu muhafaza sırasında, sulandırıcı içeriğine eklenen pestisitler gibi çevresel kirleticiler, spermatozoa motilite ve biyokimyasal parametrelerine etki ederler (Hatef vd., 2013). Daha sonrasında, spermatozoa motilitesi, bu sperm hücrelerinin uygun bir aktivasyon çözeltisi (tatlu su veya deniz suyuna benzer) ile karıştırılarak sağlanabilmektedir. İlgili literatürde, vinclozolin (VNZ), lambda-cyhalothrin (LCT), cypermethrin (CPM), captan (CPT), mancozeb (MCZ) ve azoxystrobin (AZX) pestisitlerinin in vitro sperm toksisite testlerinde kullanılmıştır (Gazo vd., 2013 Kutluyer vd., 2015 Kutluyer vd., 2016 Gündüz ve İnanan, 2024). Bu çalışmada, kullanılan bu farklı pestisitlerin in vitro toksisite testlerinde balık sperm hücrelerinin kullanımını değerlendirilmiş ve bu kullanımındaki hem avantajlar hem de dezavantajlar tartışılmıştır.

ARAŞTIRMA VE BULGULAR

Pestisit maruziyeti uygulanacak spermatozoa örnekleri, genellikle balık üretimi yapılan tesislerde barındırılan damızlık balıklardan temin edilmektedir. Önceki çalışmalarda, çuka balığından (Acipenser ruthenus) ve gökkuşağı alabalığından (Oncorhynchus mykiss) alınan spermatozoa örneklerinin kullanıldığı saptanmaktadır. Özellikle, daha yaygın olarak kullanılan gökkuşağı alabalığından spermatozoa eldesi için herhangi bir hormon enjeksiyonuna gerek duyulmamaktadır. Buna karşın, çuka balığında spermatozoa örneklerinin alınması için sperm örneklerinin eldesinden 48 saat önce, 5 mg/kg vücut ağırlığı dozunda sazan hipofiz hormonu intramüsküler enjeksiyon olarak damızlık balıklara uygulanarak uyarılma sağlanmıştır. Spermatozoa örnekleri, damızlık balıklara karın masajı (sağım) uygulanarak elde edilmektedir. Damızlık balıklara gerekli görüldüğü takdirde anestezi uygulanması gerekmektedir. Balıklar, sudan çıkartıldıktan sonra, özellikle anal bölgeleri iyice kurulanmıştır. Sağım sırasında, örneklere su, kan, idrar veya dışkı bulaşmamasına özen gösterilmiştir. Sperm örnekleri sağım ile direk tüplere alınmıştır ve bu tüpler buz üzerinde bekletilerek ivedilikle analizlere başlanmıştır. VNZ, LCT, CPM, CPT, MCZ ve AZX pestisitleri in vitro toksisite testleri için önceki çalışmalarda kullanılmıştır (Gazo vd., 2013; Kutluyer vd., 2015; Kutluyer vd., 2016; Gündüz ve İnanan, 2024). Spermatozoa örnekleri, bu pestisitleri µg/L seviyelerinde farklı konsantrasyonlarını içeren uygun sulandırıcılar ile seyreltilmişlerdir. Çuka balığı için kullanılan sperm sulandırıcı 20 mM Tris, 30 mM NaCl, 2 mM KCl, pH 8.5, gökkuşağı alabalığı için kullanılan sperm sulandırıcıların içerikleri ise 103 mM NaCl, 40 mM KCl, 1 mM $CaCl_2$, 0.8 mM $MgSO_4$, 20 mM hepes, mmol/l, pH 7.8 ve 130 mM NaCl, 40 mM KCl, 3 mM $CaCl_2$, 3 mM $MgCl_2$, 2 mM $NaHCO_3$, pH 8.0'dir. Deneylerde kontrol grubu ilgili pestisiti içermeyen sulandırıcı ile oluşturulmuştur. Sulandırma oranı belirlenirken öncelikli olarak alınan semen örneği içerisindeki spermatozoa yoğunluğu mikroskop altında 200 × büyütmede hemositometrik olarak hesaplanmıştır. Sulandırma oranı, sulandırma sonrası sonuçta elde edilen yoğunluğun 5-6×10^8 spermatozoa/ml olacağı şekilde ayarlanmıştır. Pestisit maruziyetleri, sulandırılan spermatozoa örneklerinin 2 saat 4°C'de inkübe edilmesi ile gerçekleştirilmiştir. Denemelerin tekrarları aynı sulandırma oranları ile sağlanmıştır.

Pestisit maruziyetleri sonrasında, motilite parametrelerinin kontrolü direkt olarak sulandırılan örneklerden gerçekleştirilirken, spermatozoa ile ilgili biyokimyasal parametreler sulandırılan örneklerin santrifüj edilmesi ve süpernatantlarından kurtulunması sonrasında yapılmıştır.

Elde edilmesi için sperm hücreleri uygun aktivasyon solüsyonları ile aktive edilerek motil (hareketli) hale getirilmiş ve motilite parametreleri belirlenmiştir. İlgili çalışmalarda toplam motil spermatozoa (%), spermatozoa kavisli hareket hızı (VCL, µm/s) ve sperm motilitesinin süresi (s) belirlenmiştir. Çuka balığı için aktivasyon solüsyonu olarak 10mM Tris, 10 mM NaCl, 1mM $CaCl_2$, pH 8.5 kullanılırken, gökkuşağı alabalığı için kullanılan aktivasyon solüsyonları 45 mM NaCl, 5 mM KCl, 30 mMTris–HCl, pH 8.2 ve 60 mM $NaHCO_3$, 50 mM Tris, pH=9,0'dur.

Pestisit maruziyeti sonrasında ölçülen spermatozoa biyokimyasal parametreleri ve analiz metotlarını içeren ilgili referans bilgileri Tablo 1'de gösterilmiştir.

Tablo 1. Pestisit maruziyetleri sonrasında ölçülen spermatozoa biyokimyasal parametreleri ve ilgili referansları.

Parametre	Açıklama/Birim	Referanslar
DNA hasarı	kuyruklu şekilde gözlemlenen DNA (%)	Li vd., 2008
TAK	toplam antioksidan kapasitesi (µg AA)	Prieto vd., 1999
LPO	tiyobarbitürik ile reaksiyona giren maddelerin (TBARS) miktarına dayalı lipid peroksidasyonu (nmol/10^8 spermatozoa)	Placer vd., 1966; Lushchak vd., 2005; Dzyuba vd., 2014
CP	proteinlerin karbonil türevleri (nmol/10^8 spermatozoa)	Lenz vd., 1989
SOD	süperoksit dismutaz (mU/10^8 spermatozoa)	Marklund ve Marklund, 1974
GSH	indirgenmiş glutatyon (nmol g^{-1} protein /10^8 spermatozoa)	Chavan vd., 2005
GSH-Px	glutatyon peroksidaz (IU g^{-1} protein/10^8 spermatozoa)	Matkovics vd., 1988
CAT	katalaz (kat. G^{-1} protein/10^8 spermatozoa)	Aebi, 1984
ATP miktarı	nmol ATP/10^8 spermatozoa	Boryshpolets vd., 2009
DPPH	DPPH inhibisyonu (%)	Wang vd., 2014
Yağ asitleri	çoklu doymamış, tekli doymamış ve doymuş yağ asitleri (mg/g yağ)	Bligh ve Dyer, 1959; İnanan vd., 2021

VNZ 0.5, 2, 10, 15, 20 ve 50 µg/L dozlarında çuka balığı sperm hücrelerine uygulanmıştır. Sperm motilite parametreleri olan motil spermatozoa ve VCL değerleri ≥ 2 µg/L dozlar üzerinde istatistiki açıdan önemli derecede düşüşler göstermişlerdir. Bununla beraber LPO,

CP ve SOD değerleri ≥ 10 µg/L dozlarda artış göstermişlerdir. Ayrıca, bu dozlarda, DNA hasarında artış ve ATP miktarında düşüş belirlenmiştir (Gazo vd., 2013). LCT 0.6, 1.2 ve 2.4 µg/L dozlarında gökkuşağı balığı sperm hücrelerine uygulanmıştır. ≥ 0.6 µg/L dozlarda sperm motilitesinde, ≥ 2.4 µg/L dozlarda motilite süresinde istatistiki açıdan düşüşler gözlenmiştir. ≥ 0.6 µg/L dozlarda LPO değerlerinde, ≥ 1.2 µg/L dozlarda GSH değerlerinde, ≥ 2.4µg/L dozlarda GSH-Px değerlerinde artışlar, bunlara karşın ≥ 1.2 µg/ dozlarda CAT değerlerinde düşüş saptanmıştır (Kutluyer vd., 2015). CPM 1.025, 2.05 ve 4.1 µg/L dozlarında gökkuşağı balığı sperm hücrelerine uygulanmıştır. Sperm motilitesinde ≥ 1.025 µg/L dozlarda azalma gözlemlenirken, motilite süresinde ki azalmalar istatistiki açıdan önemli bulunmamıştır. Benzer şekilde LPO ve GSH değerlerinde istatistiki açıdan anlamlı olmayan yükselmeler belirlenmiştir. Ancak, GSH-Px değerlerinde ≥ 1.025 µg/L dozlarda artış bulunmuştur. ≥ 1.025 µg/L dozlarda CAT değerlerinde yükselişler tespit edilmiştir (Kutluyer vd., 2016). CPT 1,2, 5 ve 10µg/L dozlarında gökkuşağı balığı sperm hücrelerine uygulanmıştır. Sperm motilitesi ve VCL değerleri ≥ 5 µg/L dozlarda azalmıştır. ≥ 2 µg/L dozlarda LPO, SOD ve TAK değerlerinde DPPH inhibisyonunda azalma saptanmıştır (Gündüz ve İnanan, 2024). MCZ 1, 2 ve 5 µg/L dozlarında gökkuşağı balığı sperm hücrelerine uygulanmıştır. ≥ 1 µg/L dozlarda sperm motilitesi ve VCL değerleri azalmıştır. ≥ 2 µg/L dozlarda LPO'da artış, ≥ 1 µg/L dozlarda SOD ve TAK değerlerinde ve ayrıca DPPH inhibisyonunda azalma bulunmuştur (Gündüz ve İnanan, 2024). AZX 1, 2, 5, 10, 20, 50 ve 200 µg/L dozlarında gökkuşağı balığı sperm hücrelerine uygulanmıştır. Sperm motilitesi ve VCL değerleri, SOD, TAK ve DPPH inhibisyonu ≥ 5 µg/L dozlarda azalmasına karşın LPO değerlerinde artış gözlemlenmiştir (Gündüz ve İnanan, 2024).

In vitro sperm toksisite testlerinde, pestisitlerin etkin dozları Tablo 2'de sunulmuştur. Buna göre, pestisitler farklı dozlarda motiliteyi, kontrol grubuna göre önemli derecede azaltmaktadır. Ayrıca, bu pestisitlerin motilite seviyesini yaklaşık %50 oranında azaltan dozlarında da farklılıklar bulunmaktadır.

Tablo 2. Farklı pestisitlerin sperm motilitesini önemli derecede azaltan ve motiliteyi %50'ye indiren etki dozları.

Pestisitler	**Motiliteyi önemli derecede azaltan doz**	**Motiliteyi %50'ye indiren doz**	**Referanslar**
Vinclozolin	**≥ 10 µg/L**	**50 µg/L**	Gazo vd., 2013
Lambda-Cyhalothrin	**≥ 0.6 µg/L**	**2.4 µg/L**	Kutluyer vd., 2015
Cypermethrin	**≥ 1.025 µg/L**	**4.1 µg/L**	Kutluyer vd., 2016
Captan	**≥5 µg/L**	**10µg/L**	Gündüz ve İnanan, 2024
Mancozeb	**≥ 1 µg/L**	**5 µg/L**	Gündüz ve İnanan, 2024
Azoxystrobin	**≥ 5 µg/L**	**200 µg/L**	Gündüz ve İnanan, 2024

SONUÇ VE TARTIŞMA

Çalışmalarda elde edilen sonuçlar, farklı pestisitlerin farklı konsantrasyonlarda spermatozoa parametrelerinde toksisiteye bağlı olarak etkilediği saptanmıştır. Tablo 3'de pestisitlerin kullanılması ile gerçekleştirilen in vitro sperm toksisite testlerinde ölçülen parametreler gösterilmiştir. Ortak ölçülen parametreler olarak, spermatozoa motilitesi ve LPO değerleri göze çarpmaktadır. Bu durum, gelecekteki ilgili çalışmaların bu parametrelerin devamlılığını sağlamaları yanında, diğer parametreleri de kapsayıcı olması gerektiğini göstermektedir.

In vitro sperm toksisite testleri, pestisitler haricinde, farklı çevresel kirletici maddelerin değerlendirmelerinde de kullanılabilmektedirler. Örneğin, civa ve kadmuyum gibi ağır metaller, bisfenol A ve karbamazepin gibi kirletici olarak sucul ortamda belirlenmiş maddelerin toksik etkileri balık sperm hücreleri kullanılarak başarılı bir şekilde gösterilmiştir (Chyb vd., 2001; Dietrich vd., 2010; Hatef vd., 2010; Li vd., 2010; Hatef vd., 2013; Shaliutina vd., 2021). In vitro sperm toksisite testlerinin basit, hızlı ve geçerli olmaları en önemli avantajları olarak öne çıkmaktadır. Bu testler hem hücre kültürlerinin kullanıldığı diğer in vitro testler için hem de in vivo testler için alternatif ve/veya tamamlayıcı olma potansiyelindedir. Hücre kültürü denemeleri, in vitro sperm toksisite testlerine göre pahalı olmaları, steril ortam şartları gereksinmeleri ve ilave malzemeler gerektirmeleri ile ayrılırlar. Diğer yandan, in vivo testlere göre daha hesaplıdırlar ve daha az örnekleme zahmeti gerektirmektedirler. Ayrıca in vitro sperm toksisite testleri, deney hayvanı olarak balıkların kendilerinin kullanılmamalarından dolayı etik kaygılardan uzaktırlar. Bu avantajların yanında, in vitro sperm toksisite testlerine farklı dezavantajlara da sahiptir. Özellikle metodolojik olarak farklı balık türlerinden elde edilen sperm hücreleri, farklı sperm sulandırıcılar ve farklı aktivasyon solüsyonları kullanılmıştır. Ayrıca, sperm hücrelerinin haploid, sadece nükleus ve mitokondri içermesi gibi özellikleri de elde edilmesi planlanan sonuçları sınırlayıcı özelliktedirler.In vitro sperm toksisite testleri, hem pestisitlerin sucul ortamdaki genel toksisite değerlendirilmesine yardımcı olduğu gibi hem de pestisitlerin balık üremeleri üzerine etkilerini göstererek canlı popülasyonuna etkilerini anlamada önem taşımaktadırlar. Bununla beraber, pestisitlerin etki mekanizmasının anlaşılması ve birbirlerinin toksik etkilerinin karşılaştırılmalarına olanak sağlayabilmektedirler. Şüphesiz, sucul toksisite değerlendirilmesinde balıkların direk olarak kullanılması temel bir durumdur. Ancak in vitro sperm toksisite testleri, etkin dozların kestirimine yardımcı olma durumu, daha az kimyasal ve daha az deney hayvanı olarak balık kullanımı gibi konularda in vivo testler için bir ön değerlendirme niteliğinde olabileceği saptanmaktadır.

Tablo 3. Balık sperm hücreleri kullanılarak in vitro toksisite testleri yapılan pestisitler ve sperm hücrelerinde ölçülen parametreler.

Pestisitler			**VNZ**	**LCT**	**CPM**	**CPT**	**MCZ**	**AZX**
Pestisit türü			**Fungusit**	**İnsektisit**	**İnsektisit**	**Fungusit**	**Fungusit**	**Fungusit**
Örneklenen Balık türü			A. ruthenus	O. mykiss	O. mykiss	O. mykiss	O. mykiss	O. mykiss
Ölçülen Sperm Parametreleri	**Motilite parametreleri**	MOT	+	+	+	+	+	+
		VCL	+			+	+	+
		SÜRE		+	+			
	DNA hasarı		+					
	TAK					+	+	+
	LPO		+	+	+	+	+	+
	CP		+					
	SOD		+			+	+	+
	GSH			+	+			
	GSH-Px			+	+			
	CAT			+	+			
	ATP miktarı		+					
	DPPH					+	+	+
	Yağ asitleri					+	+	+
Referans			Gazo vd., 2013	Kutluyer vd., 2015	Kutluyer vd., 2016	Gündüz ve İnanan, 2024	Gündüz ve İnanan, 2024	Gündüz ve İnanan, 2024

VNZ;Vinclozolin, **LCT**;lambda-cyhalothrin, **CPM**;cypermethrin, **CPT**;captan, **MCZ**; mancozeb, **AZX**;azoxystrobin, **A. ruthenus**; çuka balığı, **O. mykiss**; gökkuşağı alabalığı, **MOT**; toplam motil sperm (%), **VCL**; kavisli hareket hızı (µm/s), **SÜRE**; sperm motilite süresi (s), **DNA hasarı**;kuyruklu şekilde gözlemlenen DNA(%), **TAK**; toplam antioksidan kapasitesi (µg AA), **LPO**; Tiyobarbitürik ile reaksiyona giren maddelerin (TBARS) miktarına dayalı lipid peroksidasyonu (nmol/10^8 spermatozoa), **CP**; Proteinlerin karbonil türevleri (nmol/10^8 spermatozoa), **SOD**; süperoksit dismutaz (mU/10^8 spermatozoa), **GSH**; İndirgenmiş glutatyon (nmol g^{-1} protein /10^8 spermatozoa), **GSH-Px**; glutatyon peroksidaz (IU g^{-1} protein/10^8 spermatozoa), **CAT**; katalaz (kat. G^{-1} protein/10^8 spermatozoa), **ATP miktarı**; nmol ATP/10^8 spermatozoa, **DPPH**; DPPH inhibisyonu (%), **Yağ asitleri**; çoklu doymamış, tekli doymamış ve doymuş yağ asitleri (mg/g yağ)

KAYNAKLAR

Aebi, H., Catalase, in:H.U. Bergmeyer (Ed.), Methods of Enzymatic Analysis, Academic press, London 1984, pp. 671–684.

Alavi, S.M.H., Cosson, J. (2005). Sperm Motility in Fishes. I. Effects of Temperature and pH: a Review. Cell Biology International, 29, 101-110.

Birişik, N., (2018). Teoriden Pratiğe Kimyasal Mücadele ve Gelecek Stratejisi, Birişik N, editör. Teoriden Pratiğe Kimyasal Mücadele, Matsa Basımevi, Ankara.

Bligh, E.G., Dyer, W.J., 1959. A rapid method of total lipid extraction and purification. Can. J. Biochem. Physiol., 37, 911–917. https://doi.org/10.1139/y59-099.

Boryshpolets, S., Dzyuba, B., Rodina, M., Li, P., Hulak, M., Gela, D., Linhart, O. (2009). Freeze-thawing as the factor of spontaneous activation of spermatozoa motility in common carp (Cyprinus carpio L.), Cryobiology, 59, 291–296.

Chavan, S., Sava, L., Saxena, V., Pillai, S., Sontakke, A., Ingole, D. (2005). Reduced glutathione: importance of specimen collection. J. Clin. Biochem., 20(1), 150–152.

Chyb, J., Kime, D.E., Mikolajczyk, T., Szczerbik, P., Epler, P. (2000). Influence of zinc on sperm motility of common carp-a computer assisted studies. Arch. Pol. Fish., 8, 5–14.

Dzyuba, V., Dzyuba, B., Cosson, J., Boryshpolets, S., Yamaner, G., Kholodniy, V., Rodina, M. (2014). The antioxidant system of sterlet seminal fluid in testes and Wolffian ducts. Fish Physiol. Biochem, 40 (6), 1731–1739. https://doi.org/10.1007/s10695-014-9963-2.

FAO, (2024). Pesticide Use. https://www.fao.org/faostat/en/#data/RP (Erişim Tarihi: 19 Kasım 2024).

Hatef, A., Alavi, S.M., Golshan, M., Linhart, O. (2013). Toxicity of environmental contaminants to fish spermatozoa function in vitro–a review. Aquat. Toxicol. 140-141, 134–144. https://doi.org/10.1016/j.aquatox.2013.05.016.

Hatef, A., Alavi, S.M.H., Linhartova, Z., Rodina, M., Policar T., Linhart, O., (2010). In vitro effects of Bisphenol A on sperm motility characteristics in Perca fluviatilis L. (Percidae; Teleostei). Journal of Applied Ichthyology, 26, 696–701.

Inanan, B.E., Acar, Ü., ˙Inanan, T. (2021). Effects of dietary Ferula elaeochytris root powder concentrations on haematology, serum biochemical parameters, spermatozoa parameters, and oxidative status in tissues of males goldfish (Carassius auratus). Aquaculture, 544, 737087. https://doi.org/10.1016/j.aquaculture.2021.737087

Lenz, A.G., Costabel, U., Shaltiel, S., Levine, R.L. (1989). Determination of carbonyl groups in oxidatively modifiedproteins by reduction with tritiated sodium- borohydride, Anal. Biochem., 177, 419–425.

Li, P., Wei, Q., Liu, L. (2008). DNA integrity of Polyodon spathula cryopreserved sperm. J. Appl. Ichthyol., 24 121–125.

Li, Z.H., Li, P., Rodina, M., Randak, T. (2010). Effect of human pharmaceutical Carbamazepine on the quality parameters and oxidative stress in common carp (Cyprinus carpio L.) spermatozoa. Chemosphere 80, 530–534. https://doi.org/10.1016/j.chemosphere.2010.04.046.

Lushchak, V.I., Bagnyukova, T.V., Husak, V.V., Luzhna, L.I., Lushchak, O.V., Storey, K.B. (2005). Hyperoxia results in transient oxidative stress and an adaptive response by antioxidant enzymes in goldfishtissues, Int. J. Biochem. Cell.Biol., 37, 1670–1680.

Marklund, S., Marklund, G. (1974). Involvement of the superoxide anion radical in the autoxidation of pyrogallol and aconvenient assay for superoxide dismutase, Eur. J. Biochem., 47, 469–474.

Matkovics, B., Szabo, I., Varga, I.S. (1988). Determination of enzyme activities in lipid peroxidation and glutathione pathways, Lab. Diagn., 15, 248–249.

Özercan, B., Taşcı, R. (2022). Türkiye'de pestisit kullanımının iller, bölgeler ve pestisit grupları açısından incelenmesi. Ziraat Mühendisliği, (375), 75-88 https://doi.org/10.33724/zm.1120599

Placer, Z.A. Cushman, L.L., Johson, B.C. (1966). Estimation of product of lipid peroxidation (malonyldialdehyde) in biochemical systems, Anal. Biochem., 16, 359–364.

Prieto, P., Pineda, M., Aguilar, M. (1999). Spectrophotometric quantitation of antioxidant capacity through the formation of a phosphomolybdenum complex: Specific application to the determination of vitamin E. Anal. Biochem., 269, 337–341. https://doi.org/10.1006/abio.1999.4019.

Ragas, A.M.J. (2011). Trends and challenges in risk assessment of environmental contaminants, Journal of Integrative Environmental Sciences, 8:3, 195-218, DOI: 10.1080/1943815X.2011.597769

Shaliutina, O., Materiienko, A., Shaliutina-Koleˇssov´a, A., Gazo, I. (2021). Using fish spermatozoa in in vitro toxicity tests: A potential toxicology tool. Aquaculture, 539, 736647. https://doi.org/10.1016/j.aquaculture.2021.736647

T.C. Tarım ve Orman Bakanlığı, (2024). Resmi Tarımsal İlaç İstatistikleri. https://www.tarimorman.gov.tr/GKGM/Menu/115/Resmi-Tarimsal-Ilac-Istatistikleri (Erişim Tarihi: 19 Kasım 2024)

Tudi, M., Daniel Ruan, H., Wang, L., Lyu, J., Sadler, R., Connell, D., Chu, C., Phung, D.T. (2021). Agriculture development, pesticide application and its impact on the environment. Int. J. Environ. Res. Public Health, 18, 1112. https://doi.org/10.3390/ ijerph18031112.

Wang, K., Li, W., Rui, X., Chen, X., Jiang, M., Dong, M., 2014. Structural characterization and bioactivity of released exopolysaccharides from Lactobacillus plantarum 70810. Int. J. Biol. Macromol. 67, 71–78. https://doi.org/10.1016/j.ijbiomac.2014.02.056

INVESTIGATION OF ALTERNATIVE FEED SOURCES TO CORN AND SOYBEAN MEALS IN BROILER FEEDING

ETLIK PILIÇ BESLEMEDE MISIR VE SOYA FASULYESI KÜSPESINE ALTERNATIF YEM KAYNAKLARININ ARAŞTIRILMASI

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Abstract: The role of protein is essential in a healthy and balanced diet. The sources of animal protein are mostly red and white meat. White meat is an important source of animal-based protein due to its advantages, such as being cheaper than red meat, having a shorter production time, and easy accessibility. Broiler farming produces a large portion of white meat. However, the economics and sustainability of broiler farming on a global scale are becoming increasingly difficult. Because the basis of broiler rations consists of corn-soybean meal, the costs of these feed sources, especially soybean meal, are increasing day by day. In this scenario, the rising cost of white meat leads to a decrease in enterprise profitability or an increase in white meat prices. The increase in white meat prices restricts the access of segments of society to white meat and poses a significant risk to the sustainability of broiler chicken enterprises. To address this issue in broiler chicken breeding and lower the production cost of white meat, researchers have intensified their exploration of alternative feed sources for broiler chicken feeding. Researchers have been actively exploring various feed raw materials, particularly agricultural by-products, as potential alternative feed sources for broiler chickens. This study aims to disseminate knowledge on this topic by assessing the findings of recent studies in the literature on the utilization of alternative feed raw materials to corn and soybean meal, which serve as the foundation for broiler rations.
Keywords: Alternative feed source, animal protein, broiler chicken, soybean meal

Özet: Sağlıklı ve dengeli beslenmede proteinin rolü çok önemlidir. Hayvansal protein kaynağı ise yoğunlukla kırmızı ve beyaz ettir. Beyaz etin kırmızı ete göre ucuz olması, üretiminin kısa olması ve ulaşılabilirliğinin kolay olması gibi avantajlarından dolayı önemli bir hayvansal kökenli protein kaynağıdır. Beyaz etin çok büyük bir bölümü ise etlik piliç yetiştiriciliği sayesinde üretilmektedir. Ancak küresel çapta entansif etlik piliç yetiştiriciliğinin ekonomikliği ve sürdürülebilirliği giderek zorlaşmaktadır. Çünkü etlik piliç rasyonlarının temeli mısır-soya fasulyesi küspesinden oluşmakta olup, bu yem kaynaklarının özelliklede soya fasulyesi küspesinin maliyetleri her geçen gün artmaktadır. Bu durumda beyaz et maliyetini artırmakta ve dolayısıyla işletmelerin karlılık seviyesinin düşmesine veya beyaz et fiyatlarının artmasına neden olmaktadır. Beyaz et fiyatlarının artışı ise toplumun her kesiminin beyaz ete ulaşımını kısıtlamakta ve etlik piliç işletmelerinin sürdürülebilirliği açısından önemli bir risk taşımaktadır. Araştırmacılar etlik piliç yetiştiriciliğindeki bu problemin çözüme kavuşturulması ve beyaz etin üretim maliyetini düşürmek için etlik piliç beslemede alternatif yem kaynaklarının araştırılmasına hız vermişlerdir. Etlik piliç beslemede alternatif yem kaynağı olarak tarımsal yan ürünler başta olmak üzere birçok yem hammaddesi

araştırılmış ve halende araştırmalar devam etmektedir. Bu çalışmada etlik piliç rasyonlarının temelini oluşturan mısır ve soya fasulyesi küspesine alternatif yem hammaddelerinin kullanımı ile ilgili literatürdeki güncel çalışmaların sonuçları değerlendirilerek bu konu hakkında bilgiler paylaşmak amaçlanmıştır.
Anahtar Kelimeler: Alternatif yem kaynağı, etlik piliç, hayvansal protein, soya fasulyesi küspesi

GİRİŞ

Dünya nüfusu giderek artmakta olup 2050 yılına kadar nüfusun 9.7 milyar olacağı tahmin edilmektedir (Gu vd., 2021). Dünya nüfusunun artması insanların hayvansal kökenli proteine ulaşılabilirliği konusunda ciddi endişeler mevcuttur. Çünkü sağlıklı ve dengeli beslenmede proteinin rolü çok önemlidir. Hayvansal protein kaynağı ise yoğunlukla kırmızı ve beyaz ettir. Beyaz etin kırmızı ete göre ucuz olması, üretiminin kısa olması ve ulaşılabilirliğinin kolay olması gibi avantajlarından dolayı önemli bir hayvansal kökenli protein kaynağıdır. Öyle ki beyaz et tüketimi yıllar boyunca özelliklede gelişmekte olan ülkelerde istikrarlı bir şekilde artmaktadır (Ravindran, 2013). Beyaz etin çok büyük bir bölümü ise etlik piliç yetiştiriciliği sayesinde üretilmektedir. Ancak küresel çapta entansif etlik piliç yetiştiriciliğinin ekonomikliği ve sürdürülebilirliği giderek zorlaşmaktadır. Çünkü diğer hayvancılık işletmelerinde de olduğu gibi etlik piliç işletmelerinde de en büyük gider %70 oranında yem gideridir (Muleta, 2024). Etlik piliç rasyonlarının temeli mısır-soya fasulyesi küspesinden oluşmakta olup, bu yem kaynaklarının özelliklede soya fasulyesi küspesinin maliyetleri her geçen gün artmaktadır (Chandrasekaran, 2014). Çünkü soya fasulyesinde gıda-yem-biyoyakıt rekabetinin fiyatların önemli derecede artmasına neden olmaktadır. Bu durumda beyaz et maliyetini artırmakta ve dolayısıyla işletmelerin karlılık seviyesinin düşmesine veya beyaz et fiyatlarının artmasına neden olmaktadır. Beyaz et fiyatlarının artışı ise toplumun her kesiminin hayvansal protein kaynağına erişimini kısıtlamakta ve etlik piliç işletmelerinin sürdürülebilirliği açısından önemli bir risk taşımaktadır. Araştırmacılar etlik piliç yetiştiriciliğindeki bu problemin çözüme kavuşturulması ve beyaz etin üretim maliyetini düşürmek için etlik piliç beslemede alternatif yem kaynaklarının araştırılmasına hız vermişlerdir. Etlik piliç beslemede alternatif yem kaynağı yani geleneksel olmayan yem hammaddeleri tarımsal yan ürünler başta olmak üzere birçok yem hammaddesi araştırılmış ve halende araştırmalar devam etmektedir (Ravindran, 2013).
Bu çalışmada etlik piliç beslemede mısır ve soya fasulyesi küspesi yerine alternatif yem hammaddelerinin kullanımına yönelik yürütülen çalışmalar hakkında bilgiler vermek amaçlanmıştır.

Mısıra Alternatif Enerji Kaynakları

Kanatlı beslemede temel enerji kaynağı mısırdır (rasyonun %40-60). Ancak küresel çapta mısır üretimi etlik piliç sektörünün büyümesine göre daha yavaştır (Thirumalaisamy vd., 2016). Bu nedenle mısırla birlikte veya yerine darı, sorgum, arpa, buğday, çavdar ve tritikale gibi alternatif enerji kaynaklarının kullanılması geretiği vurgulanmıştır (Wiseman, 2006; Thirumalaisamy vd., 2016). Bu amaç doğrultusunda yürütülen çalışmalarda etlik piliçlerin son dönem rasyonlarında mısırın %25-30'u yerine bu tahılların kullanılabileceği belirtilmiştir (Wiseman, 2006; Krishna vd., 2014; Thirumalaisamy vd., 2016). Diğer bir çalışmada ise arpanın herhangi bir işleme tabi tutulmadan veya enzim kullanılmadan etlik piliç rasyonlarında %10-15 oranını geçmemesi gerektiği vurgulanmıştır (Yaprak ve Kırkpınar, 2003). Çünkü söz konusu alternatif enerji kaynaklarının bünyesinde birtakım antibesinsel faktörler ile nişasta tabiatında olmayan polisakkaritler bulunmaktadır (Yaşar vd., 2016). Bu nedenle arpa, buğday, çavdar ve tritikale gibi tahılların etlik piliçlerin özelliklede civciv döneminde kullanımı sınırlı olup, performansı olumsuz etkilediği bildirilmiştir (Yasar ve Gök, 2014; Yasar vd., 2016; Yasar ve Tosun, 2018). Bu yemlerin kullanımında ya enzim kullanılması gerekmektedir ya da bir takım biyoteknolojik yöntemler uygulanması gerekmektedir (Yasar vd., 2016,2018). Örneğin arpanın enzim kullanılarak rasyonda %30 oranında performansı olumsuz etkilemeden kullanılabileceğini belirtilmiştir (Temiz, 2022). Yasar vd. (2016) ise arpa, buğday ve yulafı katı faz fermentasyona tabi tutarak etlik piliç rasyonlarında %40-45 oranında kullanım olanağını araştırmışlardır. Araştırmacılar arpa ve buğdayın fermente edilerek mısır yerine etlik piliç rasyonlarında %40-45 oranında kullanılabileceğini belirtmişlerdir (Yasar vd., 2016).

Mısırın içeriğine en yakın alternatif enerji kaynağının sorgum olduğu tespit edilmiştir (Leeson ve Summers, 2005; Alshelmani vd., 2021). Ayrıca fiyatının mısırdan çok düşük olduğu belirtilmiştir (Leeson ve Summers, 2005; Alshelmani vd., 2021). Ancak sorgumun en büyük problemi bünyesinde tanen içermesidir. Çünkü tanenler büyüme performansını, yem tüketimini ve protein emilimini olumsuz etkilemektedir (Alshelmani vd., 2021). Sorgumun bünyesindeki tanenlerin azaltılması için alkali veya su ile ıslatma çalışmaları uygulanabileceği belirtilmiştir (Alshelmani vd., 2021). Mısıra alternatif aynı zamanda soya fasulyesine de alternatif olan diğer bir ürün ise biyoyakıt yan ürünü olan DDGS'dir. Nitekim etlik piliç beslemede rasyona %20 oranında kullanımında performansı iyileştirdiği belirtilmiştir (Fries-Craft ve Bobeck, 2019). DDGS'lerin etlik piliç beslemede en büyük probleminin ise besin madde kompozisyonunun çok değişkenlik göstermesi ve ulaşılabilirliğinin sınırlı olmasıdır (Fries-Craft ve Bobeck, 2019).

Tesfaye vd. (2013) yürüttükleri çalışmada manyok köklerinin etlik piliç rasyonlarında enerji kaynağı olarak kullanımını araştırmışlardır. Araştırmacılar rasyondaki mısırın %50'si yerine manyok kökünü ilave edilebileceğini belirtmişlerdir. Rasyonda %50'den fazla olduğunda içeriğindeki antibesinsel faktörden (hidrosiyonik asit) dolayı etlik piliç performansını düşürdüğünü belirtmişlerdir.

Mısıra alternatif enerji kaynakları arasında meyve ve sebze yan ürünlerinin de kullanılabileceği belirtilmiştir (Alshelmani vd., 2021). Örneğin elma ve domates posasının %15 oranında mısır yerine kullanılabileceği bildirilmiştir (Wadhwa ve Bakshi, 2013). Ancak bu yan ürünlerinde en büyük problemi antibesinsel faktörleri içermesi ve yüksek ham selüloz içeriğine sahip olmasıdır (Tosun ve Yaşar, 2020).

Etlik piliç beslemede mısıra alternatif enerji kaynaklarının doğrudan rasyonda mısırın yerine kullanılması içerdiği antibesinsel faktörlerden dolayı önemli derecede performansı olumsuz etkileyeceğinden dolayı çok mantıklı gözükmemektedir. Bunun yerine hayvanların dönemlerine göre enzim ilave edilerek mısırla kombine edilerek kullanılabilir. Söz konusu alternatif enerji kaynaklarının ekonomiklik durumu gözetilerek bir takım uygulamalarla antibesinsel faktörlerin yok edilmesi veya minimize edilmesi durumunda rasyonda kullanılma olanağı artacaktır. Böylece mısıra olan ihtiyaç azalabilir ve rasyonun maliyetinin düşürülmesi söz konusu olabilir.

Soya Fasulyesi Küspesine Alternatif Protein Kaynakları

Soya fasulyesi küspesi etlik piliçlerin neredeyse vazgeçilmez protein kaynağıdır (Gouveia vd., 2011; Filipe vd., 2023). Ancak soya fasulyesi küspesi fiyatının artması ve gıda-yem-yakıt rekabeti neticesinde araştırmacılar alternatif protein kaynaklarının araştırılmasına yönelmişlerdir (Filipe vd., 2023; Liu vd., 2024). Alternatif protein kaynağı olarak kolza tohumu küspesi, pamuk tohumu küspesi, ayçiçeği tohumu küspesi gibi yağlı tohum küspeleri ile solucanlar, böcekler ve alglerin kullanım olanaklarını araştırılmaktadır (Jazi vd., 2017; Olukomaiya vd., 2019; Coudert vd., 2020; Parolini vd., 2020; Alshelmani vd., 2021).

Ayçiçeği tohumu küspesi, yağ çıkarma işlemine ve kabuklu kabuksuz oluşuna göre %25-40 oranında ham protein içermektedir (Ceylan, 2012). Alagawany vd. (2015) etlik piliç beslemede soya fasulyesi yerine ayçiçeği tohumu küspesi kullanımını araştırmışlardır.

Araştırmacılar etlik piliç rasyonlarına soya fasulyesi küspesi yerine %25 oranında kullanılabileceğini belirtmiş, ancak rasyondaki esansiyel aminoasit içeriğini ayarlanması için sentetik esansiyel amino asit kullanılması gerektiğini vurgulamıştır. Ayrıca araştırmacılar rasyonda soya fasulyesi küspesinin %25'inden fazlası yerine ayçiçeği tohumu küspesi kullanımının yüksek selüloz ve antibesinsel faktörler nedeniyle etlik piliçlerin performansına olumsuz yansıdığını belirtmiştir (Alagawany vd., 2015).

Kolza tohumu küspesi, yağ çıkarma işlemine ve kabuklu kabuksuz oluşuna göre %30-40 oranında ham protein içermektedir (Drazbo vd., 2018). Ayrıca kolza tohumu sülfür içeren aminoasit ve lizin açısından oldukça zengindir (Drazbo vd., 2018). Kolza tohumu küspesinin her ne kadar protein içeriği yüksek olsa da etlik piliç beslemede başlangıç rasyonlarında soya fasulyesi küspesinin %10'u, diğer dönemlerinde ise %15'in üzerinde olmaması gerektiği belirtilmiştir (Hu vd., 2016; Shi vd., 2016). Çünkü bünyesindeki glikozinolatlar önemli derecede etlik piliçlerin performansını düşürdüğü belirtilmiştir (Hu vd., 2016; Shi vd., 2016).

Pamuk tohumu küspesi, pamuk tohumundan yağının alınmasından sonra geriye kalan tarımsal bir yan ürün olup, kimyasal kompozisyonunu tohum çeşidi ve nitelikleri, kabuklu-kabuksuz oluşu, yağ elde etme yöntemi gibi etmenlere göre %35-52 arasında değiştiği rapor edilmiştir (Ma vd., 2018; Tan vd., 2022; Liu vd., 2024). Diğer küspelerde olduğu gibi pamuk tohumu küspesinde de yapısal karbonhidratlar, antibesinsel faktörler (özellikle gossipol) içermesi ve protein kalitesinin soya fasulyesi küspesine nazaran düşük olması, esansiyel aminoasitlerden olan lizin açısından kısıtlı olması gibi kısıtlayıcı faktörler bulunmaktadır (Ashayerizadeh vd., 2024). Nitekim Wellman, (2008) etlik piliçlerde yürüttüğü çalışmada rasyona %15 oranında soya fasulyesi küspesine yerine ikame edilen pamuk tohumu küspesinin performansa olumsuz etkisinin olmadığını, ancak ekonomik karlılığının tartışılır olduğunu belirtmiştir.

Alglerin %50-60 oranında ham protein içerdiği ve omega-3 ve çoklu doymamış yağ asitlerince zengin olduğu belirtilmiştir (Alshelmani vd., 2021). Bazı çeşitlerinin ise %76 oranında ham protein içerdiği de belirtilmiştir (Alshelmani vd., 2021). Coudert vd. (2020) etlik piliçlerin rasyonunda %10'dan az olduğunda canlı ağırlığın %5-22 oranında arttığı, yemden yararlanmanın ise %4-15 oranında iyileştiğini belirtmiştir. Araştırmacılar etlik piliç rasyonlarında %10 üzerinde alg ilavesinde ise yem tüketiminin ve büyüme performansın düştüğünü belirtmişlerdir. Alshelmani vd. (2021) ise alglerin içeriğinde yüksek çoklu doymamış yağ içermesi nedeniyle etlik civciv rasyonlarında %21, etlik piliç rasyonlarında ise %17 oranından fazla rasyona ikame edildiğinde et kalitesini kötüleştirdiğini belirtmiştir.

Solucanlar ve böcekler gezen tavukların doğal yemleri durumundadır. Solucanlar %64-76 protein, %6-11 yağ içeriğine sahip olup esansiyel amino asitlerce zengindirler (Alshelmani vd., 2021). Solucanların etlik piliç rasyonlarında %15 üzerinde kullanılması et kalitesini olumsuz etkilediği için bu oranın üzerine çıkılmaması gerektiği belirtilmiştir (Parolini vd., 2020). Böcekler türüne göre %20-68 oranında ham protein içeriğine sahip olduğu rapor edilmiştir (Ssepuuya vd., 2017). Ayrıca böceklerin protein kaynağı olarak kanatlı rasyonlarında kullanımına dair çalışmalarda soya fasulyesi küspesi yerine %10'dan %100'e kadar kullanılabileceği belirtilmektedir (Jozefiak ve Engberg, 2015; Ssepuuya vd., 2017). Ancak böceklerde kitin içeriğinin dikkat edilmesi gerektiği vurgulanmakta, çünkü kitini kanatlılar sindirememekte ve önemli derecede büyüme performansını düşürdüğü vurgulanmıştır (Jozefiak ve Engberg, 2015; Ssepuuya vd., 2017). Böceklerin etlik piliç rasyonlarında soya fasulyesi küspesine alternatif protein kaynağı olarak kullanımındaki en büyük engel ticari çapta üretimin sınırlı olması ve mevcut fiyatının yüksek olmasıdır (Jozefiak ve Engberg, 2015; Ssepuuya vd., 2017).

Etlik piliç beslemede soya fasulyesi küspesine alternatif protein kaynakları incelendiğinde yağlı tohum küspelerinin yüksek oranda selüloz ve antibesinsel faktörlerin olduğu ve bazı esansiyel amino asitlerce fakir olduğu görülmektedir. Diğer taraftan alglerin yüksek oranda kullanıldığında et kalitesini olumsuz etkilemesi büyük bir problem teşkil etmektedir. Böcek ve solucanların ticari ölçekte üretilmesi ve fiyatlarının da düşük olması durumunda soya fasulyesi küspesine en ideal alternatif protein kaynağı olacağı öngörülmektedir.

SONUÇ

Etlik piliç beslemede soya fasulyesi küspesi yüksek protein içeriği ve kalitesi ile dengeli amino asit yapısı sayesinde vazgeçilmez protein kaynağı durumundadır. Ancak fiyatlarının giderek artması etlik piliç işletmelerinin sürdürülebilirliği için alternatif protein kaynaklarının kullanımı giderek zorunlu duruma gelmektedir. Bu bağlamda yağlı tohum küspeleri iyi bir alternatif gibi gözükse de bazı esansiyel amino asitlerce yetersiz oluşu ve en önemlisi antibesinsel faktörler içermesi nedeniyle etlik piliç rasyonlarında %15-25 oranından fazla kullanılamamaktadır. Bu nedenle bu antibesinsel faktörlerin ekonomik şartlarda minimize edildiği durumlarda etlik piliç rasyonlarında kullanım oranının artacağı düşünülmektedir. Ayrıca, böceklerin ise ticari boyuta üretim problemleri ve güncel fiyatlarının yüksek olması nedeniyle kullanımı önemli maliyet teşkil etmektedir. Ticari boyutta alternatif protein kaynağı olarak üretimi ve fiyatlarının düşük olduğu durumda soya fasulyesi küspesine iyi bir alternatif protein kaynağı olacağı düşünülmektedir.

KAYNAKLAR

Alagawany, M., Farag, M.R., Abd El-Hack, M.E., & Dhama, K. (2015). The practical application of sunflower meal in poultry nutrition. Adv. Anim. Vet. Sci, 3(12), 634-648.

Alshelmani, M.I., Abdalla, E.A., Kaka, U., & Basit, M.A. (2021). Nontraditional feedstuffs as an alternative in poultry feed. In Advances in poultry nutrition research. IntechOpen.

Ashayerizadeh, A., Jazi, V., Rezvani, M.R., Mohebodini, H., Soumeh, E.A., & Abdollahi, M. R. (2024). An investigation into the influence of fermented cottonseed meal on the productive performance, egg quality, and gut health in laying hens. Poultry Science, 103(5), 103574.

Ceylan, M.E. (2012). Farklı seviyelerde ayçiçeği tohumu küspesi içeren yumurta tavuğu rasyonlarına enzim ilavesinin performans ve yumurta kalitesine etkisi. Yüksek Lisans Tezi, Selçuk Üniversitesi, Fen Bilimleri Enstitüsü, Konya.

Chandrasekaran, D. (2014). Juvenile Broiler Nutrition. Department of Animal Nutrition, Veterinary College and Research Institute Tamil Nadu Veterinary and Animal Sciences University, Namakkal. 637 002.

Coudert, E., Baéza, E., & Berri, C. (2020). Use of algae in poultry production: A review. World's Poultry Science Journal, 76(4), 767-786.

Drazbo, A., Ognik, K., Zaworska, A., Ferenc, K., & Jankowski, J. (2018). The effect of raw and fermented rapeseed cake on the metabolic parameters, immune status, and intestinal morphology of turkeys. Poultry Science, 97(11), 3910-3920.

Filipe, D., Vieira, L., Ferreira, M., Oliva-Teles, A., Salgado, J., Belo, I., & Peres, H. (2023). Enrichment of a Plant Feedstuff Mixture's Nutritional Value through Solid-State Fermentation. Animals, 13(18), 2883.

Fries-Craft, K., & Bobeck, E. A. (2019). Evaluation of a high-protein DDGS product in broiler chickens: performance, nitrogen-corrected apparent metabolisable energy, and standardised ileal amino acid digestibility. British Poultry Science, 60(6), 749-756.

Gouveia, S., Castilho, P.C. (2011). Antioxidant Potential of Artemisia argentea L'Hér Alcoholic Extract and Its Relation with the Phenolic Composition. Food Res. Int. 44, 1620–1631

Gu, D., Andreev, K., Dupre, M.E. (2021). Major Trends in Population Growth Around the World. China CDC Wkly, 3(28), 604-613.

Hu, Y., Wang, Y., Li, A., Wang, Z., Zhang, X., Yun, T., Qiu, L., Yin. Y. (2016). Effects of fermented rapeseed meal on antioxidant functions, serum biochemical parameters and intestinal morphology in broilers. Food Agric. Immunol. 27:182–193

Jazi, V., Boldaji, F., Dastar, B., Hashemi, S.R., Ashayerizadeh, A. (2017). Effects of fermented cottonseed meal on the growth performance, gastrointestinal microflora population and small intestinal morphology in broiler chickens. British Poultry Science, 58(4), 402-428.
Jozefiak, D., Engberg, R.M. (2015). Insect as poultry feed. 20th European symposium on Poultry Nutrition, 24-27 August, Prague, Czech Republic.
Leeson, S., Summers, J. (2005). Commercial Poultry Nutrition. Department of Animal and Poultry Science, University of Guelph. 3. Ed: University Book.
Liu, B., Liu, H., Liu, D., Zhou, M., Jiang, Q., Ma, X., Wang, J., Tan, B., & Zhang, C. (2024). Free Gossypol Removal and Nutritional Value Enhancement of Cottonseed Meal via Solid-State Fermentation with Rhodotorula mucilaginosa TG529. Agriculture, 14(9), 1463.
Ma, D.L., Ma, X.K., Liu, L., Zhang, S. (2018). Chemical composition, energy, and amino acid digestibility in 7 cottonseed co-products fed to growing pigs. Animal Science Journal, 96, 1338–1349.
Muleta, C. E. (2024). The Major Potential of Non-Conventional Feed Resources in Poultry Nutrition in Ethiopia: A Review. Animal and Veterinary Sciences, 13(3), 68-77.
Olukomaiya, O., Fernando, C., Mereddy, R., Li, X., Sultanbawa, Y. (2019). Solid-state fermented plant protein sources in the diets of broiler chickens: A review. Animal Nutrition, 5, 319-330.
Parolini, M., Ganzaroli, A., & Bacenetti, J. (2020). Earthworm as an alternative protein source in poultry and fish farming: Current applications and future perspectives. Science of the Total Environment, 734, 139460.
Ravindran, V. (2013). Alternative feedstuffs for use in poultry feed formulations. Poultry development review (ed.) FAO, 72-75.
Shi, C., He. J., Wang, J., Yu, J., Yu, B., Mao, X., Zheng, P., Huang, Z., Chen, D., (2016). Effects of Aspergillus niger fermented rapeseed meal on nutrient digestibility, growth performance and serum parameters in growing pigs. Anim. Sci. J. 87:557–563.
Ssepuuya, G., Namulawa, V., Mbabazi, D., Mugerwa, S., Fuuna, P., Nampijja, Z., Ekesi, S., Fiaboe, K.K.M., Nakimbugwe, D. (2017). Use of insects for fish and poultry compound feed in sub-Saharan Africa–a systematic review. Journal of Insects as Food and Feed, 3(4), 289-302.
Tan, C.F., Kwan, S.H., Lee, C.S., Soh, Y.N.A., Ho, Y.S., Bi, X. (2022). Cottonseed meal protein ısolate as a new source of alternative proteins: a proteomics perspective. International Journal of Molecular Sciences, 23, 10105–10124.
Temiz, A.R. (2022). Farklı düzeyde arpa içeren rasyonların etlik piliçlerde büyüme performansı, bağırsak viskozitesi, altlık kalitesi ve ayak tabanı yangısına etkileri. Aydın Adnan Menderes Üniversitesi Sağlık Bilimleri Enstitüsü, Doktora tezi. S 108.
Tesfaye, E., Animut, G., Urge, M., & Dessie, T. (2013). Cassava root chips as an alternative energy feed ingredient in broiler ration. International Journal of Poultry Science, 12(5), 298-306.
Thirumalaisamy, G., Muralidharan, J., Senthilkumar, S., Hema Sayee, R., & Priyadharsini, M. (2016). Cost-effective feeding of poultry. International Journal of Science, Environment and Technology, 5(6), 3997-4005.
Tosun, R., & Yaşar, S. (2020). Nutritional enrichment of apple pomace by fungal fermentations. KSÜ Tarım ve Doğa Derg 23 (3): 754-761.
Wadhwa, M., Bakshi, M.P.S. (2013). Utilization of fruit and vegetable wastes as livestock feed and as substrates for generation of other value-added products. RAP Publication, 4, 67.
Wellmann, K.T. (2008). Farklı düzeylerde kullanılan pamuk tohumu küspesinin etlik piliçler üzerine etkileri (Doctoral dissertation, Adnan Menderes Üniversitesi).
Wiseman, J. (2006). High energy diets for poultry – effects of diet composition on performance and carcass quality. In J. Wiseman & P.C. Garnsworthy, eds. Recent

developments in non-ruminant nutrition, pp. 193–212. Nottingham, UK, Nottingham University Press.

Yaprak, Ç., & Kırkpınar, F. (2003). Arpa temeline dayalı etlik piliç karma yemlerine ilave edilen enzim ve antibiyotiğin etkileri. Ege Üniversitesi Ziraat Fakültesi Dergisi, 40(2).

Yasar, S., & Gok, M. S. (2014). Fattening performance of Japanese quails (Coturnix coturnix japonica) fed on diets with high levels of dry fermented wheat, barley and oats grains in whey with citrus pomace.

Yasar, S., & Tosun, R. (2018). Predicting chemical, enzymatic and nutritional properties of fermented barley (Hordeum vulgare L.) by second derivate spectra analysis from attenuated total reflectance-Fourier transform infrared data and its nutritional value in Japanese quails. Archives of animal nutrition, 72(5), 407-423.

Yasar, S., Boselli, E., Rossetti, F., & Gok, M. S. (2018). Effect of fermented cereals, probiotics, and phytase on the sensory quality of poultry meat. Sci. Agric. Bohem, 49, 225-235.

Yasar, S., Gök, M. S., & Gürbüz, Y. (2016). Performance of broilers fed raw or fermented and redried wheat, barley, and oat grains. Turkish Journal of Veterinary & Animal Sciences, 40(3), 313-322.

KATMA DEĞERİ YÜKSEK ÜRÜNLERİN KURUTULMASINDA YENİ BİR TEKNİK: İNDİRGEN ATMOSFERİK KURUTMA (İAK) TEKNİĞİ

AN EMERGING TECHNIQUE IN DRYING HIGH VALUE-ADDED PRODUCTS: REDUCING ATMOSPHERE DRYING

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ÖZET
Gıdaların muhafaza edilmesinde birçok farklı teknik kullanılmasına karşın kurutma, bilinen en eski muhafaza tekniğidir. Literatürde güneşte kurutma, sıcak hava ile kurutma ve vakumda kurutma gibi çok çeşitli kurutma yöntemi bulunmaktadır. Geleneksel kurutma yöntemlerinin birçoğu çoğunlukla yüksek sıcaklık ve ortam atmosferi olarak hava kullanmaktadır. Hava, oksijen ihtiva etmesi sebebiyle kurutma esnasında gıdaların duyusal ve besinsel kalitesinde kayıplara sebep olabilmektedir. Bu kurutma tekniklerinin aksine kapalı bir sistem olan İndirgen Atmosferik Kurutma (İAK) sistemi, ortam atmosferinde hidrojen (H_2) içeren gaz karışımı ($H_2/N_2/CO_2$) kullanımını temel almakta ve daha yüksek kalitede kuru gıda üretimini amaçlamaktadır. Bu amaca ulaşmada, literatürde terapötik tıbbi bir gaz olarak yer edinen ve indirgen özellik gösteren H_2'yi kullanması sebebiyle İAK tekniği dünyada bir ilk niteliğini taşımaktadır. Bu kurutma tekniğiyle H_2'nin hücre altı birimlere bile hızla difüze olabilme özelliğinden faydalanılarak hem gıdanın kendi içinde bulunan oksijen hem de ortamdaki oksijen ve serbest radikallerin indirgenmesiyle kurutma alanında daha önce çalışılmış olan karbondioksit (CO_2) ve azot (N_2) gazlarından daha etkili sonuçlar elde edilebilecektir. Daha önce yapılan denemelerde İAK sistemiyle kurutulan elma ve kayısı örneklerinde belirli kalite parametrelerinin (renk ve antioksidan) muhafaza edilmesi, söz konusu tekniğinin etkinliğini kanıtlamıştır.
Anahtar Kelimeler: Kurutma, Hidrojen gazı, İndirgen atmosfer

ABSTRACT
Drying is the oldest preservation technique. Many conventional drying methods, such as sun drying, hot air drying, and vacuum drying, mostly use high temperatures and air as a drying atmosphere. Air, the atmosphere surrounding the food, contains oxygen, causing losses in the sensory and nutritional quality of dried foods. As an alternative to these drying techniques, the Reducing Atmosphere Drying (RAD) system, which is a closed system, is based on the use of a reducing gas mixture ($H_2/N_2/CO_2$) containing hydrogen (H_2) in the drying atmosphere. In order to preserve the quality of the product, the RAD is the first technique in the world to use H_2 in the drying atmosphere. H_2 is an antioxidant gas with reducing properties. With the RAD drying technique, by utilizing the ability of H_2 to diffuse into subcellular units quickly, more effective results can be obtained in the absence of oxygen in the environment. In previous studies, the RAD system has proven effective in preserving apples and apricots' sensory and nutritional quality (color and antioxidants).
Keywords: Drying; Hydrogen gas; Reducing atmosphere; Value-added products

GİRİŞ

Kurutma, en eski muhafaza yöntemleri arasında yer almakta ve büyük ölçekli gıda muhafazasında vazgeçilmez tekniklerden biri olarak ön plana çıkmaktadır. Kurutmanın amacı, dikkatli ısı uygulamasıyla bir üründen nemi kabul edilebilir bir seviyeye indirgeyerek gıdanın bozulmasını engellemek ve kalitesini korumaktır (Khaing Hnin et al., 2019). Kuru gıdalar; ürünün raf ömrünün uzaması, paketleme, depolama ve nakliye masraflarının düşmesi, sezon dışında da bulunabilme imkânının artması ve tüketicilere daha geniş bir ürün yelpazesi sunulması gibi çok sayıda fayda sunmaktadır (Moses et al., 2014)**.**

Güneşte kurutma, sıcak hava ile kurutma, vakumda kurutma ve dondurarak kurutma gibi çok çeşitli kurutma yöntemi bulunmakla beraber geleneksel kurutma en fazla kullanılan kurutma yöntemidir. Uygun maliyetli olması sebebiyle çok tercih edilmesine karşın bağlayıcı olan birçok geleneksel kurutma yönteminde, çoğunlukla yüksek sıcaklık ve ortam atmosferi olarak hava kullanılması nedeniyle ısıya ve oksijene duyarlı bileşenlerde olumsuz değişiklikler meydana gelmekte dolayısıyla yüksek kalitede ürün elde edilmesi oldukça zordur (Alwazeer & Örs, 2019). Isıya ve oksijene duyarlı bileşenlerde meydana gelen bu istenmeyen değişiklikler iki temel şekilde kategorize edilmektedir:

i) Taze renk, tat ve aromanın kaybıyla ifade edilen duyusal değişiklik,

ii) Vitaminler, polifenoller ve doymamış yağ asidi gibi bazı biyoaktif bileşiklerin besin özelliklerinin kaybıyla ortaya çıkan besinsel değişiklik (Y. Liu et al., 2014).

Kuru ürünlerin kalite özellikleri, tüketiciler için çekiciliğini artırmada oldukça önemli kalite nitelikleridir. Düşük oksijen koşullarında kurutma, besin değerindeki kayıpları önlemektedir. Esmerleşmeyi azaltmak, ürünün gözenekli yapısını korumak ve kurutma süresini kısaltmak amacıyla kurutma atmosferinde N_2 ve CO_2 gibi gazlar kullanılabilmektedir. İnert atmosferde kurutma, normal atmosferde sıcak hava ile kurutmaya kıyasla ürün rengi ve lezzet kaybı açısından önemli avantajlar sağlamaktadır (Cam et al., 2018; Y. Liu et al., 2014).

İndirgen Atmosferik Kurutma (İAK) sistemi, modifiye atmosfer kurutmadan farklı olarak, dünyada ilk defa indirgen gaz (hidrojen/H_2) ihtiva eden bir gaz karışımının (CO_2 ve/veya N_2 ve/veya H_2) kullanımını esas alan kapalı çevrim bir kurutma sistemidir. Söz konusu teknikle katma değeri yüksek olan gıda ürünlerinin çok daha yüksek kalitede kuru ürün formuna dönüştürülmesi amaçlanmaktadır. Bu amaç doğrultusunda hidrojenin indirgen özelliğinden faydalanılarak hem kurutma atmosferindeki hem de ürün içerisindeki oksijen ve serbest radikallerin minimize edilmesi hedeflenmektedir.

KURAMSAL TEMELLER

Kurutma prosesi, MÖ 12.000'e kadar dayanmaktadır. Orta Doğu ve doğu toplumlarında çok sıcak havalarda gıda maddeleri kurutulmuştur. Hatta güneş ışığı ve rüzgârın yetersiz olduğu bölgelerde meyve, sebze ve otları kurutmak amacıyla "hareketsiz evler" inşa edilmiş ve ateşle ısıtılmıştır (Bhattacharjee et al., 2024). Güneşte kurutma, kolay erişilebilir ve uygun fiyatlı olması sebebiyle günümüzde özellikle fakir ülkelerde hala uygulanmaktadır. Ancak bu kurutma tekniği kontaminasyon, kuruma derecesinin kontrol edilememesi ve düşük kalitede kuru ürün gibi dezavantajları da beraberinde getirmektedir. Literatürde 500'den fazla kurutma yöntemi bildirilmiştir (Mujumdar & Law, 2010). Bu yöntemler hem tek hem de kombinasyon halinde gıda endüstrileri tarafından kullanılmasına rağmen geleneksel kurutma yöntemi basit ve düşük maliyetli olması sebebiyle kullanılan en yaygın kurutma yöntemidir (Alwazeer & Örs, 2019). Endüstriyel kurutucuların %85'inden fazlası, ısı transfer ortamı olarak sıcak hava kullanan konvektif tiptedir (Moses et al., 2014). Kurutma atmosferinde bulunan oksijen, gıdalardaki kimyasal ve enzimatik reaksiyonları tetikleyerek gıdaların renk, tat, dokusal yapı ve besinsel özelliklerini değiştirmekte ve genel kaliteye zarar vermektedir (Y. Liu et al., 2014). Özellikle polifenol oksidaz (PPO) grubunda yer alan enzimler, fenolik bileşiklerin oksidasyonu yoluyla kahverengi pigment oluşturarak enzimatik esmerleşmeye sebebiyet vermektedir. PPO enzim aktivitesi şu işlemlerle engellenebilmektedir (Örs, 2019).

i) Enzimin ısı yoluyla inaktivasyonu,
ii) Substratlardan (oksijen ve fenolik bileşikler) birinin veya tamamının elimine edilmesi,
iii) pH değerinin 2 veya optimum enzim pH değerinin altına düşürülmesi,
iv) PPO enzimini inhibe eden veya melanin oluşumunu önleyen bileşiklerin eklenmesi

Endüstride, bu istenmeyen esmerleşme olgusu askorbat, sodyum bisülfit, kükürtdioksit ve organik asitler (sitrik, malik ve asetik asit) gibi bazı kimyasalların kullanımıyla kontrol edilmektedir (Alwazeer & Örs, 2019). Bu enzimatik esmerleşme reaksiyonunu minimize etme amacıyla alternatif olarak; inert atmosfer koşulları altında uygulanan kurutma işlemiyle, oksidatif hasar azaltılarak meyve ve sebze gibi gıda ürünlerinin besinsel kalitesi sürdürülebilmektedir (Ramesh et al., 1999). Bozucu reaksiyonlarda rol oynayan oksijeni ortamdan uzaklaştırmak için konvensiyonel yöntemlerde, kurutma atmosferi olarak kullanılan hava; azot (N_2), argon (Ar) veya karbondioksit (CO_2) gibi belirli gazlarla değiştirilebilir (Mujumdar & Law, 2010). Bu bağlamda; ısı pompalı kurutma tekniği, birçok farklı gıda ürününde başarıyla uygulanmıştır (Jangam, 2011).

Santos & Silva, (2009), kuşburnu meyvesi üzerine yaptıkları çalışmada, oksijen (O_2) konsantrasyonunda meydana gelen artışla birlikte C vitamini miktarının azaldığını; karbondioksit (CO_2) ile kurutulan örneklerin C vitamini içeriğinin, azot (N_2) ile kurutulan örneklerinkinden daha fazla olduğunu tespit etmişlerdir. Yine kuşburnu meyvesine farklı oranlarda uygulanan hava-CO_2 karışımı sonucunda en yüksek kaliteye saf CO_2 ile muamele edilen meyvelerde rastlanmıştır (Erenturk, 2005).

Hawlader et al., (2006), farklı kurutma yöntemleriyle kurutulan zencefilde oluşan 6-gingerol kaybını tespit edebilmek için; ısı pompalı kurutma [hava, karbondioksit (CO_2) ve azot (N_2)] vakumda kurutma ve dondurarak kurutma teknikleriyle kurutma yapmış ve modifiye atmosferin [karbondioksit (CO_2) ve azot (N_2)] normal atmosfere (hava) kıyasla 6-gingerol'ün zencefilde daha yüksek miktarda kaldığını ve difüzyon etkinliğini arttırdığını bildirmiştir.

Hassas bileşikler ihtiva eden gıdaların kurutulması esnasında kurutma atmosferi olarak N_2 kullanıldığında, oksidatif reaksiyonların gerçekleşmediği bildirilmiştir (Perera & Rahman, 1997).

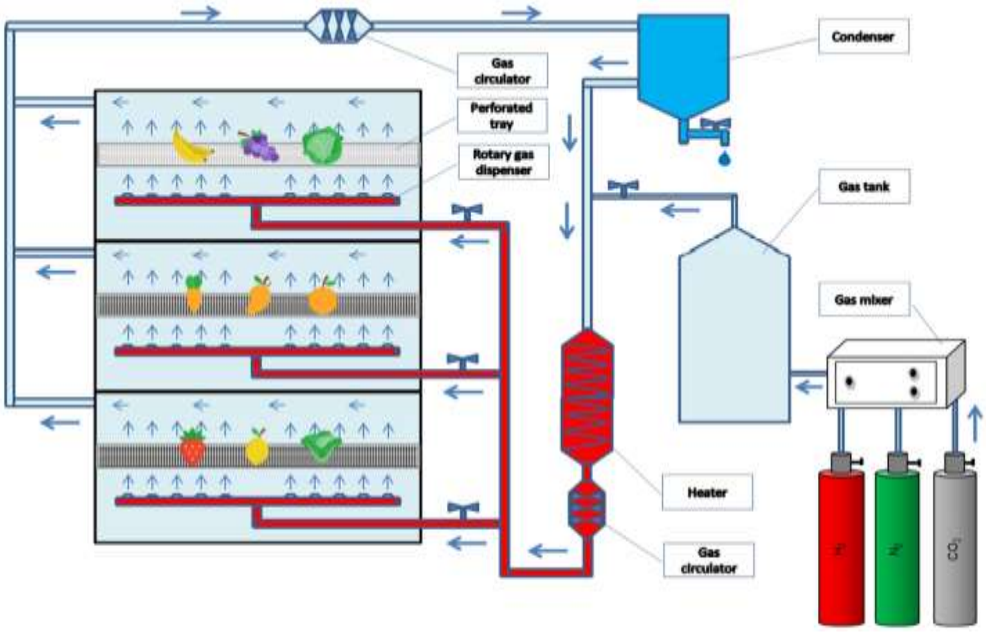
Şu ana kadar modifiye atmosfer kurutma adı altında az sayıda çalışma yapılmış ve gerçekleştirilen çalışmalar çoğunlukla azot (N_2) ve karbondioksit (CO_2) gazları ile sınırlı kalmıştır. İndirgen Atmosferik Kurutma (İAK) tekniğinde, modifiye atmosfer kurutma alanında yapılan çalışmalardan farklı olarak ısı pompalı kurutma sistemine benzer kapalı bir sistemde dünyada ilk kez ortam atmosferinde hidrojen (H_2) içeren gaz karışımı (N_2 ve/veya CO_2 ve/veya H_2) kullanılmaktadır. Bu teknikte H_2 gazı içeren bir gaz karışımının kullanımını tanımlamak için İndirgen Atmosfer terimi kullanılmıştır.

Hidrojen, moleküler formülü H_2 olan, renksiz, kokusuz, metal olmayan, tatsız ve son derece yanıcı bir iki atomlu gazdır. Gıda standartlarını belirleyen organizasyonlar tarafından, E 949 kodu ile itici gaz kategorisinde gıda katkı maddesi olarak onaylanmıştır (Alwazeer et al., 2003). H_2 gazı, suda çözünürlüğü (1 atm ve 20 ºC'de 1,57 mg/l) çok düşük olmasına rağmen; nötralite, hidrofobiklik, kütle, boyut, yüksek lipid çözünürlüğü gibi eşsiz fizikokimyasal özellikleri, hidrojenin hücre altı birimlere (örn. çekirdek, mitokondri) ve biyomembranlara (örn. plasenta, kan-beyin, hücre zarları) bile hızlıca nüfuz etmesine imkan tanımaktadır (Ohta, 2014; Qian et al., 2015). Son zamanlarda yapılan temel ve klinik araştırmalar hidrojenin hücre ve organlar üzerinde antioksidan, antiinflamatuar ve antiapoptotik koruyucu etkileri olan önemli bir fizyolojik düzenleyici faktör olduğunu ortaya koymuştur (Nakao, 2011).

Son araştırmalar, hidrojenin (H_2) biyolojik etkilerinin ardındaki kimyasal mekanizmanın, bazı serbest radikalleri nötralize etme yoluyla koruyucu etki oluşturmasından kaynaklandığını tespit etmiştir (W. Liu et al., 2015). Bu koruyucu etkisi kapsamında, reaktif oksijen türlerinden (ROT) en sitotoksik özellikte olan hidroksil radikalini (-OH) seçici şekilde ortadan kaldırarak hücreleri etkin şekilde koruduğu, fakat fizyolojik görevlere sahip diğer ROT'lar ile reaksiyona girmediği bildirilmektedir (Ohsawa et al., 2007).

Terapötik hidrojen; doğrudan inhalasyon, hidrojenle zenginleştirilmiş suyun (HZS) içilmesi ve hidrojenle doygun hale getirilmiş tuzlu su ile enjeksiyon dahil olmak üzere farklı uygulama yöntemleriyle uygulanmaktadır (Nakao, 2011)

İndirgen Atmosferik Kurutma (İAK) sistemi ile hidrojenin indirgen özelliği ve hızlı difüze olabilme yeteneğinden faydalanılarak gıdanın hem kendi bünyesindeki oksijen hem de kurutma ortamındaki oksijen ve serbest radikallerin indirgenmesiyle; modifiye atmosfer kurutmada daha önce kullanılmış olan azot (N_2) ve karbondioksit (CO_2) gazlarından çok daha etkili



sonuçlara ulaşılması ve daha yüksek kalitede kuru ürün üretimi hedeflenmektedir. Bu hedefe ulaşırken kapalı sistem kullanımı ile gaz karışımının sürekli değil belli aralıklarla beslenerek enerji verimi sağlanacaktır.

İAK tekniği hem elma hem de kayısının kurutulmasında başarıyla test edilmiştir (Alwazeer, 2018; Alwazeer & Örs, 2019). Kurutma atmosferi olarak $N_2/CO_2/H_2$ 'den (91/5/4%, v/v) oluşan bir gaz karışımının uygulanması, meyvenin renk profili ve antioksidan özelliği üzerinde koruyucu etki göstermiştir. İAK tekniği, yalnızca sıcak hava ile kurutma ve vakumda kurutma yöntemleri gibi geleneksel kurutma tekniklerine göre değil, aynı zamanda ürünün farklı kalite özellikleri üzerindeki olumlu koruyucu etkisiyle bilinen dondurarak kurutma tekniğine göre de avantajlar sağlamıştır. İkinci bir uygulamada ise İAK sisteminin elma dilimleri üzerine inoküle edilen farklı mikroorganizmalar (L. bulgaricus, S. thermophilus, P. fluorescens ve Z. rouxii suşları) üzerine etkisi incelenmiştir (Şişik, 2021).

MATERYAL-METOT

İndirgen Atmosferik Kurutma (İAK) sistemi ısı pompalı kurutma sistemine benzer kapalı çevrim bir sistem olup, prensibi kurutma atmosferi olarak indirgen gaz (H_2) içeren gaz karışımı ($N_2/CO_2/H_2$) kullanımına dayanmaktadır (Şekil 1). İlk olarak prototip formunda laboratuvar şartlarında Iğdır Üniversitesi Yenilikçi Gıda Teknolojileri Araştırma Merkezi'nde (YENİGIDAM) tasarlanmış ve yapılmıştır. Ardından Iğdır Üniversitesi ihtisas projeleri kapsamında "YİP1023i02" proje numarası ile pilot tipi İndirgen Atmosferik Kurutma sistemi üretilmiştir (Şekil 2).

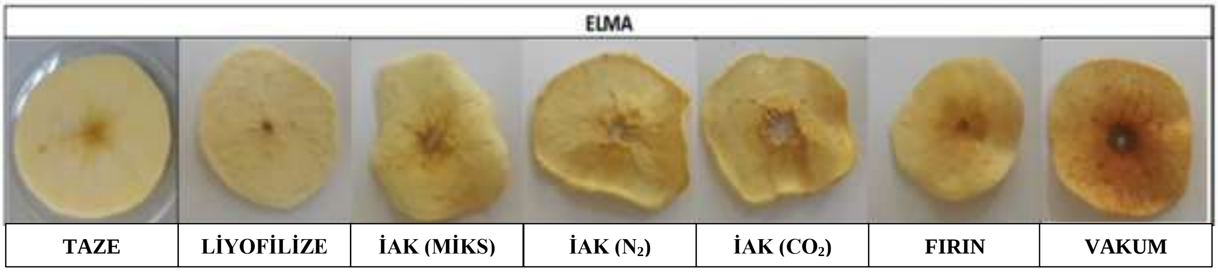
Şekil 1. İndirgen Atmosferik Kurutma Sistemine ait şematik diyagram (Alwazeer, 2020)

İAK sisteminin çalışma prensibi şu şekildedir: İlk olarak bir gaz mikseri yardımıyla gazlar istenen oranlarda karıştırılmakta (Hidrojen miktarı %4 değerini geçmeyecek şekilde) ve sistemde ısıtıldıktan sonra kurutma kabinine aktarılmaktadır. Kurutma kabininde sirkülasyonu sağlanan gaz karışımı kurutma kabininden ayrılarak kondensöre ulaşmakta ve burada gaz karışımı içerisindeki nem yoğuşturularak ayrıştırılmaktadır. Nemden arınan gaz karışımı tekrardan sisteme beslenmektedir. Gaz karışımının tekrar tekrar kullanımı enerji verimi sağlamakta ve gazlar gerektiği durumlarda sisteme beslenmektedir (Şekil 1).

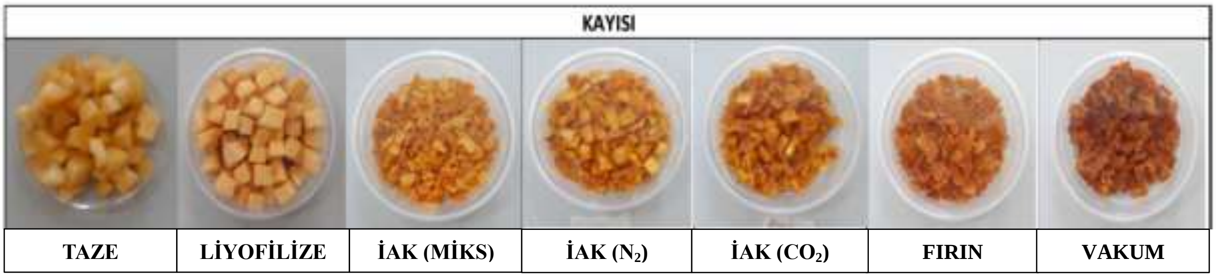
TARTIŞMA VE SONUÇ

İndirgen atmosferik kurutma (İAK) sistemi kurutma atmosferinde indirgen bir gaz olan hidrojen (H2) içeren bir gaz karışımı kullanımıyla dünyada bir ilke imza atmış ve kurutma fenomenine farklı bir bakış açısı getirmiştir. Temel amacı hâlihazırda bulunan kurutma tekniklerinden çok daha yüksek kalitede kuru ürün elde edilmesi olan İAK sistemine ait ilk çalışmalar Iğdır Üniversitesi Yenilikçi Gıda Teknolojileri Araştırma Merkezi'nde (YENİGIDAM) laboratuvar tipi İAK sisteminde kayısı ve elma meyvelerinde gerçekleştirilmiştir (Şekil 3 ve Şekil 4). Elde edilen veriler bu amacı destekler nitelikte olmuştur.

Şekil 2: Pilot Tipi İndirgen Atmosferik Kurutma Sistemi



Şekil 3. Farklı kurutma teknikleri ile kurutulmuş elma örnekleri (Alwazeer, 2018)



Şekil 4. Farklı kurutma teknikleri ile kurutulmuş kayısı örnekleri (Alwazeer & Örs, 2019)

Iğdır Üniversitesi ihtisas projeleri kapsamında "YİP1023i02" proje numarası ile üretimi gerçekleştirilen pilot tipi İndirgen Atmosferik Kurutma sistemi ile daha geniş çaplı araştırmalar gerçekleştirilmesi ve İAK sisteminin endüstriyel boyuta taşınarak büyük ölçekli yüksek kalitede kuru ürün üretiminde kullanılması hedeflenmektedir.

REFERANSLAR

Alwazeer, D. (2018). Kuru G ıdaların Rengini Muhafaza Etmeye Y önelik Yeni bir Teknik : İ ndirgen Atmosferik Kurutma Reducing Atmosphere Drying as a New Technique for the Preservation of the Color of Dried Foods. 8(4), 125–131.

Alwazeer, D. (2020). Importance of consideration of oxidoreduction potential as a critical quality parameter in food industries. Food Research International (Ottawa, Ont.), 132. https://doi.org/10.1016/J.FOODRES.2020.109108

Alwazeer, D., Delbeau, C., Divies, C., & Cachon, R. (2003). ARTICLE IN PRESS Use of redox potential modification by gas improves microbial quality, color retention, and ascorbic acid stability of pasteurized orange juice. https://doi.org/10.1016/S0168-1605(03)00125-9

Alwazeer, D., & Örs, B. (2019). Reducing atmosphere drying as a novel drying technique for preserving the sensorial and nutritional notes of foods. Journal of Food Science and Technology, 56(8), 3790–3800. https://doi.org/10.1007/s13197-019-03850-2

Bhattacharjee, S., Mohanty, P., Sahu, J. K., & Sahu, J. N. (2024). A critical review on drying of food materials: Recent progress and key challenges. In International Communications in Heat and Mass Transfer (Vol. 158). Elsevier Ltd. https://doi.org/10.1016/j.icheatmasstransfer.2024.107863

Cam, I. B., Basunal Gulmez, H., Eroglu, E., & Topuz, A. (2018). Strawberry drying: Development of a closed-cycle modified atmosphere drying system for food products and the performance evaluation of a case study. Drying Technology, 36(12), 1460–1473. https://doi.org/10.1080/07373937.2017.1409233

Erenturk, S. (2005). The effects of cutting and drying medium on the vitamin C content of rosehip during drying. 68, 513–518. https://doi.org/10.1016/j.jfoodeng.2004.07.012

Jangam, S. V. (2011). An Overview of Recent Developments and Some R&D Challenges Related to Drying of Foods. Drying Technology, 29(12), 1343–1357. https://doi.org/10.1080/07373937.2011.594378

Khaing Hnin, K., Zhang, M., Mujumdar, A. S., & Zhu, Y. (2019). Emerging food drying technologies with energy-saving characteristics: A review. In Drying Technology (Vol. 37, Issue 12, pp. 1465–1480). Taylor and Francis Inc. https://doi.org/10.1080/07373937.2018.1510417

Liu, W., Sun, X., & Ohta, S. (2015). Hydrogen element and hydrogen gas. In Hydrogen Molecular Biology and Medicine (pp. 1–23). Springer Netherlands. https://doi.org/10.1007/978-94-017-9691-0_1

Liu, Y., Wu, J., Miao, S., Chong, C., & Sun, Y. (2014). Effect of a Modified Atmosphere on Drying and Quality Characteristics of Carrots. Food and Bioprocess Technology, 7(9), 2549–2559. https://doi.org/10.1007/s11947-014-1295-9

Moses, J. A., Norton, T., Alagusundaram, K., & Tiwari, B. K. (2014). Novel Drying Techniques for the Food Industry. In Food Engineering Reviews (Vol. 6, Issue 3, pp. 43–55). Springer New York LLC. https://doi.org/10.1007/s12393-014-9078-7

Mujumdar, A. S., & Law, C. L. (2010). Drying Technology: Trends and Applications in Postharvest Processing. Food and Bioprocess Technology, 3(6), 843–852. https://doi.org/10.1007/s11947-010-0353-1

Nakao, A. (2011). Hydrogen and medical application. Gas Biology Research in Clinical Practice, 90–99. https://doi.org/10.1159/000321946

Ohsawa, I., Ishikawa, M., Takahashi, K., Watanabe, M., Nishimaki, K., Yamagata, K., Katsura, K. I., Katayama, Y., Asoh, S., & Ohta, S. (2007). Hydrogen acts as a therapeutic antioxidant by selectively reducing cytotoxic oxygen radicals. Nature Medicine, 13(6), 688–694. https://doi.org/10.1038/nm1577

Ohta, S. (2014). Molecular hydrogen as a preventive and therapeutic medical gas: initiation, development and potential of hydrogen medicine. Pharmacology & Therapeutics, 144(1), 1–11.

Örs, B. (2019). Sağlıklı ve Cazip Kuru Kayısı Üretimine Yönelik Yeni Bir Teknik: İndirgen Atmosferik Kurutma. Iğdır Üniversitesi.

Perera, C. O., & Rahman, M. S. (1997). Heat pump dehumidifier drying of food. Trends in Food Science and Technology, 8(3), 75–79. https://doi.org/10.1016/S0924-2244(97)01013-3

Qian, L., Shen, J., & Sun, X. (2015). Methods of hydrogen application. In Hydrogen Molecular Biology and Medicine (pp. 99–107). Springer Netherlands. https://doi.org/10.1007/978-94-017-9691-0_7

Ramesh, M. N., Wolf, W., Tevini, D., & Jung, G. (1999). Studies on inert gas processing of vegetables. Journal of Food Engineering, 40(3), 199–205. https://doi.org/10.1016/S0260-8774(99)00056-4

Santos, P. H. S., & Silva, M. A. (2009). Kinetics of L-ascorbic acid degradation in pineapple drying under ethanolic atmosphere. Drying Technology, 27(9), 947–954. https://doi.org/10.1080/07373930902901950

Şişik, S. (2021). İndirgen Atmosferik Kurutmanın Gıdada Bulunan Mikrobiyal Yükler Üzerine Etkisi. Iğdır Üniversitesi.

PAMUKTA (Gossypium hirsutum L.) FARKLI SULAMA SEVİYESİ UYGULAMALARININ LİFİN KİMYASAL KALİTE ÖZELLİKLERİNE ETKİSİ

EFFECT OF DIFFERENT IRRIGATION LEVELS ON THE CHEMICAL QUALITY PROPERTIES OF COTTON FIBER (Gossypium hirsutum L.)

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ÖZET

Pamuk liflerinin tekstil sanayisi ve yağının gıda sektöründe kullanılması endüstrinin önemli bir emtia ürünü olmasını sağlamıştır. Bölgemizde pamuk tarımı yoğun bir şekilde ekimi yapılmaktadır. Yüksek verim için bölgemizde gerek topraklara gerekse yapraklara makro ve micro besin elementleri uygulanmaktadır. Ayrıca yüksek ve kaliteli verim için sulamanın belli bir ölçüde verilmesi gerekir. Günümüzde küresel ısınma ve kuraklık tarımsal üretimde önemli olumsuz etkenlerin başında gelmektedir. Kuraklığın olumsuz etkisini azalmak için Pamuk tarımında suyun tasarruflu kullanılması gerekir. Bu çalışma, 2022 ve 2023 yıllarında Harran üniversitesi Ziraat Fakültesi deneme alanında yürütülmüştür**.** Çalışmada sulama uygulamaları %50, %75 kısıntı seviyeleri ve %100 tam sulama uygulanmıştır. Denemeler tesadüf blokları deneme desenine göre ve 3tekerrürlü olarak kurulmuştur. Denemede Parsel uzunluğu 12 m, sıra arası 75 cm, sıra üzeri 10 cm olacak şekilde 4 sıradan oluşturulmuştur. Parseller arasında 3 metre boşluk bırakılmıştır. Çalışmada elde edilen liflerin kimyasal özellikleri incelenmiştir. Çalışmada; liflerin kimyasal özelliklerinden olan Holoselüloz(%) ve selüloz(%) özellikleri incelenmiştir. Çalışmada Holoselüloz(%) ve selüloz(%) özellikleri istatiksel olarak p<0.01 düzeyinde önemli bulunmuştur. Holoselüloz 89.93 (%50 Sulama) ile 98.31(%100 Sulama) arasında değer almıştır. Selüloz değerleri ise 87.99 (%50 sulama) ile 96.56 (%100 sulama) arasında değer almıştır.

Deneme sonucunda elde edilen veriler JMP 13.2 istatistik paket programı ile tesadüf blokları deneme desenine göre varyans analizleri yapılıp ve LSD (0.05) testine göre ortalamalar gruplandırılmıştır.

Anahtar Kelimeler: Pamuk, lif Kimyası, lif kalitesi.

ABSTRACT

Introduction and Purpose: Cotton fibers are an important commodity in the industry due to their use in the textile industry and the oil in the food sector. Cotton farming is intensively practiced in our region. For high yields, both macro and micro nutrients are applied to the soil and leaves. Additionally, irrigation needs to be provided at a certain level for high-quality yield. Today, global warming and drought are among the major negative factors affecting agricultural production. To reduce the negative effects of drought, water usage in cotton farming must be efficient.

Materials and Methods: This study was conducted in 2022 and 2023 at the experimental field of the Faculty of Agriculture, Harran University. In the study, irrigation practices were applied at 50%, 75% reduction levels, and 100% full irrigation. The experiments were set up using a randomized block design with 3 replications. The plot length was 12 meters, with 75 cm row spacing and 10 cm intra-row spacing, and consisted of 4 rows. A 3-meter gap was left between the plots. The chemical properties of the fibers obtained in the study were analyzed.
Results: In the study, the chemical properties of the fibers, including Holocellulose (%) and Cellulose (%), were examined. The results showed that Holocellulose (%) and Cellulose (%) properties were statistically significant at p<0.01 level.
Discussion and Conclusion: Holocellulose ranged from 89.93% (50% irrigation) to 98.31% (100% irrigation). Cellulose values ranged from 87.99% (50% irrigation) to 96.56% (100% irrigation). The data obtained from the experiments were analyzed using variance analysis in the JMP 13.2 statistical software, based on a randomized block design, and means were grouped according to the LSD (0.05) test.
Keywords: Cotton, Fiber Chemistry, Fiber Quality.

GİRİŞ

Pamuk ülkemiz tarla bitkileri tarımında büyük öneme sahip bir üründür. 2023 üretim yılı itibariyle, içinde yer aldığı ‘’Tahıllar ve diğer Bitkisel Ürünler’’ grubunda buğdaydan sonra 2. Büyük hasılaya sahip, yaklaşık değerlerle grup alanının %3’ünde grup toplam gelirinin %20, pazarlanan gelirinin ise %25 kadarını sağlayan ‘’Alan Verimliliği’’ en yüksek ürün konumunda bulunmaktadır. Ayrıca yüksek tarımsal üretim değerinin yanı sıra girdi yoğun bir üretim dalı olması nedeniyle tohum, gübre, ilaç, makina sanayileri ve ticareti ile tarım işçilerinden oluşan çok geniş bir kesimin gelir kaynağı durumundadır (Anonim, 2024).

Bunların yanı sıra pamuk, asıl ve yan ürünleriyle otuz kadar sanayiye ham madde sağlayarak ülke ekonomisine katkısını katlanarak artırmaktadır. Örnekse 2023 yılında üretilen 2 milyon 100 bin ton kütlü pamuktan yaklaşık değerlerle 777 bin ton lif pamuğun (mahlıç) yanı sıra 1 milyon 134 bin ton çiğit ve bu çiğitten 170 bin ton yemeklik yağ, 793 bin ton yemlik küspe elde edilmiş olması; ayrıca 170 bin ton linter ile 19 bin ton pamuk telefinin tıbbi malzeme ve kozmetik başta olmak üzere bir çok sanayimizin kullanıma sunulmuş bulunmasıdır. Bütün bu ham maddeler ilgili sanayilerde işlenmek suretiyle katlanarak artan değerlerle ekonomiye kazandırılmaktadır. Bu anlamda sadece asıl ürün ‘lif pamuk’ örnek alındığında 2023 yılında 1 milyar 417 milyon 654 bin 477 USD değerindeki yerli pamuk ham maddesinin tekstil ve hazır giyim sanayilerimizde işlenerek yaklaşık değerlerle brüt 15 kat, net 3 kat değer artışlarıyla ülkemiz ekonomisine kazandırılmış olduğu görülmektedir. Ayrıca, yerli pamukla asli değerinin 3,9 katı kadar cari fazla yaratılmış olması söz konusu bu kazanımın önemini daha da artırmaktadır.
Günümüzde Pamuk tarımında sağlıklı bir üretimin yapılması için belli ölçekte bazı kültürel tedbirlerin alınması ve bunun sonucunda optimal bir üretimin gerçekleştirilmesi gerekir. Pamuk tarımında, verimli bir tohum çeşidi, sulama, gübreleme, bitki koruma önlemleri ve yabancı ot kontrolünün sağlanması gerekir.

Günümüzün en önemli konularından birisi sürdürülebilir tarım sisteminin yerleştirilmesi ve rantabl bir üretimin gerçekleştirilmesi en önemli konudur. Sürdürülebilir pamuk üretiminde; pamuk bitkisinin vejetasyon süresince ihtiyaç duyduğu sulama suyunun karşılanması en önemli konudur. Küresel ısınmanın etkilerinin her geçen gün daha çok görüldüğü bir süreci yaşamaktayız. Bu süreçte pamuğun fizyolojik gelişim sürecinde ihtiyaç duyduğu kadar sulama suyunun verilmesi en önemli konudur. Pamuk tarımında suyun kısıntılı olarak kullanılması sürdürülebilir çevre ve tarım açısından son derece önemlidir.

Ülkemizde pamuk bitkisinde kısıntılı sulama uygulamalarının verim ve bitki bileşenleri üzerine etkisi ile ilgili birçok çalışma yapılmıştır (Elçi ve Hançer, 2016; Keten, 2016; Karademir ve ark., 2011; Dağdelen ve ark., 2009; Kaçar, 2007). Ancak kısıntılı sulama uygulamalarının, pamukta yaprak besin elementi içeriği üzerine yapılan çalışma yok denecek kadar azdır. Tarımsal üretimde sınırlı bir kaynak olan suyun, daha verimli ve ekonomik kullanımında kısıntılı sulama uygulamaları önemli bir yaklaşımdır. Bu konuda çalışma yapan Tekinel ve Kanber (1979), pamuk sulamasında %30'a kadar bir su kısıntısının verim değişiminin istatistiksel olarak önemli olmadığını belirtmişlerdir.
Pamuk bitkisinin kuraklık stresine karşı toleranslı olduğu bilinmekte olup, toprağın nem seviyesi düştüğünde kuraklık stresine karşı koymak amacıyla bir takım koruma mekanizmaları geliştirdiği bildirilmiştir (Woodstock, 1998). Ancak bu koruma mekanizmalarının varlığına rağmen, çok şiddetli kuraklık stresine maruz kaldığında bitki büyümesinde ve ürün veriminde önemli derecelerde azalmalar görülebilmektedir (Blackman ve ark., 1992). Uzun yıllardan beri bitkilerdeki kuraklık stresine karşı tolerans mekanizmaları araştırılmakta ve bazı kuraklık stresi tarama yöntemleri geliştirilmektedir. Bu yöntemlerden en eski, kolay ve güvenilir olanlardan bir tanesi de arazi koşulları altında yürütülen kuraklık stresi tarama yöntemidir (Zhang ve ark., 2007).
Gelecekte yaşanması muhtemel bir kuraklık ve su kıtlığına karşı hazırlıklı olunması için kuraklığa dayanıklı çeşitlerin de geliştirilmesi gerekmektedir. Kuraklığa dayanıklı çeşitlerin tespit edilmesi için birçok indeks geliştirilmiştir. Bu indeksler bitkilerin su stresi ve su stresinin olmadığı koşullardaki verimlerinden yola çıkılarak oluşturulmuştur. Tolerans indeksleri kurak koşullar altındaki verim kaybına bağlı olarak kuraklığa dayanıklı genotipleri seçmek için kullanılır (Mitra, 2001; Anwar ve ark., 2011).
Bu amaçla çalışmada pamukta verim ve kaliteyi azaltmadan farklı sulama suyu seviyelerinin uygulanabilirliği araştırılmış ve bunun sonucunda en uygun sulama seviyesinin lifin kimyasal kalitesine etkisi konusu incelenmiştir.

MATERYAL VE METOD

Araştırma, 2021 ve 2022 pamuk yetiştirme sezonlarında Harran Üniversitesi'nin Şanlıurfa, Türkiye'deki deneme alanlarında gerçekleştirildi. Deneme alanları 37°070 ve 38°480 enlemlerinde, en üst noktası deniz seviyesinden 467 metre yükseklikte bulunmaktadır. Deneyde kullanılan toprak, 9 mm h^{-1} infiltrasyon oranına sahip kil (USSL 1954) olarak sınıflandırılmıştır. Hafif alkali bir pH'a sahiptir ve tuzdan arındırılmıştır. Ayrıca, toprağın 0 ila 90 cm derinlik aralığındaki su tutma kapasitesi 182 mm olarak ölçülmüştür. Araştırma alanı (Akın ve Kaya 2024) tarafından belgelendiği gibi araştırma alanı toprağının (0–90 cm) ek parametrelerini sağlar. Deneme alanı tarafından bildirildiği üzere kurak bir iklime sahip olarak sınıflandırılmıştır. Bölge, tipik olarak %10 ila %15 arasında değişen yüksek sıcaklıklar ve düşük bağıl nem kombinasyonuyla karakterize edilen kayda değer yazlar yaşar. Buna karşılık, bu alandaki kışlar nispeten soğuk sıcaklıklar ve artan yağışlarla karakterize edilir. Kış aylarında yağış ilkbahara kadar devam eder, ancak yıldan yıla önemli dağılımlar vardır. En sıcak ve en kurak aylar Haziran, Temmuz, Ağustos ve Eylül'dür ve günlük maksimum sıcaklıklar genellikle 40 °C'yi aşar. (Beyyavaş ve ark. 2024).
Pamuklar iki ayrı yılda, 14 Mayıs 2021 ve 10 Mayıs 2022'de ekilmiştir. Ekimde parseller 12 metre uzunluğunda dört sıra halinde, 75 cm'lik sıra aralığı ve 10 cm'lik sıra üzeri ölçeğinde planlanmıştır. Ekimde Fiona pamuk çeşidi kullanıldı. Seçilen çeşidin yüksek verim potansiyeli vardır, orta-geç vejetasyon dönemi kategorisine girer, %44-46'lık bir çırçırlama verimliliğine sahip olup makinalı hasada oldukça uygundur. Kenar etkilerini azaltmak için her parselin hem başından hem de sonundan 1 metre mesafe ve her parselin sağ ve sol taraflarından iki sıra hasat edilmedi. Bu alandaki pamuk verimleri çalışmada dikkate alınmadı. Sonuç olarak, Pamuklar hasat olgunluğuna geldiğinde iki kez elle hasat edildi. Birincil hasadı,

pamuk kozalarının %90 açıklık seviyesine ulaştığında gerçekleştirildi, sonraki hasat ise kalan %10 koza tamamen açıldığında gerçekleştirildi. Araştırma, 3 tekrarlamadan oluşan tesadüf blokları parsel tasarımıyla yürütüldü. Araştırmada ekimden hasada kadar çeşitli kültürel önlemler alınmıştır. Yabancı ot mücadelesi, hastalık ve zararlılara karşı çeşitli kültürel ve kimyasal yöntemler uygulanmıştır. Sulama uygulaması damla sulama yöntemine göre yürütülmüştür. Sulamada %50, %75 kısıntı ve tam sulama uygulanmıştır.
Deneme sonucunda elde edilen veriler JMP 13.2 istatistik paket programı ile tesadüf blokları deneme deseni göre varyans analizleri yapılıp ve LSD (0.05) testine göre ortalamalar gruplandırılmıştır.

ARAŞTIRMA BULGULARI VE TARTIŞMA

1. Holoselüloz Oranı:

Çizelge 1. Pamuk bitkisinde uygulanan kısıtlı sulamaya göre elde edilen Holoselüloz değerleri, CV değeri ve LSD testine göre oluşan gruplar.

Sulama Uygulaması	Holoselüloz Oranı (%)	Gruplar
%100 Uygulama	98,31	a
%75 Uygulama	94,98	b
%50 Uygulama	89,93	c
Ortalama	94.40	
CV(%): 0.5	LSD(%1): 1.108	

Çizelge 1.'den uygulanan sulama suyu seviyelerine göre bulunan Holoselüloz oranları verilmektedir. Holoselüloz oranlar (%) 94.40 ile 98.31 arasında değişmektedir. En düşük değer %50 su kısıtlamasında ve en yüksek değer tam sulamada (%100) elde edilmiştir. Holoselüloz, pamuk bitkisinin fotosentez sonucu elde edilen nişastadan meydana gelen ve pamuk lifinin yapısında yer alan bir üründür. Holoselüloz; Odundan ligninin uzaklaştırılmasıyla elde edilen selüloz ve hemiselülozun toplamıdır. Holoselüloz, hemiselüloz ve selüloz bileşenlerinin toplamıdır (Mert, 2017).

2. Selüloz Oranı (%):

Çizelge 2. Pamuk bitkisinde uygulanan kısıtlı sulamaya göre elde edilen Selüloz değerleri, CV değeri ve LSD testine göre oluşan gruplar.

Sulama Uygulaması	Selüloz Oranı (%)	Gruplar
%100 Uygulama	96,56	a
%75 Uygulama	92,72	b
%50 Uygulama	87,99	c
Ortalama	92.42	
CV(%): 1.02	LSD(%1): 2.13	

Çizelge 2.'den uygulanan sulama suyu seviyelerine göre bulunan Selüloz oranları verilmektedir. Selüloz oranlar (%) 87.99 ile 96.56 arasında değişmektedir. En düşük değer %50 su kısıtlamasında ve en yüksek değer tam sulamada (%100) elde edilmiştir. Selüloz oranı bitkinin fotosentez etkinliğinin bir göstergesidir. Selüloz oranı yükseldiği ölçüde pamuk lifinin kalitesinde iyileşme olmaktadır. Selüloz, doğada yaygın olarak bulunan ve bitkisel hücrelerin temel yapı taşını oluşturan doğal bir polimerdir.

Pamuk çeşitlerindeki selüloz oranı genetik ve çevresel faktörlere bağlıdır (Hund vd., 2008) ve %82 ile %96 arasında değişir (Mert, 2017). Selüloz oranına genetik faktörlerin yanında çevresel faktörlerde etkindir. Beyyavaş ve ark. (2024)'nın Çevresel ve kültürel faktörlerden biride pamuk üretiminde önemli etken faktör olan ekim zamanının pamuk koza pozisyonları ve lif kalitesi üzerinde önemli bir etkisi vardır. Geç ekim koza olgunlaşması, selüloz sentezi, verim ve lif kalitesi üzerinde olumsuz bir etkiye sahipti. Bu nedenle, pamuk ekimindeki gecikme verimde bir düşüşe neden olmaktadır şeklindeki bulguları bizim çevresel bir faktör olan kısıntılı sulamanın lifteki selüloz oranını etkiler yönündeki bulgumuz ile örtüşmektedir. Fenotip; genotip ve çevre interaksiyonunun sonucudur şeklindeki bulgu bizim bulgumuzu teyit etmektedir. Lifin sekonder duvarının %80'den fazlasını selüloz oluşturmaktadır. Lifteki selüloz oranı bilimsel kanıtlara göre %85 ve üzeridir. Lifteki selüloz oranının yüksek olması lifin sağlamlığının bir ifadesidir.

SONUÇ

Her iki yılda da Holoselüloz ve Selüloz parametrelerinde istatistiki olarak %1 düzeyinde bir farklılık bulunmuştur. Kısıntılı sulamanın Holoselüoz ve Selüloz üzerinde önemli etki yaptığı görülmüştür. Sulama miktarı düşünce lifin sekonder çeperinde biriken selüloz miktarında bir azalma olmuştur. Bu azalma lifin kalitesinin ve özellikle mukavemetin düşmesi anlamına gelmektedir. Tekstil yapılabilirlik ve kalitesi açısından selüloz miktarının maksimum noktaya ulaşması, lifin mukavemeti ve üniformitesi açısından son derece önemlidir. Bu nedenle pamuk tarımında elde edilen liflerin veriminin yüksek olması yanında, lif kalite parametrelerinin de istenen düzeyde olması son derece önemlidir. Lif kalite özelliklerini belirleyen unsurların başında bitki besleme gelmektedir. Kaliteyi etkileyen diğer unsur da sulamadır. Aşırı sulama ve çok kısıntılı sulama verimin yanında kaliteyi olumsuz anlamda etkilemektedir. Sulamanın optimum düzeyde olması lifin kalitesi ve selüloz oranının yükselmesi açısından olumlu bir etkiye sahiptir.

KAYNAKLAR

Akin, S., & Kaya, C. (2024). Impact of salicylic acid and sodium hydrosulfide applied singly or in combination on drought tolerance and grain yield in wheat plants. Food and Energy Security, 13(1), e532.

Anonim, 2024. http://www.upk.org.tr/

Anwar, J., Subhani, G. M., Hussain, M., Ahmad, J., Hussain, M., & Munir, M. (2011). Drought tolerance indices and their correlation with yield in exotic wheat genotypes. Pakistan Journal of Botany, 43(3), 1527-1530.

Beyyavas, V., Akin, S., İlhan Cevheri, C., Ramazanoglu, E., & Cun, S. (2024). Investigation of Suitable Osmolytes for Enhancing Cotton Plant Adaptation to Drought Scenarios and Improving Water Use Efficiency. Journal of Crop Health, 76(5), 1193-1208.

Beyyavaş, V., Cevheri, C. I., & Yılmaz, A. (2024). Effect of Sowing Tıme in Cotton (Gossypium hirsutum L.) On Boll Dıstrıbutıon, Cellulose Ratıo And Fıber Qualıty. JAPS: Journal of Animal & Plant Sciences, 34(1).

Blackman, S. A., Obendorf, R. L., & Leopold, A. C. (1992). Maturation proteins and sugars in desiccation tolerance of developing soybean seeds. Plant physiology, 100(1), 225-230.

Dağdelen, N., Başal, H., Yılmaz, E., Gürbüz, T., & Akcay, S. (2009). Different drip irrigation regimes affect cotton yield, water use efficiency and fiber quality in western Turkey. Agricultural water management, 96(1), 111-120.

Eminur, E. L. Ç. İ., & Hançer, T. (2016). Pamuk (Gossypium hirsutum L.) Genotiplerinin Kısıntılı Sulama Koşullarında Çimlenme Analizleri ve Moleküler Karakterizasyonu. Türkiye Tarımsal Araştırmalar Dergisi, 3(2), 122-129.

Hund. A., Y. Francheboud, A. Soldati, and P. Stamp (2008). Cold Tolerance of Maize Seedlings as Determined by Root Morphology and Photosynthetic Traits. Euro. J. Agron., 28:178- 185. doi:10.1016/j.eja.2007.07.003.

Kacar B 1996. Bitki ve Toprağın Kimyasal Analizleri. Toprak Analizleri. Ankara Üniversitesi Ziraat Faültesi Vakfı Yayınları No=3.

Karademir, C., Karademir, E., Ekinci, R., & Berekatoğlu, K. (2011). Yield and fiber quality properties of cotton (Gossypium hirsutum L.) under water stress and non-stress conditions. African Journal of Biotechnology, 10(59), 12575-12583.
Keten, M. (2016). Sulama Suyunda Uygulanan Kısıntı Seviyelerinin Farklı Pamuk Genotiplerinde Su-Verim İlişkilerine Etkisi (Master's thesis, Fen Bilimleri Enstitüsü).
Mert, M (2017). Fiber crops. Updated 2. Impression. Publication no: 1734. Science, 130.
Mitra, J. (2001). Genetics and genetic improvement of drought resistance in crop plants. Current science, 758-763.
Tekinel, O., & Kanber, R. (1979). Çukurova Koşullarında Kısıntılı Su Uygulama Durumunda Pamuğun Su Tüketimi ve Verimi. Tarsus Bölge Topraksu Ens. Müd. Yay., Gen, (98).
USSL (1954) Diagnosis and improvement of saline and alkaline soils. Soil Sci Soc Am J 18:348. https://doi.org/10.2136/sssaj1954. 03615995001800030032x
Woodstock, L. W. (1988). Seed imbibition: A Critical Period For Successful Germination. Journal of Seed Technology, 1-15.
Zhang, X. Y., Liu, C. L., Wang, J. J., Li, F. G., & Ye, W. (2007). Drought-tolerance evaluation of cotton with PEG water-stress method. Cotton Sci, 19, 205-209.

TOPRAKTAN VE YAPRAKTAN UYGULANAN KÜKÜRT FORMLARININ PAMUK (Gossypium hirsutum L.) BİTKİSİNDE LİF KALİTESİNE ETKİSİ

THE EFFECT OF SULFUR FORMS APPLIED THROUGH SOIL AND FOLIAR ON FIBER QUALITY IN COTTON (Gossypium hirsutum L.) PLANTS

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ÖZET
Pamuk kullanıldığı yerlerin çeşitli olması, dünya tarımı açısından hem endüstri hem de ticari alanda başlıca önemli ürünlerden birisidir. Bölgemizde pamuk tarımı yoğun bir şekilde ekimi yapılmaktadır. Yüksek verim için bölgemizde gerek topraklara gerekse yapraklara makro ve micro besin elementleri uygulanmaktadır. Çalışma, 2023 ve 2024 yıllarında Şanlıurfa Haliliye ilçesine bağlı Gürpınar köyünde çiftçi arazisinde yürütülmüştür**.** Çalışmada topraktan ve yapraktan kükürt formları uygulanmıştır. Denemeler tesadüf blokları deneme desenine göre ve 4 tekerrürlü olarak kurulmuştur. Denemede Parsel uzunluğu 12 m, sıra arası 75 cm, sıra üzeri 10 cm olacak şekilde 4 sıradan oluşturulmuştur. Parseller arasında 3 metre boşluk bırakılmıştır. Çalışmada çırçır randımanı (%), 100 tohum ağırlığı (g), lif inceliği (mic), lif uzunluğu (mm) ve lif mukavemeti (g/tex) parametreleri incelenmiştir. Çalışmada istatiksel olarak ($p<0.01$ ve $p<0.05$) çırçır randımanı iki yılda da önemsiz; 100 tohum ağırlığı (g), lif uzunluğu (mm) ikinci yılda önemli ($p<0.05$) bulunmuştur. Ayrıca lif inceliği (mic) ve lif mukavemeti (g/tex) ilk yıl önemli ($p<0.05$) bulunmuştur. Kükürt formlarının lif kalitesine yıllar arasında fark olmasına rağmen etki ettiği görülmüştür.
Deneme sonucunda elde edilen veriler JMP 13.2 istatistik paket programı ile tesadüf blokları deneme desenine göre varyans analizleri yapılıp ve LSD (0.05) testine göre ortalamalar gruplandırılmıştır.

Anahtar Kelimeler: Pamuk, kükürt, lif kalitesi

ABSTRACT
Introduction and Purpose: The diverse uses of cotton make it one of the most important products in both the industrial and commercial sectors of global agriculture. In our region, cotton farming is carried out intensively. To achieve high yields, both macro and micro nutrient elements are applied to the soil and leaves in our region.
Materials and Methods: This study was conducted during the May-October 2023-2024 period. The study applied sulfur forms via soil and foliar methods.The experiment was carried out on a farmer's field in Gürpınar village, located in the Haliliye district of Şanlıurfa. The planting was done in the second week of May after field plowing. The trials were set up according to a randomized block design with four replications. The plot length was 12 meters,

with 75 cm between rows and 10 cm between plants within a row, consisting of four rows. A 3-meter gap was left between the plots.
Results: The study examined parameters such as ginning percentage (%), 100-seed weight (g), fiber fineness (mic), fiber length (mm), fiber strength (g tex^{-1}). **Discussion and Conclusion:** In the study, statistically ($p<0.01$ and $p<0.05$), the cotton yield was found to be insignificant in both years; 100-seed weight (g) and fiber length (mm) were significant in the second year ($p<0.05$). Additionally, fiber fineness (mic) and fiber strength (g/tex) were significant in the first year ($p<0.05$). Although there were differences between years, it was observed that sulfur forms had an effect on fiber quality. The data obtained from the experiment were analyzed using the JMP 13.2 statistical software, and variance analyses were performed according to the randomized block design. Means were grouped based on the LSD (0.05) test.
Keywords: Cotton, sulfur, fiber quality

GİRİŞ

Pamuk bitkisi; dünyanın birçok farklı bölgelerinde tarımının yapılması, dünya tarımı bakımından hem endüstriyel hem de ticari alanlarda başlıca önemli ürünler arasında yer almaktadır. Pamuğun kütlü halinde tarladan alınması, başta lifinin tekstil ve hazır giyim gibi alanlarda hammadde olarak kullanılmaktadır. Ayrıca çiğit olarak bilinen tohumuyla yağ sanayisi, küspesiyle de yem sanayisi gibi alanlarda kullanılması pamuk bitkisinin birçok alanda vazgeçilmez bir ürün olarak görülmektedir. Son yıllarda petrol ihtiyacının önemli bir bölümünde dışa olan bağımlılık ve petrol gibi yakıtların neden olduğu ekolojik riskleri en aza indirmek için pamuk çekirdeğinden elde edilen yağların biyodizel üretiminde her geçen gün daha da artış göstermektedir (Özüdoğru, 2021).
Dünyada olduğu gibi ülkemizde de pamuk üretimi önemli bir yere sahiptir. Ülkemizde 2022/2023 sezonunda 573 bin ha alanda pamuk ekimi yapılmış ve bunun sonucunda 1.017 bin ton lif pamuk üretimi gerçekleştirmiştir (TÜİK, 2023). Pamuk üretiminin öne çıkan başlıca bölgelerimiz Güneydoğu Anadolu Bölgesi, Ege ve Çukurova Bölgeleri olmak üzere 3 bölgede yoğun bir şekilde pamuk üretimi yapılmaktadır. Ülke üretiminin yaklaşık olarak %55'i Güneydoğu Anadolu Bölgesinden karşılanmaktadır (TÜİK, 2021). Pamuk üretiminin en fazla yapıldığı ve ülkemizde üretilen pamuğun yarısına yakın bir üretim sağlayan Şanlıurfa ili gelmektedir. Kentte 2022/2023 sezonu itibariyle 2.424.783 dekarlık bir alan üzerinde pamuk ekimi yapılmış ve bunun sonucunda 408.055 ton lif pamuk üretimi elde edilmiştir (TÜİK, 2023).

Ülkemiz için stratejik bir öneme sahip olan pamukta mikro ve makro besin elementlerinin verim ve kalitesine olan etkisi ile ilgili birçok çalışma yürütülmüştür. Yürütülen çalışmaların büyük bir çoğunluğu azot ve fosfor içerikli bitki besin elementlerinin etkisi üzerine yoğunlaşmıştır. Kükürt azot, fosfor ve potasyumdan sonra dördüncü en önemli makro bitki besin elementidir. Kükürt 'ün tarımdaki önemi birçok önceki çalışmada ortaya konmuş ve vurgulanmıştır (Scherer, 2009; Jamal ve ark., 2010; Kazgöz ve Ödemiş, 2021; Kılıç, 2024). Kükürt noksanlığı görülmesi halinde bitkide bodurlaşma, gövdede incelme ve çalımsı bir görünüm meydana gelmektedir. Çünkü kükürt, bitkide protein yapısını inşa etmekle birlikte klorofilde de kilit bir role sahip besin elementlerinden birisidir (Duke ve Reisenaue, 1986). Ayrıca kükürt uygulamaları ile klorofil miktarında artış sağlanabilir ve abiyotik stressin etkisi düşürülebilir (Jie ve ark., 2008; Kazgöz ve Ödemiş, 2021). Pamuk bitkilerinin proteinleri ve enzimleri yapmak için gerekli olan amino asitleri üretmek için kükürt ihtiyacı vardır. Bitki dokusunun yaklaşık yüzde 3'ü kükürtten oluşur. Tohumda yüksek protein bulunan pamuk gibi bitkiler, daha büyük bir miktarda kükürt'e ihtiyaç duyar. Normal bir verim için 20 ile 45 kg/ha kükürt'e ihtiyacı vardır (Aulakh ve ark., 1985). Bu nedenle pamuk üretiminde kükürt için gübre önerileri oldukça yüksektir. Pamuk bitkisinin ihtiyaç duyduğu kükürt miktarı kütlü pamuk verimi ile doğru orantılıdır. Kükürt ilavelerine yanıt olarak pamuğun önemli verim artışları yürütülen önceki çalışmalarda da rapor edilmiştir (Makhdum ve ark., 2001; Kılıç, 2024).

Awad ve ark. (1996), çalışmalarında CaCO3 bakımından zengin topraklarda kükürt uygulamasıyla toprak pH'sının düştüğü, Fe ve Zn'nin ise alınabilirliğinde artış olduğunu, Singh ve Chaudhari (1997) ise kireç miktarının yoğun olduğu topraklarda yer fıstığı bitkisi kullanıldığı bir çalışmada kükürt uygulamasıyla bitki yapraklarının kuru madde ile besin elementleri konsantrasyonlarında da artış meydana gelmiştir.

Çalışmamızda hem topraktan hem de yapraktan farklı micro element içeren kükürt uygulamaları yapılmıştır. Bitkinin maruz kalacağı stres faktörlerinden kurtarılması amaçlandığından kükürt uygulamalarının yapraklardan da uygulanarak engellenmeye çalışılmıştır.

MATERYAL ve YÖNTEM

Deneme Şanlıurfa Haliliye ilçesine bağlı Gürpınar köyünde çiftçi arazisinde yürütülmüştür. FİONA pamuk çeşidi denemede bitki materyali olarak kullanılmıştır. Fiona pamuk çeşidinin verim potansiyeli oldukça yüksek, vejetasyon süresi orta-geç ve meyve dalları ise kısadır (Basf Tarım Çözümleri Türkiye, 2020). Çalışmalar, 2023-2024 yıllarında Mayıs- Ekim periyodunda yürütülmüştür. Ekim işlemi tarla sürümü tamamlandıktan sonra 10 Mayıs 2023 tarihinde yapılmıştır. Denemeler tesadüf blokları deneme desenine göre ve 4 tekerrürlü olarak kurulmuştur. Denemede her parselin uzunluğu 12 m, sıra arası 75 cm, sıra üzeri ise 10 cm ve 4 sıra olacak şekilde belirlenmiştir. Hasat işlemleri 15 Ekim 2023 ve 22 Ekim 2024 tarihinde gerçekleştirilmiştir. Her uygulama arasında 4 sıradan oluşan kontrol parselleri oluşacak şekilde dizayn edilmiştir.

Araştırma konuları

Çizelge 1. Çalışmada konu olan uygulamalar ve uygulamaların dönemleri

Uygulamalar	Taraklanma başlangıcı	Çiçeklenme başlangıcı	Çiçeklenme doruğu
Kontrol	-	-	-
$ZnSO_4$	Zn 0.5 g/l+Üre 0.5 g/l	Zn 0.5 g/l+Üre 0.5 g/l	Zn 0.5 g/l+Üre 0.5 g/l
K_2SO_4	K 0.5 g/l+Üre 0.5 g/l	K 0.5 g/l+Üre 0.5 g/l	K 0.5 g/l+Üre 0.5 g/l
$ZnSO_4$ + K_2SO_4	Zn 0.5 g/l+ K 0.5 g/l+Üre 0.5 g/l	Zn 0.5 g/l+ K 0.5 g/l+Üre 0.5 g/l	Zn 0.5 g/l+ K 0.5 g/l+Üre 0.5 g/l
Toz Kükürt	2 kg/da	1.5 kg/da	1.5 kg/da
Toz Kükürt+ ($ZnSO_4$+K_2SO_4+Üre)	2 kg/da+ Zn 0.5 g/l+ K 0.5 g/l+Üre 0.5 g/l	1.5 kg/da+ Zn 0.5 g/l+ K 0.5 g/l+Üre 0.5 g/l	1.5 kg/da+ Zn 0.5 g/l+ K 0.5 g/l+Üre 0.5 g/l

Toprak özellikleri

Deneme yerinin toprak özellikleri çalışmanın yürütüldüğü araziden farklı bölgelerinden 0-30 cm derinliğinde toprak örneği alınarak, fiziksel ve kimyasal özelliklerinin belirlenmesi amacıyla analiz edilmiştir.

Çizelge 2. Deneme alanı topraklarının bazı kimyasal ve fiziksel özellikleri

Derinlik (cm)	(%) Suy. Doy	PH	Ec ds/m	Kireç (%)	P	K	Organik Madde (%)
0-30	64	7.76	1.13	19.0	10.21	162.3	1.02

İklim Özellikleri

Denemenin kurulduğu bölgede kış ayları soğuk ve yağışlı olarak geçerken, yaz aylarında ise genellikle sıcak ve kural olduğundan karasal geçit iklimi görülmektedir.

Çizelge 3. Şanlıurfa ili 2023 yılı ve uzun yıllara ait iklim verileri

2023 Yılı				**1929-2023 Uzun Yıllar Ortalamaları**	
Aylar	**Ort. Sıcaklık (°C)**	**Ort. Nispi Nem (%)**	**Ort. Yağış (mm)**	**Ort. Sıcaklık (°C)**	**Yağış (mm)**
Mayıs	22.77	36.06	0.27	22.54	27.27
Haziran	29.16	30.2	0.3	28.63	4.6
Temmuz	33.16	21.16	0	32.58	2
Ağustos	33.93	23.19	1.17	32.77	4.67
Eylül	28.56	26.76	0.33	27.88	4.93
Ekim	21.80	44.61	0.61	21.2	26.21
Toplam	169.38	181.98	2.68	165.6	69.68
Ortalama	28.23	30.33	0.54	27.6	11.61

Kaynak: Şanlıurfa Meteoroloji il müdürlüğü, 2023

Araştırmanın yürütülmesinde uygulanan tarımsal işlemler

Denemenin yürütüldüğü alan pulluk ile işlenmiş, Şubat ayının sonu ile Mart ayının başında kültüvatör ile sürme işlemi yapılmıştır. Kültüvatör işleminden sonra diskaro ve sırt çekilerek deneme alanı ekim işlemi için hazır hale getirilmiştir. Bitkilerin çıkışından sonra 2-4 gerçek yaprak meydana geldiğinde tekleme, 2 hafta sonra ise seyreltme işlemi yapılmıştır. Ekimle birlikte dekara saf 10 kg N ve P (20–20-0 kompoze) gübresi ve üst gübrelemelerde ise 10 kg/da saf N (%46 üre) uygulanmıştır. Fosfor'un tamamı ve azotun yarısı ekimle beraber, azotun diğer yarısı üre gübresinden (% 46 üre) ilk sulamadan hemen önce toprağa uygulanmıştır. Sulama ve diğer kültürel bakım işleri ihtiyaca göre yapılmıştır. Sulama işlemi, ekim işleminden sonra yağmurlama sulama olacak şekilde yapılmış olup toplamda 11 kez sulama yapılmıştır. Sulama işlemi, parsellerde kozaların %20'sinin açılması göz önüne alınarak sonlandırılmıştır.

Yabancı ot ve zararlı kontrolü
Fidenin meydana geldiği dönemde Tütün tripsi (Thrips tabaci) zararlılarıyla mücadele etmek için dekara 100 ml 400g/l Dimethoate uygulanmıştır. Ayrıca köklerin gelişmesine destek olmak için dekara 250 ml humik asit uygulaması da yapılmıştır. Pamukta bir diğer zararlılar ise Yaprak biti (Apis gossypii) ile Yaprak pirelerinin (Empoasca spp.) mücadelelerinde dekar hesabıyla 25 g %20 Acemiprid uygulanmıştır. Ayrıca taraklanmayı artırmak için de dekar hesabıyla 200 g fosfor uygulaması yapılmıştır. Son olarak Yeşilkurt (Helicoverpa armigera) zararlılarının önüne geçmek için dekar hesabıyla 17.5 ml Coragen (200g/l Chlorantraniliprole) olacak şekilde uygulama yapılmıştır.

Verilerin Değerlendirilmesi
Deneme sonucunda elde edilen veriler JMP 13.2 istatistik paket programı ile tesadüf blokları deneme deseni göre varyans analizleri yapılıp ve LSD (0.05) testine göre ortalamalar gruplandırılmıştır.

ARAŞTIRMA BULGULARI VE TARTIŞMA

Çırçır randımanı (%)

Çizelge 4'den, yapılan varyans analizi sonucunda; çalışmanın iki yılında da farklı gübre uygulamalarının çırçır randımanı (%) yönünden önemli düzeyde ($p<0.01$ve $p<0.05$) farklılıklar bulunmadığı tespit edilmiştir.

Denemede kullanılan farklı kükürt uygulamaların % 44.83 – 46.70 arasında değiştiği izlenmektedir. En fazla çırçır randımanı K_2SO_4+üre uygulamasından (% 46.70); en düşük çırçır randımanı toz kükürt uygulamasından (% 44.83) elde edildiği tespit edilmiştir.
Çırçır randımanına ilişkin sonuçlar daha önce yürütülen ve kükürt uygulamasının çırçır randımanı değerinde önemli bir etkisinin olmadığını tespit eden Bukarlı (2007) ve Kutat (2023)'ün sonuçları ile paralellik göstermiştir, ancak kükürt uygulamasının anılan özellikte önemli artışlar sağladığını bildiren Gobi ve ark. (2010). Parmar ve ark. (2010)'in elde ettikleri sonuçlar ile örtüşmemektedir.

100 tohum ağırlığı (g)

Çizelge 4' den, yapılan varyans analizi sonucunda; çalışmanın ilk yılında farklı gübre uygulamalarının 100 tohum ağırlığı (g) yönünden önemli düzeyde ($p<0.01$ve $p<0.05$) farklılıklar bulunmadığı, ikinci yılda ise $p<0.05$ düzeyinde önemli bulunduğu saptanmıştır.

100 tohum ağırlığı incelendiğinde denemede kullanılan farklı kükürt uygulamalarının 8.93 – 10.01 g arasında değiştiği izlemektedir. En fazla 100 tohum ağırlığı kontrol uygulamasından (10.01 ve 9.95 g); en düşük 100 tohum ağırlığı toz kükürt+ $ZnSO_4$+ K_2SO_4+üre uygulamasından (9.28 ve 8.93 g) elde edildiği tespit edilmiştir.

Çizelge 5. Pamuk bitkisinde farklı uygulamalardan elde edilen ortalama Çırçır randımanı (%) ve 100 tohum ağırlığı (g) değerlerine ilişkin sonuçlar ile % CV ve LSD değerleri

	Çırçır randımanı (%)		100 Tohum Ağırlığı (g)	
Uygulamalar	2023	2024	2023	**2024**
Kontrol	45.76 ö.d	44.85	10.01	9.95* a
$ZnSO_4$+Üre	46.20	45.16	9.37	9.31 bc
K_2SO_4+Üre	46.70	46.00	9.46	9.58 ab
$ZnSO_4$+ K_2SO_4+Üre	46.03	45.26	9.79	9.22 bc
Toz kükürt	45.56	44.83	9.32	9.02 c
Toz Kükürt+ $ZnSO_4$+ K_2SO_4+Üre	46.40	45.73	9.28	8.93 c
%CV	1.23	1.25	3.03	2.89
LSD	0.47	0.46	0.23	0.22

p<0.01: ** , p<0.05:*, ö.d: önemli değil

Lif uzunluğu (mm)

Çizelge 5'den, yapılan varyans analizi sonucunda; çalışmanın ilk yılında farklı gübre uygulamalarının 100 tohum ağırlığı (g) yönünden önemli düzeyde (p<0.01ve p<0.05) farklılıklar bulunmadığı, ikinci yılda ise p<0.05 düzeyinde önemli bulunduğu saptanmıştır.

Lif uzunluğu incelendiğinde denemede kullanılan farklı uygulamaların 27.98 – 30.25 (mm) arasında değiştiği izlenmektedir. En fazla lif uzunluğu ilk yıl ZnSO4+ K_2SO_4+üre uygulamasından (29.86 mm), ikinci yıl toz kükürt+ZnSO4+ K_2SO_4+üre uygulamasından (30.25 mm) elde edilmiştir. En düşük lif uzunluğu iki yılda da toz kükürt uygulamasında görülmüştür (Çizelge 5). Lif uzunluğuna ilişkin bulgularda, daha önce yürütülen ve kükürt uygulamasının lif uzunluğu özelliğinde önemli bir etkisinin olmadığını tespit eden Kutat (2023)'ün sonuçları ile benzerlik gösterdiği saptanmıştır.

Çizelge 5. Pamuk bitkisinde farklı uygulamalardan elde edilen ortalama lif uzunluğu (mm), lif inceliği (mic) ve lif mukavemeti (g/tex) değerlerine ilişkin sonuçlar ile % CV ve LSD değerleri

	Lif uzunluğu (cm)		Lif inceliği (mic.)		Lif mukavemeti (g/tex)	
Uygulamalar	2023	2024	2023	2024	2023	2024
Kontrol	29.82 ö.d	29.05 bc*	4.58 abc*	4.57	29.86 ab*	29.41
$ZnSO_4$+Üre	29.01	29.00 bc	4.25 d	4.26	31.23 a	30.52
K_2SO_4+Üre	28.98	30.08 a	4.68 ab	4.36	30.96 a	30.92
$ZnSO_4$+ K_2SO_4+Üre	29.86	29.88 ab	4.73 a	4.39	28.73 b	29.43
Toz kükürt	27.98	28.96 c	4.32 cd	4.27	29.16 b	29.72
Toz Kükürt+ $ZnSO_4$+ K_2SO_4+Üre	28.14	30.25 a	4.44 bcd	4.31	28.86 b	30.03
%CV	0.82	1.69	3.11	2.98	2.75	2.66
LSD	0.74	0.41	0.11	0.11	0.67	0.65

p<0.01: ** , p<0.05:*, ö.d: önemli değil

Lif inceliği (mic.)

Çizelge 5'den, yapılan varyans analizi sonucunda; farklı gübre uygulamalarının ilk yılda lif inceliği (micronaire) yönünden önemli düzeyde ($p<0.05$) farklılıklar bulunduğu ikinci yıla ise önemsiz bulunduğu tespit edilmiştir.

Lif inceliği incelendiğinde denemede kullanılan farklı uygulamalarının 4.25 – 4.73 arasında değiştiği izlenmektedir. En fazla lif inceliği ZnSO4+ K_2SO_4+üre uygulamasından (4.73); en düşük lif inceliği $ZnSO_4$+üre uygulamasında görülmüştür (Çizelge 5).

Kükürt uygulamasının pamukta lif inceliği özelliğinde önemli artışlar sağladığını bildiren Parmar ve ark. (2010) ile Gobi ve ark. (2010)'un elde ettikleri sonuçlar ile ilk yılın sonuçları ile örtüştüğü; ikinci yıl sonuçlarının önemli bir etkisinin olmadığını tespit eden Bukarlı (2007) ve Kutat (2023)'ün sonuçları ile benzerlik gösterdiği saptanmıştır.

Lif kopma dayanıklılığı (g/tex)

Çizelge 5'den, yapılan varyans analizi sonucunda; farklı gübre uygulamalarının lif kopma dayanıklılığı (g/tex) yönünden önemli düzeyde ($p<0.05$) farklılıklar bulunduğu ikinci yıla ise önemsiz bulunduğu tespit edilmiştir.

Lif kopma dayanıklılığı incelendiğinde denemde kullanılan farklı uygulamaların 28.73 – 31.23 g/tex arasında değiştiği izlenmektedir. En fazla lif kopma dayanıklılığı $ZnSO_4$+üre uygulamasından (31.23); en düşük lif kopma dayanıklılığı ZnSO4+ K_2SO_4+üre uygulamasından (28.73) elde edildiği tespit edilmiştir. Lif kopma dayanıklılığına ilişkin bulgularda, daha önce yürütülen ve kükürt uygulamasının lif kopma dayanıklılığı özelliğinde önemli artışlar elde eden Bukarlı (2007), Gobi ve ark. (2010), Parmar ve ark. (2010), Yin ve ark. (2012), Görmüş (2014), Geng ve ark. (2016), Ashmouny ve ark. (2017), Candemir ve Ödemiş (2018), Parlawar ve ark. (2018), Ibrahim (2022), Lad ve ark. (2022)'nin sonuçları ile benzer sonuçlar göstermiştir, ancak Faircloth ve ark. (2004)'ün elde ettikleri sonuçlar ile örtüşmemektedir.

SONUÇ ve ÖNERİLER

Sonuç olarak; çalışmada incelenen parametrelerden iki yılda da çırçır randımanı (%) istatiksel olarak önemsiz bulunmuştur.100 tohum ağırlığı (g) ve lif uzunluğu (mm) ilk yıl ($p<0.05$) düzeyinde önemli ikinci yıl istatiksel olarak önemsiz saptanmıştır. Lif inceliği (mic.) ve lif kopma dayanıklılığı (g/tex) istatiksel olarak ilk yıl önemsiz, çalışmanın ikinci yılında ($p<0.05$) düzeyinde bulunmuştur.

Çalışmada yıllar içerisinde farklılık olmasına rağmen lif kalitesine olumlu etki eden lif uzunluğu (mm), lif inceliği (mic.) ve lif kopma dayanıklılığına (g/tex) pozitif etkide bulunmuştur. Çalışma sonucunda pamuk üreticilerine toprağın pH yapısını dikkate alarak toprağa kükürt uygulamasını tavsiye edebilir ve yapraktan besin elementi olarak da değişik formda kükürt karışımlarını önererek lif kalitesine katkıda bulunduğunu ifade edebiliriz.

KAYNAKLAR

ASHMOUNY, A.A.E., NAQMA K.A.E, HENDAWY, A.A.E., 2017. Effect of Pre-Sowing Application of Nitrogen, Potassium and Sulfur and İts Relationship on Egyptian Cotton Productivity, International Journal of Environment, Agriculture and Biotechnology, 2 (5), 2387-2393.

AULAKH, M.S., SİDHU, B.S., ARORA, B.R., SİNGH, B., 1985. Content and Uptake of Nutrients By Pulses and Oilseed Crops, Indian Journal of Ecology, 12 (2), 238-242.

AWAD, A.M., RAMADAN, H.M., EL-FAYOUMY, M.E., 1996. Effect of Sulphur, Phosphorus and Nitrogen Fertilizers on Micronutrient Availability Uptake and Wheat Production on Calcareous Soils. Journal of Agricultural Research, 41: (3), 311-327

BASF TARIM ÇÖZÜMLERİ TÜRKİYE, 2020. https://www.agro.basf.com.tr/tr/%C3%9Cr%C3%BCnler/%C3%9Cr%C3%BCnBilgileri/Tohum/Fiona.html#section-details.

BUKARLI, M.N., 2007. Diyarbakır Koşullarında Kükürt Uygulamasının Pamuğun Verim ve Kalite Özelliklerine Etkisi, Yüksek lisans Tezi, Çukurova Üniversitesi Fen Bilimleri Enstitüsü, Adana, 90s.

CANDEMİR, D. K. ve ÖDEMİŞ, B., 2018. Yapraktan Uygulanan Farklı Kükürt Dozlarının Pamuk Bitkisinin (Gossypium hirsutum L.) Değişik Gelişme Dönemlerindeki Su Stresinin Azaltılması Üzerine Etkileri. Derim, 35(2), 161-172.

DİETZ, K.J., 1989. Recovery of Spinach Leaves From Sulphate and Phosphate Deficiency. Journal Plant Physiol, 134: 551-557.

DUKE, S.H., REİSENAUER, H.M., 1986. Roles and Requirements of Sulfur in Plant Nutrition. in: tabatabai, M.A.(Ed), Sulfur in Agriculture, Argon, Monogr, Vol. 27.Asa, Cssa and Sssa, Madison, W. I.,123-168.

FAİRCLOTH, W.H., MONKS, C.D., PATTERSON, M.G., WEHTJE, G.R., DELANEY, D.P., SANDERS, J. C., 2004, Cotton and Weed Response to Glyphosate Applied With Sulfur Containing Additives, Weed Technology, 18 (2), 404 - 411.

GENG, J., MA, Q., CHEN, J., ZHANG, M., Lİ, C., YANG, Y., YANG, X., ZHANG, L., 2016. Effects of Polymer Coated Urea and Sülfür Fertilization on Yield, Nitrogen Use Efficiency and Leaf Senescence of Cotton, Field Crops Research, 187, 87-95.

GOBI, V.R., SRİRAMACHANDRASEKHARAN, M.V., KALAİYARASAN, C., 2010. Effect of Sulfur Fertilization on Cotton Seed Yield and Quality Grown on Clay Loam Soil Deficient in Sülfür, Advances in Plant Sciences, 23 (1), 335-336.

GÖRMÜŞ, Ö., 2014. Cotton Yield Response to Sulfur as İnfluenced by Source and Rate in The Çukurova Region, Turkey. Süleyman Demirel Üniversitesi Ziraat Fakültesi Dergisi 9 (1):68 76.

IBRAHİM, A.A., 2022. Effect of Soil Salinity Improvers on Cotton Productivity on Land Reclamation, Egyptian Journal of Agronomy, 44 (1), 19-31.

JAMAL, A., MOON, Y.S., ABDİN M.Z., 2010. Enzyme Activity Assessment of Peanut (Arachis hypogea) Under Slowrelease Sulphur Fertilization, Australian Journal of Crop Science, 4(3),169-174.

JİE, XU, DONG, QU, Lİ-NA, ZHOU. 2008. Effects of Sulfur Nutrition on The Chlorophyll Content of Maize Leaf under Zinc and Drought Stress. Agricultural Research in The Arid Areas. 2008-02.

KAZGÖZ, D.C., & ÖDEMİŞ, B., 2021. Pamuk Bitkisinde Yapraktan Kükürt Uygulamalarının Uzun Süreli Su Stresi Koşullarında Stoma İletkenliğine Etkisi. Mustafa Kemal Üniversitesi Tarım Bilimleri Dergisi, 26 (1), 171-182. https://doi.org/10.37908/mkutbd.806526

KILIÇ, 2024. Pamuk (Gossypium hirsutum L.) Tarımında Uygulanan Farkli Kükürt Dozlarının Verim ve Verim Parametrelerine Etkisi Konusunda Bir Araştırma, Harran Üniversitesi Fen Bilimleri Enstitüsü (Yüksek Lisans Tezi), Şanlıurfa.

KUTAT, H. 2023. Pamukta Kükürt Uygulamasının Verim ve Lif Kalite Kriterleri Üzerine Etkisinin Belirlenmesi. Siirt Üniversitesi Fen Bilimleri Enstitüsü, Yüksek Lisans Tezi.

LAD, H.S., RAMANİ, H.R., PANSURİYA, N.B., 2022. Effect of Different Level of Sulphur on Physiological Characters of Cotton (Gossypium hirsutum L.), The Pharma Innovation Journal , 11 (8), 1523-1526.

MAKHDUM, M.I., MALİK, M.N.A., CHAUDHRY, F.I., DİN, S.U., 2001. Effects of Gypsum as A Sulfur Fertilizer in Cotton (Gossypium hirsutum L.) Production, International Journal of Agriculture and Biology, 3 (3), 375–377.

ÖZÜDOĞRU, T. 2021. Dünya ve Türkiye'de Pamuk Üretim Ekonomisi. Tekstil ve Mühendis, Cilt: 28 Sayı: 122, 149 – 161.

PARLAWAR, N. D., GİRİ, M. D., RAUT, R. S., & KATKAR, R. N. 2018. Response of Bt Cotton (Gossypium hirsutum L.) to Sulphur application under Rainfed Conditions. Journal of Pharmacognosy and Phytochemistry, 7(1), 1694-1698.

PARMAR, K. B, HADİYA, T.M., BABARİYA, N.B., POLARA, K.B., 2010. Effect of Potassium and Sulphur on Yield of Cotton, An Asian Journal of Soil Science, 4 (2), 172-174.

SCHERER, H.W., 2009. Sulfur in Soils, Journal of Plant Nutrition and Soil Science, 172, 326-335.

SİNGH, A. L., CHAUDHARİ, V., 1997. Sulphur and micronutrient nutrition of groundnut in a calcareous soil. J. Of Agronomy and crop sci, 179 (2): 107-114

TÜİK, 2021. Türkiye İstatistik Kurumu. Bitkisel Ürün İstatistikleri. https://data.tuik.gov.tr/. (E.T.: Nisan 2021).

TÜİK, 2023. Türkiye İstatistik Kurumu, Çeşitli istatistikler. https://www.tuik.gov.tr/ (Erişim tarihi: 01.01.2023)

YİN, X. H., GWATHMEY, C. O., and MAİN, C. L., 2012. Sulfur Effects on Cotton Yield Components. Agron. J, 103, 1794-1803.

KISITLI SULAMA KOŞULLARINDA YETİŞTİRİLEN BİBERDE NANO-SİLİSYUM UYGULAMALARININ ETKİSİ

EFFECT OF NANO-SILICON APPLICATIONS ON PEPPER GROWN UNDER DEFICIT IRRIGATION CONDITIONS

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ÖZET
Kuraklık dünyanın pek çok bölgesinde olduğu gibi ülkemizde de şimdiden tarımın en önemli sorunlarının başında yer almaktadır. Çalışmada kısıtlı sulama koşullarında yetiştirilen biberde nano-silisyum (NS) uygulamalarının morfolojik, fizyolojik ver verim üzerindeki etkisi incelenmiştir. Fideler sıkıştırılmış cocopeat slablarına şaşırtılmış, bitkilerin şaşırtılmasından 45 gün sonra kuraklık stresine başlanmıştır. Bu amaçla kontrol bitkilerinde tam sulama (S_{100}), kuraklık stresi için tam sulamaya göre % 30 oranlarında azaltılmış sulama (S_{70}) ve tam sulamaya göre % 50 oranlarında azaltılmış sulama (S_{50}) olmak üzere iki farklı seviyede su kısıtlaması ile stres oluşturulmuştur. Çalışmada nano silisyumun 0.5 mM dozu kullanılmıştır. Dikimden 95 gün sonra, bitki büyüme ve verim parametreleri bakımıdna değerlendirmeler yapılmıştır. Kuraklık stresi koşullarında incelenen parametrelerde %6-50 oranında kontrol bitkilerine oranla azalma meydana gelmiş, bu olumsuz etki S_{50} düzeyinde belirginleşmiştir. Membran zararlanma indeksi (MZİ) ise S_{70} uygulamasında %35 ve S_{50} uygulamasında %65 oranında artış göstermiştir.. Bununla birlikte NS uygulaması stresin olumsuz etkisini sınırlandırmış değişen oranlarda (%4-46) iyileşme sağlamıştır. Araştırma sonucunda elde edilen bulgular ışığında özellikle kuraklık gibi abiyotik stres koşullarının etkili olduğu alanlarda, NS uygulamasının süründürülebilir bir üretimin sağlanması açısından etkili olabileceği kanaatine varılmıştır.
Anahtar Kelimeler: Capsicum annum, İyon Regülasyonu, Kuraklık, Nanoteknoloji, Verim

ABSTRACT
Drought is already one of the most important problems of agriculture in our country as in many parts of the world. In this study, the effect of nano-silicon (NS) applications on morphological and physiological yield of pepper grown under limited irrigation conditions was investigated. Seedlings were transplanted on compacted cocopeat slabs and drought stress was started 45 days after transplanting. For this purpose, stress was created with two different levels of water restriction: full irrigation (S100) in control plants, irrigation reduced by 30% compared to full irrigation (S70) and irrigation reduced by 50% compared to full irrigation (S50) for drought stress. A 0.5 mM dose of nano silicon was used in the study. Plant growth and yield parameters were evaluated 95 days after planting. Under drought stress conditions, the parameters examined decreased by 6-50% compared to control plants, and this negative effect was evident at the S50 level. Membrane damage index (MZI) increased by 35% in S70 treatment and 65% in S50 treatment. However, NS treatment limited the negative effect of stress and provided improvement at varying rates (4-46%). In the light of the findings

obtained as a result of the research, it was concluded that NS application may be effective in terms of ensuring a sustainable production, especially in areas where abiotic stress conditions such as drought are effective.
Keywords: Capsicum annum, Ion Regulation, Drought, Nanotechnology, Yield

GİRİŞ

Tarımsal üretimde önemli oranda verim kayıplarının yaşanmasına neden olan etmenlerin başında kuraklık gelmektedir. Türkiye dâhil olmak üzere tüm dünyada kuraklık, bitki verimliliğini etkileyen en önemli abiyotik streslerden olup yaklaşık 2.4 milyar insan yüksek oranda su stresi olan bölgelerde yaşamaktadır. Bu veriler kuraklıkla mücadelede kuraklığa dayanıklı bitki çeşitlerinin elde edilmesi üzerinde yapılan çalışmaların önemini açığa çıkarmaktadır. Günümüzde gerçekleşen iklim değişikliği; doğal kaynaklar yerine fosil yakıtların kullanımı, ormanlık alanların giderek azalması, sanayi gelişimine bağlı olarak atmosfere salınan gazların meydana getirdiği sera etkisi ve tarım alanlarının yanlış kullanımına bağlı olarak ortaya çıkmaktadır (Yüksel ve Aksoy, 2017).

Su noksanlığı bitkilerde turgorite kaybıyla beraber ozmotik potansiyelin de azalmasına neden olmaktadır. Su eksikliğine bir cevap olarak ortaya çıkan bu durum, bitkide çeşitli eriyebilir maddelerin birikimine neden olmakta ve vakuolden yapraklara su ile birlikte taşınan ozmotik maddelerin miktarlarında artışlar görülmektedir. Bu durum kök bölgesindeki ozmotik potansiyel ve su alımı mekanizması çerçevesinde ozmotik uyum veya ozmoregülasyon olarak tanımlanmaktadır. Ozmotik uyum kuraklık, su ve tuz stresine karşı bitkinin yaşamsal faaliyetlerini sürdürebilmesi açısından oldukça önemli bir mekanizmadır. Bu yaşamsal faaliyetler arasında stomal ve fotosentetik uyum mekanizmaları, bitki gelişmesi ve ürün vermesi ile hücre gelişiminin devamlılığı sayılabilir.

Silisyum (Si), oksijenden sonra yer kabuğunda (%28) en çok bulunan ikinci toprakta ise (%54) en bol bulunan elementtir. Stres altındaki bitkilerde önemli rollerinden dolayı Si, faydalı veya yarı gerekli bir element olarak bilinmesine karşın gereklilik kriterlerini karşılamadığı ve bitki metabolizmasında yer aldığına dair yeterli kanıt olmadığı için gerekli olmayan bir besin maddesi olarak sınıflandırılmıştır. Si, temel bir besin maddesi olarak geniş çapta tanınmamakla birlikte, genellikle bitki büyümesi, fizyolojik/metabolik yollar, hücre yapısı ve çok çeşitli abiyotik ya da biyotik çevresel streslerin hafifletilmesi için yararlı olan "değerli bir element" veya "yapısal element" olarak kabul edilir. Birçok çalışma farklı bitki türlerinde tuzluluk, ağır metal stresi, kuraklık gibi abiyotik stres koşullarında bitki büyüme ve gelişmesi ile verimi artırmadaki rolünü doğrulamıştır (El-Ramady ve ark., 2022).

Hem miktar hem de tür sayısı bakımından ülkemizde yetiştirilen sebzelerin büyük çoğunluğu Solanaceae familyasına aittir. Dünyada ve ülkemizde önemli bir potansiyele sahip olan biber, geniş alanlarda yetiştirilmekte, taze- sofralık ve sanayilik olarak değerlendirilebilen önemli bir sebze grubunu oluşturmaktadır. Dünya biber üretimi 2022 yılında 2 milyon ha alanda 36.5 milyon ton olup, Türkiye biber üretiminde Çin ve Meksika'dan sonra üçüncü sırada yer almaktadır. 2023 yılı Türkiye biber üretimi ise 762.234 da alanda 3.081.010 ton olarak gerçekleşmiştir. (Anonim, 2024).

Gerçekleştirilen bu çalışmada, biberde kısıtlı sulama koşullarında (S_{70} ve S_{50}) nano silisyum (NS) uygulamasının morfolojik, fizyolojik ve verim parametreleri üzerindeki ektisi incelenmiştir.

ARAŞTIRMA ve BULGULAR

Çalışmada materyal olarak daha önceki çalışmalarda yer alan BİB-8 biber genotipi kullanılmıştır. Çankırı Karatekin Üniversitesi, Gıda ve Tarım Meslek Yüksekokulu Araştırma ve Uygulama serasında yürütülen çalışmada tohumlar, torf:perlit (2:1) ortamı içeren viyollere

ekilmiş, bitkiler üç gerçek yapraklı aşamaya ulaştıklarında, sıkıştırılmış cocopeat slablarına (100x20x10) şaşırtılmıştır.
Bitkilerin şaşırtılmasından 45 gün sonra kuraklık stresine başlanmıştır. Bu amaçla kontrol bitkilerinde tam sulama (S_{100}), kuraklık stresi için tam sulamaya göre %30 oranlarında azaltılmış sulama (S_{70}) ve Tam sulamaya göre %50 oranlarında azaltılmış sulama (S_{50}) olmak üzere iki farklı seviyede su kısıtlaması ile stres oluşturulmuştur. Nano silisyum dozu olarak önceki çalışmalarda belirlenen 0.5 mM dozu kullanılmış ve yapraktan 15 gün süre ile uygulanmıştır. Sezon süresince verim değerleri kaydedilmiştir. Sezon sonunda (dikimden 95 gün sonra) bitki büyüme parametreleri (bitki yeşil aksam yaş ve kuru ağırlığı, bitki boyu, yaprak alanı, yaprak oransal su içeriği, yaprak su potansiyeli, klorofil-SPAD, yaprak K, Ca, Mg ve P içeriği) ve kalite parametreleri (toplam verim, ortalama meyve ağırlığı, meyve boyu, meyve çapı, meyve hacmi, meyve suyunda SÇKM, meyve suyu EC ve pH) bakımından ölçüm ve analizler gerçekleştirilmiştir.
Çalışmada tesadüf parselleri faktöriyel deneme deseni kullanılmış, edilen sayısal değerler, JMP istatistik paket programında (version 13.0 SAS Institute Inc., USA) varyans analizine tabi tutulup istatistiksel açıdan uygulamalar arasındaki farklılıklar asgari önemli fark (Least significant difference, LSD) testi ile önemlilik dereceleri ortaya konularak $p<0.05$ düzeyinde harflendirme yoluyla gösterilmiştir.
Kısıtlı sulama koşullarında nano silisyum (NS) uygulamasının etkinliğinin incelendiği çalışmada yeşil aksam yaş ve kuru ağırlık değerleri belirlenmiş ve Tablo 1'de gösterilmiştir. En yüksek yeşil aksam yaş ve kuru ağırlık değerleri kontrol bitkilerinde (789.01 ve 152.06 g/bitki) belirlenmiş stres koşullarında kontrol bitkilerine oranla %15-35 oranında azalma meydana gelirken bu değişim S50 uygulamasında ön plana çıkmıştır. NS uygulaması ile genel olarak stresin olumsuz etkisi sınırlandırılmış ortalama olarak %10-20 oranında iyileşme sağlanmıştır.
Biberde kısıtlı sulama ve NS uygulamasının etkisi bitki boyu bakımından değerlendirilmiş ve Tablo 1'de'te sunulmuştur. En yüksek bitki boyu değerleri 124.78 cm/bitki ile kontrol (S100), bunu S_{70}+NS (122.33 cm/bitki) izlemiştir. Bitki boyu değerleri stres koşullarında %6-13 oranında azalma göstermiş, NS uygulaması ile birlikte %5-6 oranında iyileşme ile S_{70} düzeyinde azalma %2 ve S50 düzeyinde azalma % oranında kalmıştır.
Yaprak alanı, yaprak oransal su içeriği ve SPAD değeri stres koşullarında azalırken bu azalma S70 düzeyinde %19, %14 ve %13; S50 düzeyinde ise %35, %25 ve %26 oranlarında gerçekleşmiştir. NS uygulaması ile %10-30 oranında yaprak alanı, YOSİ ve SPAD değerleri korunmuştur (Tablo 1).

Tablo 1. Bitki büyüme parametreleri, yaprak oransal su içeriği (YOSİ) ve SPAD değerleri bakımından meydana gelen değişimler

		Bitki boyu (cm)	Yeşil Aksam Yaş Ağırlık (g/bitki)	Yeşil Aksam Kuru Ağırlık (g/bitki)	Yaprak Alanı	YOSİ	SPAD
Uygulama	S_0 (Kontrol)	124.78 **a**	789.01 **a**	152.06 **a**	9068.14 **a**	90.75 a	56.58 **a**
	S_{70}	117.11 **b**	641.74 **c**	128.60 **bc**	7337.51 **d**	77.84 **c**	48.67 **c**
	S_{70}+NS	122.33 **a**	705.41 **b**	145.20 **ab**	8741.74 **b**	85.67 **b**	54.53 **ab**
	S_{50}	107.38 **c**	542.25 **d**	99.87 **d**	5887.95 **e**	68.55 **d**	42.04 **d**
	S_{50}+NS	113.91 **b**	618.30 **c**	119.99 **c**	7643.42 **c**	77.03 **c**	50.44 **bc**

Potasyum (P), kalsiyum (Ca), magnezyum (Mg) ve fosfor (P) içerikleri incelenmiş, Tablo 2'de sunulmuştur. İyon içeriklerinin kuraklık stresine bağlı olarak azaldığı ve bu azalmanın özellikle S50 uygulamasında ön plan çıktığı belirlenmiştir (%22-33 azalma). NS uygulaması iyon içeriklerinin korunmasında etkili olmuş S_{70}+NS uygulamasında K, Ca ve Mg içeriğinde kontrol bitkilerine oranla %3-7 oranında artış meydana gelmiş, P içeriğinde ise %5.31 oranında azalma meydana gelmiş, %12-19 oranında iyileşme sağlanmıştır. S_{50}+NS uygulaması ile K, Ca, Mg ve P içeriklerinde %5-18 oranında azalma ortaya çıkmış ve %17-41 oranında iyileşme sağlanmıştır.

Tablo 2. İyon içerikleri bakımından meydana gelen değişimler

		K (%)	Ca (%)	Mg (%)	P (%)
Uygulama	S_0 (Kontrol)	4.37 **b**	2.65 **ab**	0.58 **b**	0.39 **a**
	S_{70}	4.03 **c**	2.37 **bc**	0.51 **c**	0.31 **b**
	S_{70}+NS	4.52 **a**	2.80 **a**	0,62 **a**	0.37 **a**
	S_{50}	3.21 **d**	2.07 **c**	0.39 **d**	0.27 **c**
	S_{50}+NS	3.94 **c**	2.42 **bc**	0.55 **bc**	0.32 **b**

Verim ve kalite parametrelerinin de incelendiği çalışmada en yüksek verim S_{100} uygulamasında toplam verim değerleri genel olarak 2.27-4.55 kg/m^2 arasında değişim göstermiş stres koşullarına bağlı olarak kontrol (S_{100}) bitkilerine oranla azalmıştır. En yüksek toplam verim kontrol uygulamalarında 4.55 kg/m^2 belirlenmiştir (Tablo 3). En düşük toplam verim ise S_{50} uygulamasında 2.27 kg/m^2 olarak saptanmıştır. Toplam verim kontrol bitkilerine oranla %29-50 oranında azalmış, bu azalma S_{50} uygulamasında ön plana çıkmıştır. NS uygulaması ile ortalama olarak %20-45 oranında iyileşme sağlanmıştır. Buna NS uygulaması ile birlikte S_{70} düzeyinde kontrol bitkilerine oranla %15, stresin en belirgin olarak ortaya çıktığı S_{50} düzeyinde ise %38 oranında azalma meydana gelmiştir (Tablo 3).

Meyve ağırlığı (35.26-57.42 g), meyve boyu (7.36-12.64 cm) ve meyve çapı (24.07-38.78 mm) bakımından en yüksek değerler kontrol uygulamasında belirlenmiş, değerler genel olarak stres koşullarına bağlı olarak kontrol (S_{100}) bitkilerine oranla azalmış, Bu azalma meyve ağırlığında %17-39, meyve boyunda %7-42, meyve çapında ise %3-38 oranlarında değişim göstermiştir. En düşük meyve ağırlığı, meyve boyu ve meyve çapı S_{50} uygulamasında sırasıyla 35.26 g (%39 azalma), 7.36 cm (%42 azalma) ve 24.07 mm (%358 azalma) olarak saptanmıştır. NS uygulaması stres koşullarında %5-46 oranında iyileşme sağlanmasında etkili olmuştur. Bu iyileşme S_{70}+NS uygulamasında %5-22, S_{50}+NS uygulamasında ise %25-46 oranında gerçekleşmiştir (Tablo 3).

Biberde kısıtlı sulama ve NS uygulamasının etkisi suda çözünebilir kuru madde (SÇKM), meyve pH ve EC değerleri bakımından incelenmiş ve Tablo 3'de sunulmuştur. Buna göre SÇKM oranlarında genel kontrol bitkilerine oranla ortalama olarak %1-3 oranında artış meydana gelirken; pH ve EC değerleri bakımından %2-7 oranında azalma tespit edilmiştir. NS uygulamaları SÇKM içeriğinde %1-4 oranında artış sağlanmasında etkili olmuştur. Bununla birlikte uygulamalar arasında ortaya çıkan fark istatistiksel olarak önemsiz bulunmuştur.

Tablo 3. Verim ve kalite parametreleri bakımından meydana gelen değişimler

		Toplam Verim (kg/m^2)	**Meyve Ağırlığı (g)**	**Meyve Boyu (cm)**	**Meyve Çapı (mm)**	**SÇKM (%)**	**pH**	**EC (dS/m)**
Uygulama	S_0 (Kontrol)	4.55 **a**	57,42 **a**	12.64 **a**	38.78 **a**	5.01	5.98	4.92
	S_{70}	3,22 **c**	45,28 **bc**	9.69 **c**	30.89 **b**	4.94	5.83	4.78
	S_{70}+NS	3.87 **b**	47.56 **b**	11.81 **ab**	37.70 **a**	5.08	5.56	4.82
	S_{50}	2.27 **d**	35.26 **d**	7.36 **d**	24.07 **c**	5.13	5.81	4.72
	S_{50}+NS	3.29 **c**	43.92 **c**	10.74 **bc**	32.97 **b**	5.14	5.91	4.76

TARTIŞMA

Bitki büyüme ve gelişmesini olumsuz etkileyen abiyotik stres faktörlerinden bir diğeri ise kuraklıktır. Kalefetoğlu ve Ekmekçi (2005), kuraklık stresini %26'lık payıyla en büyük dilim içerisinde olduğunu ifade etmektedir. Topraktaki su içeriğinin bitkilerin su azlığından sıkıntı çektiği miktara kadar, belirgin yağışın olmadığı bir periyodu ifade eden kuraklık, toprağın su tutma kapasitesi ve bitkiler tarafından gerçekleştirilen evapotranspirasyon hızına bağlı olarak gerçekleşmektedir.

Silisyum (Si) yaklaşık %28'lik oran ile oksijenden sonra en çok bulunan ikinci element konumundadır. Tarımsal üretimde önemli bir yere sahip olan Nano-Si partikülleri nano-herbisitler, nano-gübreler ve nano-pestisitler olarak kullanımları yoluyla çeşitli abiyotik stresleri hafifletmede etkinlik gösterebilmektedirler (Rastogi ve ark. 2019). Silisyum bitkilerde fizyolojik fonksiyonları uyarmanın yanı sıra bitkinin stres koşullarında hayatta kalma potansiyelini geliştirmede önemli bir yer tutmaktadır. Bu doğrultuda silisyum, bitkinin abiyotik stres toleransını artırmakta, fotosentetik aktiviteyi iyileştirilmesinde, iyon regülasyonunun sağlanmasında ve elementlerin toksisite etkisinin azaltılmasında rol oynamaktadır (Merwad ve ark. 2018).

Kuraklık stresinin ilk olumsuz etkileri büyüme ve gelişmede meydana gelen olumsuzluklardır. Kuraklık stresi sonucu hücrede meydana gelen su kaybı, plazma membranında oluşan çökmeye ve serbest kalan hidrolitik enzimler ise sitoplazmanın otolizine neden olmakta, sonuçta büyümede yavaşlama ve turgorda azalma meydana gelmektedir. Su noksanlığı karşısında hücre bölünmesi ve büyümesinde meydana gelen azalma, karbon ve azot metabolizmalarında oluşan değişimler, bitkilerde yaş ve kuru ağırlık değerlerinin de azalmasına neden olmaktadır. Çalışmada, yaş ve kuru ağırlık, gövde boyu, yaprak alanı gibi büyüme parametrelerinde kuraklık stresi ile birlikte kontrol bitkilerine oranla değişen oranlarda azalma meydana gelmiştir (%6-35 azalma). NS uygulaması ile birlikte stresin ortaya koyduğu olumsuzluk ve zararlanmaları önemli düzeyde sınırlandırdığı, bu sınırlandırmanın genel olarak bitki büyüme parametreleri bakımından %5-30 düzeyinde iyileşme sağladığı görülmüştür. Nano silisyum uygulamalarının bitki büyüme ve gelişmesi ile yaprak oransal su içeriğinde artışı teşvik ettiğini ifade eden Ahmadian ve ark. (2021), buğdayda gerçekleştirmiş oldukları çalışmalarında, kuraklık stresinde turgor ve protoplazma dehidrasyonundaki azalma ile birlikte fotosentezde azalma meydana geldiğini buna bağlı olarak bitki büyüme ve gelişmesinde azalma ortaya çıktığını ifade etmiş, nano silisyum uygulaması ile birlikte bitki büyüme parametrelerinde artış görüldüğünü ifade etmiş, Deskoy ve ark. (2021) ise nano silisyumun turgor basıncını artırarak bitkinin su alımı ve besin maddelerindeki artış ile birlikte bitki büyüme ve gelişmesi ile yaprak oransal su içeriğinin arttığını bildirmiştir. Çilek (Zahedi ve ark., 2020) ve bezelyede (Sutuliene ve ark., 2022) gerçekleştirilen çalışmalarda kuraklık stresi koşullarında nano silisyum uygulamasının kuraklık stresine toleransın sağlanmasında etkili olduğu bildirilmiştir. Kuraklık stresi klorofil içeriğinde (SPAD) değişen oranlarda azalmaya neden olmuştur. Kontrol bitkilerine oranla %4-26 oranında ortaya çıkmış ve en belirgin değişim S50 uygulamasında (%26 azalma) belirlenmiştir. Klorofil içeriğindeki azalmanın klorofil degradasyonundaki artma veya klorofil sentezindeki azalmadan kaynaklanabileceği bildirilmiştir (Santos, 2004). Nano silisyum uygulaması klorofil içeriğinde meydana gelen azalmayı önemli düzeyde sınırlandırmıştır. Kontrol bitkilerine oranla NS uygulanan stres bitkilerinde NS uygulanmayan stres bitkilerine oranla %12-20 düzeyinde iyileşme sağlanmıştır. Hellal ve ark. (2020) arpada kuraklık stresi ile birlikte SPAD değerlerinde azalma meydana geldiğini, stres düzeyindeki artış ile birlikte SPAD değerindeki azalmanın daha yüksek olduğunu ifade etmiş, nano silisyum uygulaması ile birlikte SPAD değerlerinin korunduğunu bildirmiştir. Greger ve ark. (2018), silisyumun yalnızca besinlerin kullanılabilirliğini ve alımını değil, aynı zamanda besinlerin kökten sürgüne taşınmasını da etkilediğini bildirmiş, özellikle klorofilin yapısındaki ana element olan Mg alımındaki artışın fotosentez üzerinde etkili olduğunu ifade etmiştir.

Su miktarı, besin maddelerinin kökler yoluyla alınmasında ve sürgünlere taşınmasında önemli bir etkiye sahiptir. Topraktaki su mevcudiyetinin azalması, genellikle sınırlı toplam besin alımı ve bitkilerde dokuda besin konsantrasyonlarının azalmasıyla sonuçlanır. Su kısıtı koşullarında hücre zarlarının zarar görmesi, bitkilerde iyon dengesinin bozulmasına yol açan önemli bir faktördür. Genel olarak, kuraklık stresi bitkilerde N konsantrasyonunda artışa, P konsantrasyonunda azalmaya neden olurken, K konsantrasyonu üzerinde kesin bir etkisi yoktur. Fakat yapılan bir araştırmada su stresi koşullarında bitkilerin Ca, Mg, Na ve K içeriğinde bir azalma olduğu da bildirilmiştir (Ors ve Suarez, 2017). Sahin ve ark. (2018) lahanada yürüttükleri bir çalışmada kuraklık stresi altında N, P, K, Mg, B, Fe ve Zn konsantrasayonlarında azalmalar belirlenmiştir. Benzer şekilde kuralık stresi altında yetiştirilen domateste N, P, K, Ca, Mg ve Zn gibi bitki besin elementi içeriklerinin önemli düzeyde azaldığı rapor edilmiştir (Ors ve ark., 2021). Gerçekleştirilen bu çalışmada K, Ca, Mg ve P içeriklerinde stres ile birlikte azalma meydana gelmiş bu azalma S50 düzeyinde belirginleşmiştir. Nano silisyum uygulaması her iki stres düzeyinde de iyon alımını iyileştirici bir role sahip olmuş ve ortalama olarak %12-41 düzeyinde iyon alımı teşvik edilmiştir. Hıyarda kuraklık stresine bağlı olarak K iyon alımında azalma meydana geldiğini ifade eden Alsaeedi ve ark. (2019), nano silisyum uygulamalarının K alımını artırdığını, Rea ve ark.

(2022) Si uygulamasının N, P, ve K alımı üzerinde olumlu etkisi olduğunu, çeltikte kuraklık stresi koşullarında nano silisyum uygulamaları ile K, Ca ve Mg alımının artış gösterdiğini bildirmişlerdir.
Kuraklık stresi verim ve kalite özellikleri bakımından azalmaya neden olmuştur. Kısıntılı sulama konuları ile oluşturulmuş kuraklık stresinin farklı sebze türlerinde bitki gelişimi ve verim üzerine benzer etki gösterdiği görülmektedir (Wach ve ark., 2007; Kuslu ve ark., 2014). Kuraklık stresinin (%60 tarla kapasitesi) biberde bitki büyüme ve gelişmesi ile verim üzerindeki etkisinin incelendiği bir çalışmada, stres koşulları sonucu bitki büyüme parametreleri, toplam klorofil, meyve sayısı, meyve uzunluğu, meyve çapı, meyve hacmi, meyve kuru ağırlığı ve verimde azalma meydana gelirken; bitki prolin ve serbest amino asit içeriği, meyve aakorbik asit, toplam şeker, toplam fenol ve flavanoid içeriğ, SÇKM düzeyinde artış meydana geldiği ifade edilmiştir (Mostafa ve ark., 2024). Gerçekleştirilen bu çalışmada, NS uygulaması verim ve kalite değerlerinde %1-45 oranında iyileşme sağlarken kalite özellikleri bakımından olumlu etki ortaya koymuştur. Kuraklık stresi hıyarda verim ve kalite parametrelerini olumsuz etkilemiş nano silisyum uygulaması stres koşullarında verimde artış sağlanmasında etkili olmuştur. Araştırıcılar nano silisyumun besim elementi alımını teşvik etmesi, yapraklarda fotosentez düzeyinin artmasına bağlı olarak verimde artışın meydana geldiğini bildirmişlerdir. Nitekim domates (Ebrahimi ve ark., 2024) ve domateste (Islam ve ark., 2018) gerçekleştirilen araştrmalarda, nano silisyumun verim ve kalite paramatrelerinde iyileşme sağladığı rapor edilimiştir.
Çalışma sonucunda S_{70} ve S_{50} kısıtlı sulama düzeyi ile oluşturulan kuraklık stresinin biberde morfolojik, fizyolojik, verim ve kalite parametreleri bakımından olumsuz etkiler ortaya koyduğu, bu etkinin özellikle S_{50} düzeyinde belirginleştiği görülmüştür. Nano silisyumun 0.5 mM dozu stresin ortaya koyduğu olumsuz etkiyi sınırlandırmış ve değişen oranlarda iyileşme sağlanmasına imkan vermiştir.

KAYNAKLAR

Ahmadian, K., Jalilian, J., & Pirzad, A. (2021). Nano-fertilizers improved drought tolerance in wheat under deficit irrigation. Agricultural Water Management, 244, 106544.
Alsaeedi, A., El-Ramady, H., Alshaal, T., El-Garawany, M., Elhawat, N., & Al-Otaibi, A. (2019). Silica nanoparticles boost growth and productivity of cucumber under water deficit and salinity stresses by balancing nutrients uptake. Plant Physiology and Biochemistry, 139, 1-10.
Anonim, (2024). FAOSTAT. https://www.fao.org/faostat/en/#data/QCL. Erişim Tarihi: 20.11.2024
Desoky, E. S. M., Mansour, E., El-Sobky, E. S. E., Abdul-Hamid, M. I., Taha, T. F., Elakkad, H. A., & Yasin, M. A. (2021). Physio-biochemical and agronomic responses of faba beans to exogenously applied nano-silicon under drought stress conditions. Frontiers in plant science, 12, 637783.
Ebrahimi, H., Soltani Mohammadi, A., Boroomand Nasab, S., Alamzadeh Ansari, N., & Juárez-Maldonado, A. (2024). Evaluation the impact of silicon nanoparticle on growth and water use efficiency of greenhouse tomato in drought stress condition. Applied Water Science, 14 (9), 196.
El-Ramady, H., Verma, K. K., Rajput, V. D., Minkina, T., Elbehery, F., Elbasiony, H. and Amer, M. (2022). Sources of silicon and nano-silicon in soils and plants. In: Silicon and Nano-silicon in Environmental Stress Management and Crop Quality Improvement.
Greger, M., Landberg, T., & Vaculík, M. (2018). Silicon influences soil availability and accumulation of mineral nutrients in various plant species. Plants, 7 (2), 41.

Hellala, F., Amerb,A., El-Sayeda, S., and El-Azabb, K., (2020). Mitigating The Negative Effect Of Water Stress On Barley By Nano Silica Application. Plant Archives Vol. 20, Supplement 1, 2020 pp. 3224-3231

Islam, M. Z., Mele, M. A., Choi, K. Y. & Kang, H. M. (2018).The effect of silicon and boron foliar application on the quality and shelf life of cherry tomatoes. Zemdirbyste Agric. 105, 159–164

Kalefetoğlu, T., Ekmekçi, Y. (2005). The effects of drought on plants and tolarance mechanisms (Review). G.U. Journal of Science, 18 (4): 723-740.

Kuslu, Y., Sahin, U., Kiziloglu, F.M., Memis, S. (2014). Fruit yield and quality, and irrigation water use efficiency of summer squash drip-irrigated with different irrigation quantities in a semi-arid agricultural area. Journal of Integrative Agriculture. 13 (11): 2518-2526.

Merwad, A. R. M., Desoky, E. S. M. and Rady, M. M. (2018). Response of water deficit-stressed Vigna unguiculata performances to silicon, proline or methionine foliar application. Scientia Horticulturae, 228: 132-144.

Mostafa, M. M., El-wahed, A., Ahmed, H. M., Hamad, S. A., Sheta, M. H. (2024). Improved water use efficiency and yield of drip-irrigated pepper under full and deficit irrigation conditions. Egyptian Journal of Soil Science, 64 (2): 423-442.

Ors, S., Ekinci, M., Yildirim, E., Sahin, U., Turan, M., Dursun, A. (2021). Interactive effects of salt and drought stress on photosynthetic characteristics and physiology of tomato (Lycopersicon esculentum L.) seedlings. South African Journal of Botany, 137: 335-339.

Ors, S., Suarez, D. (2017). Spinach biomass yield and physiological response to interactive salinity and water stress. Agricultural Water Management, 190: 31-41.

Rastogi, A., Tripathi, D. K., Yadav, S., Chauhan, D. K., Živčák, M., Ghorbanpour, M. and Brestic, M. (2019). Application of silicon nanoparticles in agriculture. 3 Biotech, 9 (3): 1-11.

Rea, R. S., Islam, M. R., Rahman, M. M., Nath, B., & Mix, K. (2022). Growth, nutrient accumulation, and drought tolerance in crop plants with silicon application: A review. Sustainability, 14: 4525.

Sahin, U., Ekinci, M., Ors, S., Turan, M., Yildiz, S., Yildirim, E. (2018). Effects of individual and combined effects of salinity and drought on physiological, nutritional and biochemical properties of cabbage (Brassica oleracea var. capitata). Scientia Horticulturae 240: 196-204.

Santos, C.V. (2004). Regulation of chlorophyll biosynthesis and degradation by salt stress in sunflower leaves. Scientia Horticulturae, 103 (1), 93-99.

Wach, A., Pyrzynska, K., Biesaga, M. (2007), Quercetin content in some food and herbal samples. Food Chemistry, 100 (2): 699-704.

Yüksel, B., Aksoy, Ö. (2017). Su stresi koşullarında bitkilerde gözlenen değişimler. Turkish Journal of Scientific Reviews, 10 (2): 01-05.

Zahedi, S. M., Moharrami, F., Sarikhani, S., & Padervand, M. (2020). Selenium and silica nanostructure-based recovery of strawberry plants subjected to drought stress. Scientific reports, 10 (1), 17672.

THE RELATIONSHIP OF PLANT GROWTH REGULATORS WITH EPIGENETICS

BİTKİ BÜYÜME DÜZENLEYİCİLERİNİN EPİGENETİK İLE İLİŞKİSİ

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ÖZET
DNA metilasyonu, histon modifikasyonları ve small interferaz RNA'lar (siRNAs) içeren epigenetik mekanizmalar, DNA dizisini değiştirmeden gen ifadesini düzenlemede çok önemlidir. Bitkilerde bu mekanizmalar büyüme, gelişme ve stres tepkileriyle sıkı sıkıya bağlantılıdır. Oksinler, gibberellinler, sitokininler, absisik asit (ABA), etilen ve brassinosteroidler gibi genellikle hormon olarak adlandırılan bitki büyüme düzenleyicileri, bu epigenetik süreçlerin kritik aracıları olarak hizmet eder. Oksinler, histon asetilasyonu ve DNA demetilasyonu yoluyla kromatin yapısını değiştirerek, hücre bölünmesi, uzaması ve farklılaşmasında rol oynayan anahtar gen ağlarını aktive ederek kök ve sürgün gelişimini düzenler. Gibberellinler, histon metilasyonunu modüle ederek, DNA metilasyon modellerini değiştirerek ve DELLA proteinleri gibi transkripsiyon düzenleyicileri ile etkileşime girerek epigenetik mekanizmaları düzenler ve çimlenme, çiçeklenme ve stres adaptasyonu gibi süreçlerin hassas bir şekilde kontrol edilmesini sağlar. Sitokininler, histon asetilasyonunu artırarak, DNA demetilasyonunu teşvik ederek ve gen ifadesini, hücre bölünmesini, farklılaşmayı ve stres tepkilerini kontrol etmek için kromatin yeniden şekillendirme kompleksleriyle etkileşime girerek epigenetik mekanizmaları düzenler. ABA, kuraklık ve tuz stresi koşulları altında kromatin durumlarını değiştirerek strese duyarlı genleri yönetir. Etilen, histon modifikasyonları yoluyla olgunlaşma ve yaşlanmaya katkıda bulunur. Ayrıca, hormonların kombinatoryal etkileri, epigenetik yollar üzerindeki sinerjik etkilerini vurgulayarak çevresel ve gelişimsel ipuçlarına yanıt olarak gen ifadesi üzerinde hassas kontrol sağlar. Bitki hormonları epigenetik mekanizmaları önemli ölçüde etkileyerek büyüme, gelişme ve stres adaptasyonu için çok önemli olan dinamik gen düzenlemesini sağlar. Bu etkileşimleri anlamak, değişen çevresel koşullar altında ürün verimi ve kalite artırmaya yönelik değerli bilgiler sağlar. Bu mekanizmalarla ilgili daha fazla araştırma, ürün ıslah çalışmalarında hedeflenen uygulamaları mümkün kılarak tarımsal verimliliği artırabilir. Bu bildiri, bitki hormonları ve epigenetik mekanizmalar arasındaki karmaşık ilişkileri aydınlatarak bitki bilimi ve strese dayanıklılık stratejileri alanındaki bilgileri ilerletmeyi amaçlamaktadır.
Anahtar Kelime: Oksin, ABA, DNA metilasyonu, siRNA

ABSTRACT
Epigenetic mechanisms including DNA methylation, histone modifications and small interfering RNAs (siRNAs) are crucial in regulating gene expression without altering the DNA sequence. In plants, these mechanisms are tightly linked to growth, development and stress responses. Plant growth regulators, often called hormones, such as auxins, gibberellins, cytokinins, abscisic acid (ABA), ethylene and brassinosteroids, serve as critical mediators of

these epigenetic processes. Auxins regulate root and shoot development by altering chromatin structure through histone acetylation and DNA demethylation, activating key gene networks involved in cell division, elongation and differentiation. Gibberellins regulate epigenetic mechanisms by modulating histone methylation, altering DNA methylation patterns and interacting with transcription regulators such as DELLA proteins, enabling precise control of processes such as germination, flowering and stress adaptation. Cytokinins regulate epigenetic mechanisms by increasing histone acetylation, promoting DNA demethylation and interacting with chromatin remodelling complexes to control gene expression, cell division, differentiation and stress responses. ABA governs stress-responsive genes by altering their chromatin state under drought and salt stress conditions. Ethylene contributes to maturation and senescence through histone modifications. Furthermore, the combinatorial effects of hormones allow precise control over gene expression in response to environmental and developmental cues, emphasising their synergistic effects on epigenetic pathways. Plant hormones significantly influence epigenetic mechanisms, enabling dynamic gene regulation that is crucial for growth, development and stress adaptation. Understanding these interactions provides valuable information for improving crop yield and quality under changing environmental conditions. Further research into these mechanisms could improve agricultural productivity by enabling targeted applications in crop breeding endeavours. This paper aims to advance knowledge in the field of plant science and stress tolerance strategies by elucidating the complex relatiXonships between plant hormones and epigenetic mechanisms.
Keywords: Auxin, ABA, DNA Methylation, siRNA

GİRİŞ

Epigenetik, DNA dizisinde değişiklik olmaksızın gen ifadesinde kalıtsal ve kalıcı değişikliklere neden olan mekanizmaları inceler ve bitkilerin çevresel streslere adaptasyonunda kritik bir rol oynar (Bird, 2007). Bu mekanizmalar arasında DNA metilasyonu, histon modifikasyonları ve kodlamayan RNA'lar bulunur (Gagnidze ve Pfaff, 2022). Bu süreçler, gen ifadesinin dinamik ve esnek bir şekilde düzenlenmesini sağlayarak, bitkilerin değişen çevresel koşullara uyum sağlamasına yardımcı olur (Skinner ve Nilsson, 2021). Bitki büyüme düzenleyicileri (BBD'ler), oksin, gibberellin, sitokinin, absisik asit (ABA) ve etilen gibi hormonlardan oluşur ve bitki büyümesi, gelişimi ve stres tepkilerinde önemli roller oynar (Davies, 2013). Oksin ve gibberellinler hücre bölünmesi, uzaması (Woodward ve Bartel, 2005) ve çimlenmeyi desteklerken (Davies, 2013), sitokininler besin remobilizasyonu (Kudo ve ark., 2010) ve rejenerasyonda (Sakakibara, 2006) etkili olur. ABA ve etilen ise stres koşullarında su kaybını azaltır (Davies, 2013), stomatal kapanmayı düzenler ve meyve olgunlaşması (Jiang ve ark., 2024) ile yaşlanmayı kontrol eder. Bitki büyüme düzenleyicileri (BBD'ler) epigenetik düzenlemelerde önemli bir rol oynar. Oksin, gibberellin, sitokinin ve absisik asit (ABA) gibi hormonlar, epigenetik mekanizmaları etkileyerek gen ekspresyonunu modüle eder. Örneğin, oksinler, histon asetilasyonu ve DNA demetilasyonu yoluyla hücre bölünmesi ve uzamasını teşvik eder (Poulios ve ark., 2022). Gibberellinler, histon modifikasyonları aracılığıyla çimlenme ve çiçeklenme süreçlerini düzenler (Hou ve ark., 2015). Sitokininler, kromatin yeniden şekillendirme kompleksleriyle etkileşerek gen düzenlenmesinde rol oynar (Jégu ve ark., 2015). ABA ise kuraklık ve tuzluluk gibi stres koşullarında strese duyarlı genlerin ekspresyonunu epigenetik yollarla düzenler (Han ve ark., 2023). Bu hormonlar ve epigenetik mekanizmalar arasındaki etkileşim, bitkilerin çevresel değişimlere yanıt verme kapasitesini artırır. Hormonların genetik kontrol üzerindeki bu etkileri, bitki büyümesi ve gelişiminin yanı sıra tarımsal verimliliği artırma potansiyeline de sahiptir (Rudolf ve ark., 2024). Dolayısıyla, epigenetik ve BBD'ler arasındaki ilişkilerin derinlemesine incelenmesi, daha dirençli ve verimli bitki türlerinin geliştirilmesine yönelik stratejiler sunmaktadır.

BİTKİLERDE EPİGENETİK MEKANİZMALAR

Epigenetik, DNA dizisinin kendisinde değişiklik içermeyen gen ifadesindeki kalıtsal değişikliklerin incelenmesidir ve bitkilerin çevresel dalgalanmalara uyum sağlaması için bir mekanizma sağlar (Bird, 2007). “Epigenetik” terimi, genom üzerindeki düzenleyici etkisini ifade eden ve ‘üst’ anlamına gelen Yunanca ‘epi’ kelimesinden türemiştir (Agarwal ve ark., 2020). Epigenetik değişiklikler genellikle sıcaklık değişimleri, besin eksiklikleri ve ışık gibi çevresel faktörler tarafından tetiklenir (Skinner ve Nilsson, 2021; Skinner, 2023). Bu modifikasyonlar, bitki genomlarının önemli bir bölümünü oluşturan ve aksi takdirde gen işlevini bozabilecek olan transposable elementlerin susturulmasında hayati bir rol oynar (Hassan ve ark., 2024). Tarımda, epigenetik mekanizmalardan yararlanmak, abiyotik ve biyotik streslere karşı daha fazla tolerans gösteren ürünler geliştirmek için umut verici stratejiler sunmaktadır (Abdulraheem ve ark., 2024). Örneğin, pirinçte kuraklığa dayanıklılığı artırmak için epigenetik müdahaleler kullanılmış ve bu da kuraklık koşulları altında verimin artmasıyla sonuçlanmıştır (Kumar ve ark., 2023). DNA metilasyonu, histon modifikasyonları ve kodlamayan RNA'lar, bitkilerde epigenetik düzenlemenin gerçekleştiği üç ana mekanizmadır (Gagnideze ve Pfaff, 2022).

DNA metilasyonu

DNA metilasyonu, bitki genomlarında yaygın olarak CG, CHG ve CHH bağlamlarında meydana gelen sitozin kalıntılarına bir metil grubunun eklenmesidir (Bartels ve ark., 2018). Bu süreç tipik olarak gen aktivitesini baskılar, transposable elementleri ve tekrarlayan dizileri susturarak genom stabilitesini korur (Zhang ve ark., 2021). Bitkiler, strese duyarlı genlerin düzenlenmesinde kritik rol oynayan CG dışı bağlamlarda benzersiz metilasyon modelleri sergiler (Chen, 2019). Pirinçte (Oryza sativa), kuraklığa tolerans, su kullanım verimliliğine dahil olan lokuslarda artan DNA metilasyonu ile ilişkilendirilmiştir (Kou ve ark., 2022). Mısırda (Zea mays) DNA metilasyonu, azot eksikliği koşullarında besin alım genlerinin düzenlenmesine yardımcı olarak bitki büyümesini iyileştirir (Mager ve Ludewig, 2018). Öte yandan DNA demetilasyonu, tuz stresi altındaki Arabidopsis thaliana'da gözlemlendiği gibi stresle ilişkili genleri aktive edebilir (Yang ve ark., 2022).

Histon modifikasyonları

Histon modifikasyonları, DNA'yı kromatine paketleyen ve düzenleyen, gen erişilebilirliğini etkileyen histon proteinlerindeki kimyasal değişiklikleri içerir (Gagnidze ve Pfaff, 2022). Histon kuyruklarının asetilasyonu kromatin yapısını gevşeterek gen ifadesini kolaylaştırırken, metilasyon konumuna bağlı olarak genleri aktive edebilir veya baskılayabilir (Law ve Jacobsen, 2010). Histon asetilasyonu, kromatin yeniden şekillenmesinin zamanında çiçek geçişini sağladığı Arabidopsis thaliana'da çiçeklenme kontrolü ile ilişkilendirilmiştir (Yu ve ark., 2011; He ve ark., 2021). Histon H3 lizin 27'nin (H3K27me3) metilasyonu, yaprak yaşlanmasında rol oynayan genleri baskılayarak buğday (Triticum aestivum) gibi bitkilerde yaşlanma süreçlerini geciktirir (Wang ve ark., 2019; Cao ve ark., 2024; Liu ve ark., 2024). Histon modifikasyonları stres tepkilerinde de rol oynar; örneğin, histon asetilasyonu pirinçte (Oryza sativa) stresle ilgili genleri aktive ederek kuraklığa toleransı artırır (Zhao ve ark., 2021; Sun ve ark., 2024).

Kodlamayan RNA'lar (ncRNA)

siRNA'lar ve miRNA'lar gibi kodlamayan RNA'lar (ncRNA'lar), mRNA'yı bozunma veya translasyonel baskılama için hedefleyerek gen ifadesini transkripsiyon sonrası düzenler (Chen, 2019). siRNA'lar DNA metilasyonuna ve histon modifikasyonlarına rehberlik ederek bitkilerde transkripsiyonel gen susturmaya katkıda bulunur (Zhang ve ark., 2021). miRNA'lar yaprak morfogenezi ve kök yapısı gibi gelişimsel süreçlerin düzenlenmesinde önemli roller oynar (Ali ve Tang, 2024). Arabidopsis thaliana'da miRNA aracılı yollar, fotoperiyodik değişikliklere yanıt olarak çiçeklenme süresini modüle eder (Spanudakis ve Jackson, 2003).

siRNA'ların kuraklığa duyarlı gen susturmaya aracılık ettiği pirinçte (Oryza sativa) görüldüğü gibi, ncRNA'lar stres tepkileri için gereklidir (Kumar ve ark., 2023).

BİTKİ BÜYÜME DÜZENLEYİCİLERİ (HORMONLAR)

Bitki büyüme düzenleyicileri, bitkilerde büyüme, gelişme ve stres tepkilerini düzenleyen kimyasal düzenleyicilerdir (Davies, 2013). BBD'lerin temel sınıflandırılması şunları içerir:

Oksinler

Oksinler ağırlıklı olarak sürgün tepesinde ve genç yapraklarda sentezlenir ve burada hücre uzamasını ve farklılaşmasını düzenler (Woodward ve Bartel, 2005). Polar oksin taşıma mekanizmaları aracılığıyla bazipetal olarak (sürgün ucundan köke) taşınarak uygun organ gelişimini ve simetriyi sağlarlar (Petrášek ve Friml, 2009). Oksinler, ana gövdenin yan tomurcukların büyümesini bastırdığı ve ışık yakalama için bitki yapısını optimize ettiği apikal baskınlıkta çok önemli bir rol oynar (Cline, 1997). Ayrıca, su ve besin alımı için kritik olan yanal ve adventif köklerin oluşumunu teşvik ederek kök gelişimini düzenlerler (Overvoorde ve ark., 2010). Ekonomik olarak, oksinler meyve tutumu ve tohum oluşumunu geliştirerek bir bitkinin değerine katkıda bulunur ve bu da onları domates ve biber gibi ürünler için vazgeçilmez kılar (Mockaitis ve Estelle, 2008).

Gibberellinler

Gibberellinler (GA'lar) öncelikle olgunlaşmamış tohumlar, genç yapraklar ve sürgün uçları gibi genç dokularda sentezlenir (Hedden ve Thomas, 2012). Bu hormonlar tohum dormansisini kırmak ve endospermdeki depolanmış besinleri harekete geçirerek çimlenmeyi teşvik etmek için çok önemlidir (Davies, 2013). GA'lar, hücre bölünmesini ve boğum aralarındaki uzamayı uyararak gövde uzamasını düzenler ve bitki boyunun artmasına katkıda bulunur (Hedden ve Sponsel, 2015). Üreme gelişiminde, gibberellinler uzun gün bitkilerinde çiçeklenmeyi indükler ve partenokarpik meyvelerde tohum içeriğini azaltarak meyve kalitesini artırır (King ve Evans, 2003).

Sitokininler

Sitokininler öncelikle kök uçlarında sentezlenir ve sürgün büyümesini ve gelişimini etkiledikleri sürgünlere taşınır (Mok ve Mok, 2001). Bu hormonlar meristematik dokularda hücre bölünmesini (sitokinez) teşvik ederek sürekli büyüme ve rejenerasyon sağlar (Sakakibara, 2006). Sitokininler, besinlerin meyve ve tohum gibi gelişmekte olan organlara yeniden dağıtılmasını teşvik ederek besin remobilizasyonunda da rol oynarlar (Kudo ve ark., 2010).

Absisik Asit (ABA)

Absisik asit (ABA) ağırlıklı olarak kuraklık, tuzluluk ve soğuk gibi stres koşulları altında olgun yapraklarda, gövdelerde ve köklerde sentezlenir (Cutler ve ark., 2010). Stomatal kapanmayı düzenleyerek önemli bir stres hormonu olarak işlev görür ve böylece kuraklık sırasında su kaybını azaltır (Davies, 2013). ABA ayrıca tohum dormansisi ve çimlenme inhibisyonunda hayati bir rol oynar ve tohumların yalnızca uygun koşullar altında çimlenmesini sağlar (Finkelstein ve ark., 2008)

Etilen

Etilen, bitkinin hemen hemen tüm kısımlarında, özellikle olgunlaşan meyvelerde, yaşlanan yapraklarda ve stresli dokularda sentezlenen gaz halinde bir hormondur (Davies, 2013). Hücre duvarı yumuşaması, şeker birikimi ve pigment oluşumundan sorumlu genlerin ekspresyonunu indükleyerek meyve olgunlaşmasını düzenler (Jiang ve ark., 2024). Olgunlaşmaya ek olarak, etilen yaprak absisyonunu, çiçek senesensini ve biyotik ve abiyotik faktörlere karşı stres tepkilerini kontrol eder. 1-MCP (1-metilsiklopropen) gibi etilen inhibitörlerinin uygulanması, muz ve elma gibi klimakterik meyvelerde olgunlaşmayı geciktirerek raf ömürlerini uzatır (Barry ve ark., 2007).

EPİGENETİK VE BİTKİ BÜYÜME DÜZENLEYİCİLERİ ARASINDAKİ İLİŞKİ

Epigenetik mekanizmalar ve bitki büyüme düzenleyicileri (BBD'ler) arasındaki etkileşim, bitkinin çevresel koşullara adaptasyonunda önemli bir rol oynar. BBD'ler gen ifadesini modüle ederek büyüme ve gelişmeyi düzenlerken, epigenetik mekanizmalar bu genlerin aktive edilip edilmediğini veya susturulup susturulmadığını belirler (Abdulraheem ve ark., 2024). Örneğin, hormonlar DNA metilasyonunu, histon modifikasyonlarını ve kodlamayan RNA'ları etkileyebilir, böylece çevresel uyaranlara gen tepkilerini şekillendirebilir (Rudolf ve ark., 2024). Tersine, epigenetik değişiklikler BBD'lerin biyosentezini ve sinyal yollarını etkileyerek bitkinin hem iç hem de dış ipuçlarına verdiği tepkileri optimize eden dinamik bir geri bildirim döngüsü oluşturabilir (Kaya ve ark., 2024).

Oksinler

Oksinler, köke özgü genlerdeki DNA metilasyon modellerini değiştirerek epigenetik mekanizmaları düzenler ve stres koşulları altında kök gelişimini artırır. Oksin tarafından indüklenen histon asetilasyonu, hücre uzamasından sorumlu genlerin ekspresyonunu teşvik ederek optimum bitki büyümesini sağlar (Poulios ve ark., 2022; Yin ve ark., 2024). Arabidopsis thaliana'da, oksinlerin yan kök oluşumunu modüle etmek için küçük RNA'lar ile etkileşime girdiği bulunmuştur (Marin ve ark., 2010). Oksin sinyali, kuraklığa toleranslı mısırda kromatin yeniden şekillenmesiyle bağlantılıdır ve adaptif gen ifadesini kolaylaştırır (Liu ve ark., 2024). Son çalışmalar, epigenetik susturma yoluyla transposable element aktivitesini azaltmada ve genomik stabiliteyi sağlamada oksinin rolünü vurgulamaktadır (Ali ve Tang., 2024).

Gibberellinler

Gibberellinler (GA), çiçeklenme sürecini histon modifikasyonları aracılığıyla düzenler. Özellikle, GA sinyal yolakları, DELLA proteinleri gibi büyümeyi baskılayan faktörlerin yıkımını teşvik ederek, histon asetilasyonunu artırır ve çiçeklenmeyi başlatan genlerin ekspresyonunu destekler. Bu mekanizma, bitkilerin çevresel koşullara uygun zamanlamayla çiçeklenmesini sağlar (Balouri ve ark., 2024). GA'lar, tohum çimlenmesinde de histon asetilasyon seviyelerini artırarak, çimlenmeyi destekleyen genlerin aktivasyonunu sağlar. Özellikle, mısır aleuron tabakasında yapılan bir çalışmada, GA uygulamasının histon H3 ve H4'ün asetilasyon seviyelerini yükselttiği ve bunun da çimlenme sürecini hızlandırdığı gösterilmiştir. Bu süreçte, histon asetiltransferazların (HAT'lar) ve histon deasetilazların (HDAC'lar) ekspresyonu artmakta ve bu enzimlerin dengeli etkileşimi, genlerin uygun şekilde ifade edilmesini sağlamaktadır (Hou ve ark., 2015).

Sitokininler

sRNA'lar (küçük RNA'lar) sitokinin biyosentez genlerini baskılayarak sitokinin seviyelerini azaltır ve yaşlanmayı teşvik ederler (Zhang ve ark., 2020). SWI/SNF kromatin düzenleyici kompleksleri gibi proteinler, sitokinin biyosentez genlerinin (örneğin, IPT3 ve IPT7) transkripsiyonunu düzenler. Bu düzenleyiciler kromatin konformasyonunu değiştirerek gen ekspresyonunu etkiler (Jégu., 2015). Polycomb Repressive Complex 2 (PRC2), CKX2 (sitokinin oksidaz) gibi genlerin promotör bölgelerine H3K27me3 modifikasyonu yerleştirerek gen ekspresyonunu baskılar (Li ve ark., 2013). Örneğin, pirinçte PRC2'nin bir bileşeni olan OsVIL2, OsCKX2 geninin ekspresyonunu baskılayarak sitokinin seviyelerini artırır ve bu da biyokütle ve verim artışı sağlar (Wu ve ark., 2022). Sitokinin yanıt düzenleyicileri (ARR1, ARR10 ve ARR12 gibi), sitokinin yanıt genlerinin kromatin erişilebilirliğini hızlı bir şekilde değiştirir. Özellikle sitokinin/açılımsız kallus doku gelişimi sırasında kromatin yapı değişiklikleri gözlemlenmiştir. Bu süreçte gen ekspresyonu ve pluripotensi (hücrelerin farklılaşma yeteneği) korunur veya indüklenir (Potter ve ar., 2018; Wu ve ark., 2022). Sitokininler, pluripotensiyi teşvik eden histon modifikasyonlarını (örneğin H3K27me3'ün kaldırılması ve histon asetilasyonu) etkiler. Kimyasal histon asetilasyon inhibitörleri, kallus oluşumunu engellerken histon deasetilasyon inhibitörleri, sitokininlerin yerini kısmen alarak kallus büyümesini destekler. (Furuta ve ark., 2011; Zhang ve ark., 2017;

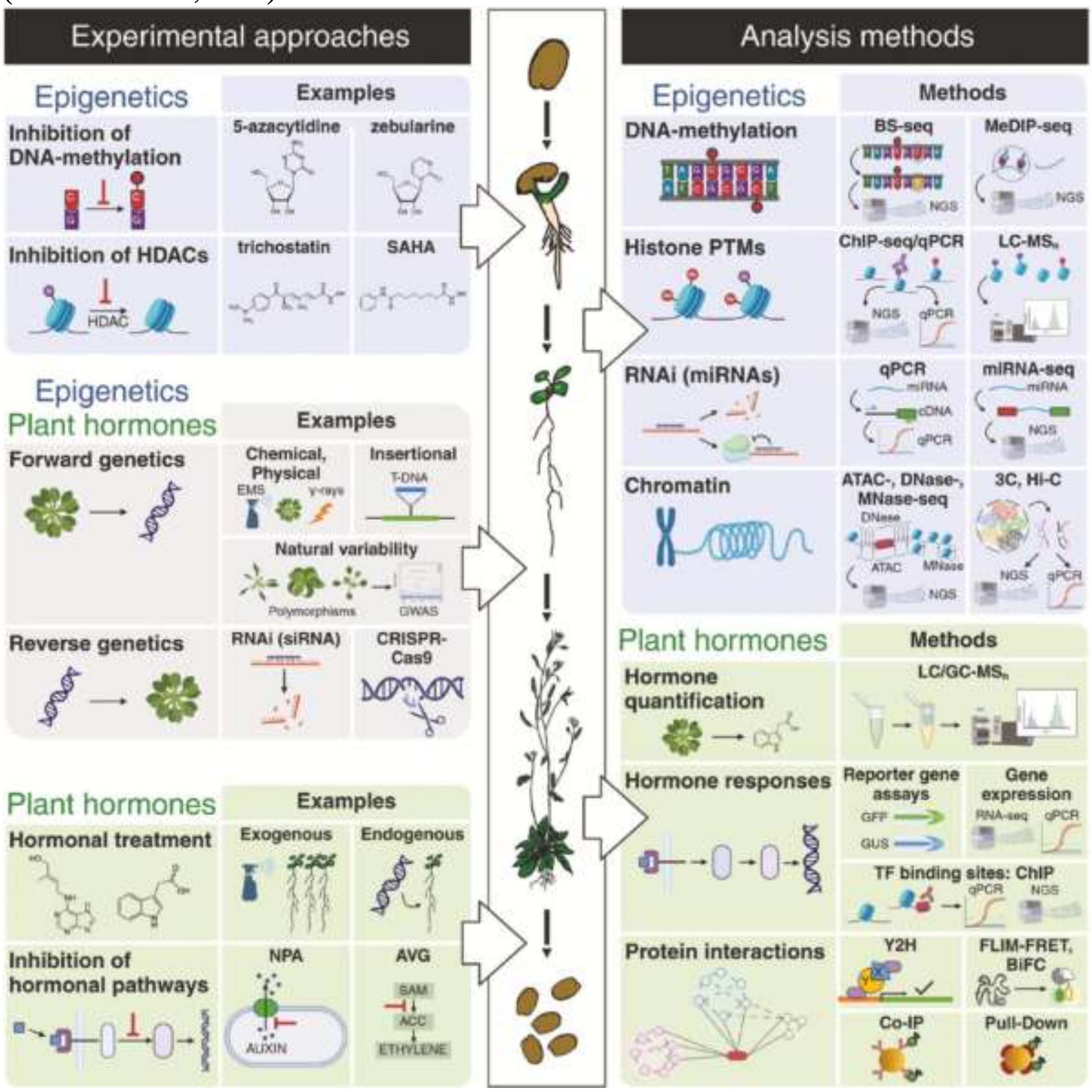
Rymen ve ark., 2019). miRNA ve siRNA'lar, sitokinin biyosentez ve degradasyon genlerini düzenleyerek epigenetik kontrol sağlar (Zhang ve ark. 2020) Örneğin, gülde miRNA159, CKX6 genini hedef alır ve sitokinin seviyelerini düzenler (Jing ve ark., 2023).

Absisik Asit (ABA)

ABA, kuraklığa duyarlı genlerde DNA metilasyonunu indükleyerek stres toleransını artıran epigenetik bir "hafıza" oluşturur (Cutler ve ark., 2010). ABA'nın aracılık ettiği histon deasetilasyonu, kuraklık koşulları sırasında büyümeyle ilgili genleri baskılayarak kaynakları korur (Han ve ark., 2021). Mısırda ABA, kök yapısı genlerinin epigenetik düzenlemesiyle bağlantılıdır ve su alım verimliliğini artırır (Vendramin ve ark., 2020). ABA, olumsuz koşullar altında stresle ilgili genleri susturmak için kodlamayan RNA yollarını, özellikle de siRNA'ları etkiler (Contreras-Cubas ve ark., 2012).

Etilen

Etilen, histon asetilasyonunu modüle ederek meyve olgunlaşması ve yaşlanmadan sorumlu genleri aktive eder (Wang ve ark., 2017). Domateste (Solanum lycopersicum) etilen, olgunlaşmaya özgü genleri düzenlemek için DNA metilasyon yollarıyla etkileşime girer (Chen and Duan, 2023).



Şekil 1. Epigenetik-bitki büyüme düzenleyicilerinin arasındaki ilişkiyi anlamak için oluşturulan şema (Rudolf, 2024)

SONUÇ

Bitki büyüme düzenleyicileri ve epigenetik mekanizmalar arasındaki karmaşık etkileşim, bitki gelişimi, stres adaptasyonu ve üretkenlikteki önemli rollerini vurgulamaktadır. Bu etkileşimler, bitkilerin büyüme ve üremeyi sürdürürken çevresel zorluklara dinamik olarak yanıt vermesini sağlar. Bu sistemlerin birleşik etkisi, bitkilerin gen düzenlemesinde böylesine dikkate değer bir esnekliğe nasıl ulaştığını anlamak için sağlam bir çerçeve sağlar. Gelecekteki araştırmalar, çeşitli bitki türlerinde bitki büyüme düzenleyicilerini epigenetik süreçlere bağlayan moleküler yolları keşfetmeye odaklanmalıdır. Bu bilginin, özellikle abiyotik ve biyotik streslere karşı daha dirençli çeşitlerin geliştirilmesinde, ürün iyileştirme programlarına uygulanmasına önem verilmelidir. Ayrıca, epigenom düzenleme ve hormon bazlı tedaviler gibi gelişmiş araçların entegre edilmesi, sürdürülebilir tarım uygulamalarının oluşturulması için umut vaat etmektedir. Bu içgörülerden yararlanarak, iklim değişikliğinin küresel gıda güvenliği üzerindeki etkilerini hafifletirken ürün verimini ve kalitesini artırmak mümkün olacaktır.

KAYNAKÇA

Abdulraheem, M. I., Xiong, Y., Moshood, A. Y., Cadenas-Pliego, G., Zhang, H. ve Hu, J. (2024). Mechanisms of plant epigenetic regulation in response to plant stress: Recent discoveries and implications. Plants, 13(2), 163.

Agarwal, G., Kudapa, H., Ramalingam, A., Choudhary, D., Sinha, P., Garg, V., ... ve Varshney, R. K. (2020). Epigenetics and epigenomics: underlying mechanisms, relevance, and implications in crop improvement. Functional & Integrative Genomics, 20, 739-761.

Ali, S., ve Tang, Y. (2024). Noncoding RNA-Mediated Regulation of DNA Methylation: Insights into Plant Epigenetic Mechanisms. Journal of Plant Growth Regulation, 1-16.

Balouri, C., Poulios, S., Tsompani, D., Spyropoulou, Z., Ketikoglou, M. C., Kaldis, A., ... ve Vlachonasios, K. E. (2024). Gibberellin Signaling through RGA Suppresses GCN5 Effects on Arabidopsis Developmental Stages. International Journal of Molecular Sciences, 25(12), 6757.

Bartels, A., Han, Q., Nair, P., Stacey, L., Gaynier, H., Mosley, M., ... ve Xiao, W. (2018). Dynamic DNA methylation in plant growth and development. International journal of molecular sciences, 19(7), 2144.

Barry, C. S. ve Giovannoni, J. J. (2007). Ethylene and fruit ripening. Journal of Plant Growth Regulation, 26, 143-159.

Bird, A. (2007). Perceptions of epigenetics. Nature, 447(7143), 396–398. https://doi.org/10.1038/nature05913

Cao, Y., Yan, H., Sheng, M., Liu, Y., Yu, X., Li, Z., ... ve Su, Z. (2024). KAKU4 regulates leaf senescence through modulation of H3K27me3 deposition in the Arabidopsis genome. BMC Plant Biology, 24(1), 177.

Chen, T. ve Duan, W. (2023). DNA methylation changes were involved in inhibiting ethylene signaling and delaying senescence of tomato fruit under low temperature. Biologia, 78(2), 415-427.

Chen, X. (2019). Small RNAs and their roles in plant development. Annual Review of Cell and Developmental Biology, 35, 21–44. https://doi.org/10.1146/annurev-cellbio-100618-102701

Cline, M. G. (1997). Concepts and terminology of apical dominance. American journal of botany, 84(8), 1064-1069.

Contreras-Cubas, C., Palomar, M., Arteaga-Vázquez, M., Reyes, J. L. ve Covarrubias, A. A. (2012). Non-coding RNAs in the plant response to abiotic stress. Planta, 236, 943-958.

Cutler, S. R., Rodriguez, P. L., Finkelstein, R. R. ve Abrams, S. R. (2010). Abscisic acid: Emergence of a core signaling network. Annual Review of Plant Biology, 61, 651–679. https://doi.org/10.1146/annurev-arplant-042809-112122

Davies, P. J. (Ed.) (2013). Plant hormones: physiology, biochemistry and molecular biology. Springer Science ve Business Media. 844 page.

Finkelstein, R., Reeves, W., Ariizumi, T. ve Steber, C. (2008). Molecular aspects of seed dormancy. Annu. Rev. Plant Biol., 59(1), 387-415.

Furuta K, Kubo M, Sano K, Demura T, Fukuda H, Liu Y-G, Shibata D, Kakimoto T. 2011. The CKH2/PKL chromatin remodeling factor negatively regulates cytokinin responses in Arabidopsis calli. Plant and Cell Physiology 52, 618–628.

Gagnidze, K. ve Pfaff, D. W. (2022). Epigenetic mechanisms: DNA methylation and histone protein modification. In Neuroscience in the 21st Century: From Basic to Clinical (pp. 2677-2716).

Han, Y., Haouel, A., Georgii, E., Priego-Cubero, S., Wurm, C. J., Hemmler, D., ... ve Lindermayr, C. (2023). Histone Deacetylases HD2A and HD2B Undergo Feedback Regulation by ABA and Modulate Drought Tolerance via Mediating ABA-Induced Transcriptional Repression. Genes, 14(6), 1199.

Hassan, A. H., Mokhtar, M. M. ve El Allali, A. (2024). Transposable elements: multifunctional players in the plant genome. Frontiers in Plant Science, 14, 1330127.

He, Y., Michaels, S. D., Amasino, R.M., (2003). Regulation of flowering time by histone acetylation in Arabidopsis. Science, 5;302(5651):1751-4. doi: 10.1126/science.1091109.

Hedden, P., ve Sponsel, V. (2015). A century of gibberellin research. Journal of Plant Growth Regulation, 34(4), 740–760. https://doi.org/10.1007/s00344-015-9546-1

Hedden, P. ve Thomas, S. G. (2012). Gibberellin biosynthesis and its regulation. Biochemical Journal, 444(1), 11-25.

Hou, H., Wang, P., Zhang, H., Wen, H., Gao, F., Ma, N., ... ve Li, L. (2015). Histone acetylation is involved in gibberellin-regulated sodCp gene expression in maize aleurone layers. Plant and Cell Physiology, 56(11), 2139-2149.

Jégu T, Domenichini S, Blein T., ve ark. 2015. A SWI/SNF chromatin remodelling protein controls cytokinin production through the regulation of chromatin architecture. PLoS One 10, e0138276.

Jiang, F., Xu, M., Zhang, H., Liu, M., Zhao, L., ve Du, G. (2024). Ethylene promotes fruit softening of ‘Nanguo’pear via cell wall degradation. Journal of Plant Growth Regulation, 1-12.

Jing W, Gong F, Liu G ve ark. (2023). Petal size is controlled by the MYB73/ TPL/HDA19–miR159–CKX6 module regulating cytokinin catabolism in Rosa hybrida. Nature Communications, 14, 7106.

Kaya, C., Uğurlar, F. ve Adamakis, I. D. S. (2024). Epigenetic Modifications of Hormonal Signaling Pathways in Plant Drought Response and Tolerance for Sustainable Food Security. International Journal of Molecular Sciences, 25(15), 8229.

King, R. W. ve Evans, L. T. (2003). Gibberellins and flowering of grasses and cereals: prizing open the lid of the “florigen” black box. Annual Review of Plant Biology, 54(1), 307-328.

Kou, S., Gu, Q., Duan, L., Liu, G., Yuan, P., Li, H., ... ve Liu, L. (2022). Genome-wide bisulphite sequencing uncovered the contribution of DNA methylation to rice short-term drought memory formation. Journal of Plant Growth Regulation, 41(7), 2903-2917.

Kudo, T., Kiba, T. ve Sakakibara, H. (2010). Metabolism and long-distance translocation of cytokinins. Journal of integrative plant biology, 52(1), 53-60.

Kumar, S., Seem, K., ve Mohapatra, T. (2023). Biochemical and epigenetic modulations under drought: remembering the stress tolerance mechanism in rice. Life, 13(5), 1156.

Law, J. A., ve Jacobsen, S. E. (2010). Establishing, maintaining and modifying DNA methylation patterns in plants and animals. Nature Reviews Genetics, 11(3), 204–220. https://doi.org/10.1038/nrg2719

Li, J., Nie, X., Tan, J. L. H. ve Berger, F. (2013). Integration of epigenetic and genetic controls of seed size by cytokinin in Arabidopsis. Proceedings of the National Academy of Sciences, 110(38), 15479-15484.

Liu, L., Gong, Y., Yahaya, B. S., Chen, Y., Shi, D., Liu, F., ... ve Wu, F. (2024). Maize auxin response factor ZmARF1 confers multiple abiotic stresses resistances in transgenic Arabidopsis. Plant Molecular Biology, 114(4), 75.

Mager, S. ve Ludewig, U. (2018). Massive loss of DNA methylation in nitrogen-, but not in phosphorus-deficient Zea mays roots is poorly correlated with gene expression differences. Frontiers in plant science, 9, 497.

Marin, E., Jouannet, V., Herz, A., Lokerse, A. S., Weijers, D., Vaucheret, H., ... ve Maizel, A. (2010). miR390, Arabidopsis TAS3 tasiRNAs, and their AUXIN RESPONSE FACTOR targets define an autoregulatory network quantitatively regulating lateral root growth. The Plant Cell, 22(4), 1104-1117.

Mockaitis, K. ve Estelle, M. (2008). Auxin receptors and plant development: a new signaling paradigm. Annual review of cell and developmental biology, 24(1), 55-80.

Mok, D. W. S. ve Mok, M. C. (2001). Cytokinin metabolism and action. Annual Review of Plant Biology, 52(1), 89–118. https://doi.org/10.1146/annurev.arplant.52.1.89

Overvoorde, P., Fukaki, H. ve Beeckman, T. (2010). Auxin control of root development. Cold Spring Harbor perspectives in biology, 2(6), a001537.

Petrášek, J. ve Friml, J. (2009). Auxin transport routes in plant development.

Potter, K. C., Wang, J., Schaller, G. E., Kieber, J. J. 2018. Cytokinin modulates context-dependent chromatin accessibility through the type-B response regulators. Nature Plants, 4, 1102–1111.

Poulios, S., Tsilimigka, F., Mallioura, A., Pappas, D., Seira, E., ve Vlachonasios, K. (2022). Histone acetyltransferase GCN5 affects auxin transport during root growth by modulating histone acetylation and gene expression of PINs. Plants, 11(24), 3572.

Rymen B, Kawamura A, Lambolez A ve ark. (2019). Histone acetylation orchestrates wound-induced transcriptional activation and cellular repro- gramming in Arabidopsis. Communications Biology, 2, 404.

Rudolf, J., Tomovicova, L., Panzarova, K., Fajkus, J., Hejatko, J. ve Skalak, J. (2024). Epigenetics and plant hormone dynamics: a functional and methodological perspective. Journal of Experimental Botany, erae054.

Sakakibara, H. (2006). Cytokinins: activity, biosynthesis, and translocation. Annu. Rev. Plant Biol., 57(1), 431-449.

Skinner, M. K. (2023). Environmental epigenetics and climate change. Environmental Epigenetics, 9 (1), dvac028, https://doi.org/10.1093/eep/dvac028

Skinner, M. K. ve Nilsson, E. E. (2021). Role of environmentally induced epigenetic transgenerational inheritance in evolutionary biology: Unified Evolution Theory. Environmental Epigenetics, 7(1), dvab012, https://doi.org/10.1093/eep/dvab012

Spanudakis, E. ve Jackson, S. (2014). The role of microRNAs in the control of flowering time. Journal of Experimental Botany, 65(2), 365-380.

Sun, Y., Xie, Z., Jin, L., Qin, T., Zhan, C. ve Huang, J. (2024). Histone deacetylase OsHDA716 represses rice chilling tolerance by deacetylating OsbZIP46 to reduce its transactivation function and protein stability. The Plant Cell, 36(5), 1913-1936.

Wang, L., Zhang, F., Rode, S., Chin, K. K., Ko, E. E., Kim, J., ... ve Qiao, H. (2017). Ethylene induces combinatorial effects of histone H3 acetylation in gene expression in Arabidopsis. BMC genomics, 18, 1-13.

Wang, X., Gao, J., Gao, S., Song, Y., Yang, Z. ve Kuai, B. (2019). The H3K27me3 demethylase REF6 promotes leaf senescence through directly activating major senescence regulatory and functional genes in Arabidopsis. PLoS Genetics, 15(4), e1008068.
Woodward, A. W. ve Bartel, B. (2005). Auxin: regulation, action, and interaction. Annals of botany, 95(5), 707-735.
Wu, L.Y., Shang, G. D., Wang, F. X., Gao, J., Wan, M. C., Xu, Z. G., Wang, J. W. (2022). Dynamic chromatin state profiling reveals regulatory roles of auxin and cytokinin in shoot regeneration. Developmental Cell, 57, 526–542.
Vendramin, S., Huang, J., Crisp, P. A., Madzima, T. F. ve McGinnis, K. M. (2020). Epigenetic regulation of ABA-induced transcriptional responses in maize. G3: Genes, Genomes, Genetics, 10(5), 1727-1743.
Yang, L., Lang, C., Wu, Y., Meng, D., Yang, T., Li, D., ... ve Zhou, X. (2022). ROS1-mediated decrease in DNA methylation and increase in expression of defense genes and stress response genes in Arabidopsis thaliana due to abiotic stresses. BMC Plant Biology, 22(1), 104.
Yin, M., Wang, S., Wang, Y., Wei, R., Liang, Y., Zuo, L., ... ve Wang, W. (2024). Impact of Abiotic Stress on Rice and the Role of DNA Methylation in Stress Response Mechanisms. Plants, 13(19), 2700.
Yu, C. W., Liu, X., Luo, M., Chen, C., Lin, X., Tian, G., ... ve Wu, K. (2011). HISTONE DEACETYLASE6 interacts with FLOWERING LOCUS D and regulates flowering in Arabidopsis. Plant Physiology, 156(1), 173-184.
Zhang F, Wang L, Qi B, Zhao B, Ko EE, Riggan ND, Chin K, Qiao H. (2017). EIN2 mediates direct regulation of histone acetylation in the ethylene response. Proceedings of the National Academy of Sciences, USA 114, 10274–10279.
Zhang, H., Lang, Z. ve Zhu, J. K. (2021). Dynamics and function of DNA methylation in plants. Nature Reviews Molecular Cell Biology, 22(9), 677–693. https://doi.org/10.1038/s41580-021-00358-0
Zhang Y, Yin S, Tu Y, Mei H, Yang Y. (2020). A novel microRNA, SlymiR208, promotes leaf senescence via regulating cytokinin biosynthesis in tomato. Physiologia Plantarum ,169, 143–155.
Zhao, J., Zhang, W., da Silva, J. A. T., Liu, X. ve Duan, J. (2021). Rice histone deacetylase HDA704 positively regulates drought and salt tolerance by controlling stomatal aperture and density. Planta, 254, 1-15.

MICROPLASTIC CONTAMINATION AND SOIL HEALTH

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ABSTRACT
Microplastics, defined as plastic particles smaller than 5 millimeters, have emerged as apervasive environmental pollutant, with significant implications for soil ecosystems. Research shows that microplastics can disrupt soil microbial communities, which play a vital role in nutrient cycling and organic matter decomposition. They enter terrestrial ecosystems through agricultural inputs, sewage sludge, industrial emissions, and atmospheric deposition. Once in the soil, microplastics alter physical properties, such as porosity and water retention, disrupt chemical processes by binding harmful pollutants, and affect biological functions by interfering with microbial diversity and activity. The effects of microplastics on soil ecosystems are further complicated by their interactions with other pollutants. Microplastics can absorb harmful pollutants, delaying their degradation and exacerbating their effects on soil health. Studies have shown that microplastics can increase the toxicity of coexisting contaminants such as heavy metals and organic pollutants, thus posing additional risks to soil health and food safety. Microplastics can interfere with interactions between soil microbes and plants, affecting nutrient availability and overall plant health The interaction of microplastics with soil components can negatively impact various soil properties such as pH, porosity, and water retention capacity, which are vital for maintaining soil health and supporting plant growth. Addressing microplastic pollution in soils requires comprehensive strategies, including reducing plastic use in agriculture, improving waste management systems, and developing bioremediation technologies.

Key Words: Soil health, microplastic, accumulation, soil properties

INTRODUCTION
Microplastics, tiny plastic fragments less than 5 millimeters in size, have garnered attention primarily for their impact on marine ecosystems (Duis and Coors, 2016). However, their presence in terrestrial environments poses a less visible yet equally significant challenge (Figure 1). As global plastic production continues to rise, understanding the implications of microplastics on soil health is critical.

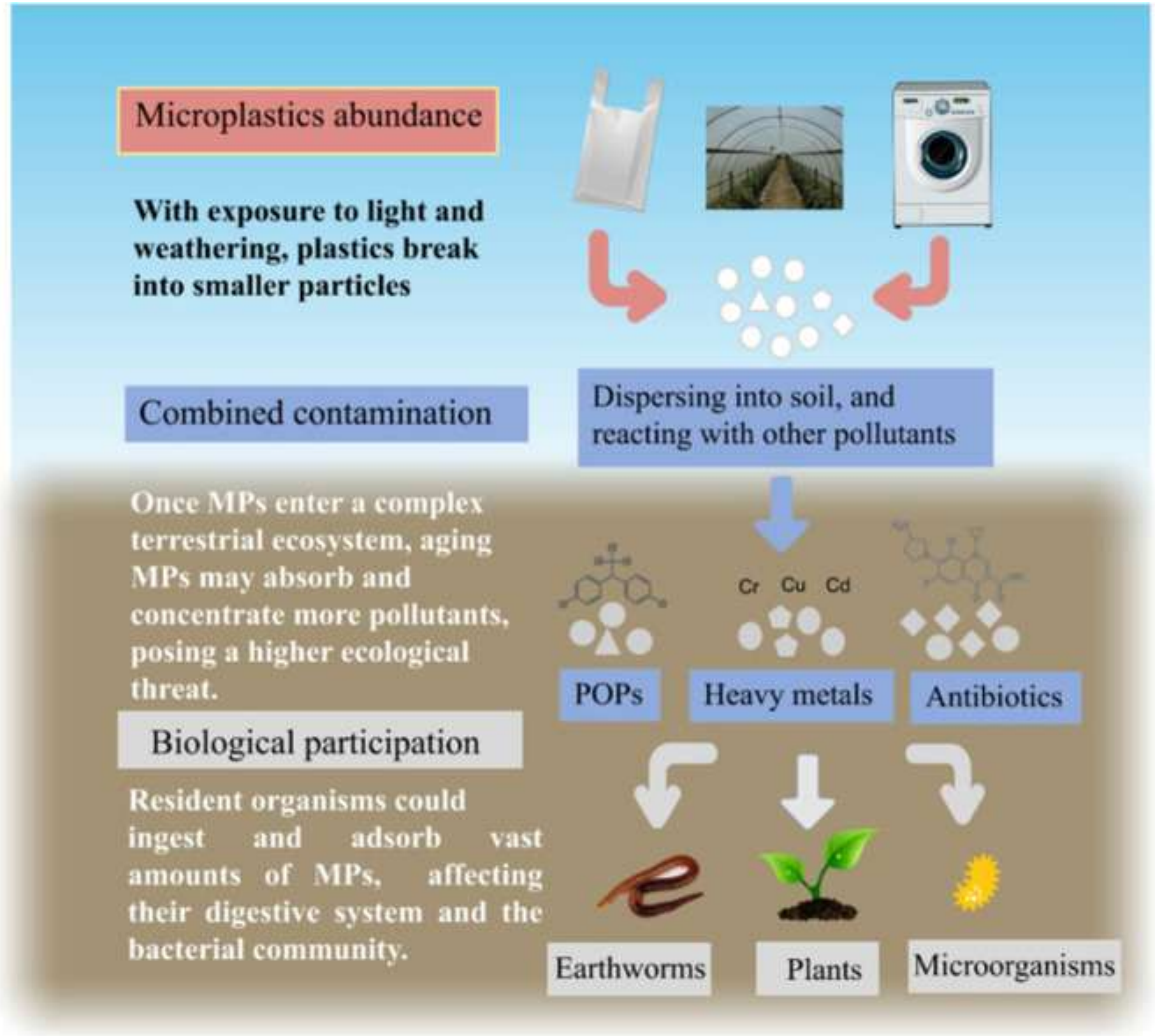

Figure 1. MPs as contaminants in the soil system (Wang et al. 2019)

Research shows that microplastics can disrupt soil microbial communities, which play a vital role in nutrient cycling and organic matter decomposition. They enter terrestrial ecosystems through agricultural inputs, sewage sludge, industrial emissions, and atmospheric deposition. Once in the soil, microplastics alter physical properties, such as porosity and water retention, disrupt chemical processes by binding harmful pollutants, and affect biological functions by interfering with microbial diversity and activity (Yu et al., 2024). The effects of microplastics on soil ecosystems are further complicated by their interactions with other pollutants. Microplastics can adsorb harmful pollutants, delaying their degradation and exacerbating their effects on soil health. Studies have shown that microplastics can increase the toxicity of coexisting contaminants such as heavy metals and organic pollutants, thus posing additional risks to soil health and food safety. Microplastics can interfere with interactions between soil microbes and plants, affecting nutrient availability and overall plant health The interaction of microplastics with soil components can negatively impact various soil properties such as pH, porosity, and water retention capacity, which are vital for maintaining soil health and supporting plant growth. Addressing microplastic pollution in soils requires comprehensive strategies, including reducing plastic use in agriculture, improving waste management systems, and developing bioremediation technologies.

Sources of Microplastics in Soil

The concentration of microplastics in soils can vary about to eight orders of magnitude, and agricultural soils reflect the greatest range of variation compared to different soil management or freshwater systems (Koutnik et al., 2021). Even though in Europe only 4 % of the produced plastic materials in 2022 were used in 'agriculture, farming and gardening' (Plastics Europe, 2023), agricultural practices seem to be the key input pathway of plastics into soils (Blasing and Amelung, 2018; Lechthaler et al., 2020; Piehl et al., 2018). These agricultural sources include fertilizing with compost or sewage sludge, plastic mulching and irrigation (Hurley and Nizzetto, 2018).

Microplastics find their way into soils through various pathways (Figure 2)

1. Agricultural Inputs: Plastics in fertilizers, mulch films, and irrigation systems often degrade into microplastics.

Since the middle of the 1950s plastic polymers, such as polyethylene or polypropylene, have been widely used in agriculture for greenhouses, high and low tunnels, plastic mulches, fruit bagging, wind breaks, seed coatings, fertilizer and seed bags, containers for growing plants, and irrigation and drainage tubing and fittings (Kirkham et al., 2020). They have allowed farmers to increase crop production. Much of the plastic is used for plastic mulches, which are made out of polyethylene film (Yu et al., 2024).

2. Sewage Sludge: Treated sludge from wastewater plants, commonly used as fertilizer, is a significant source of microplastic contamination.

3. Industrial Emissions: Plastic waste from industries can leach into surrounding soils.

4. Atmospheric Deposition: Wind and rain transport microplastics from urban areas to agricultural fields.

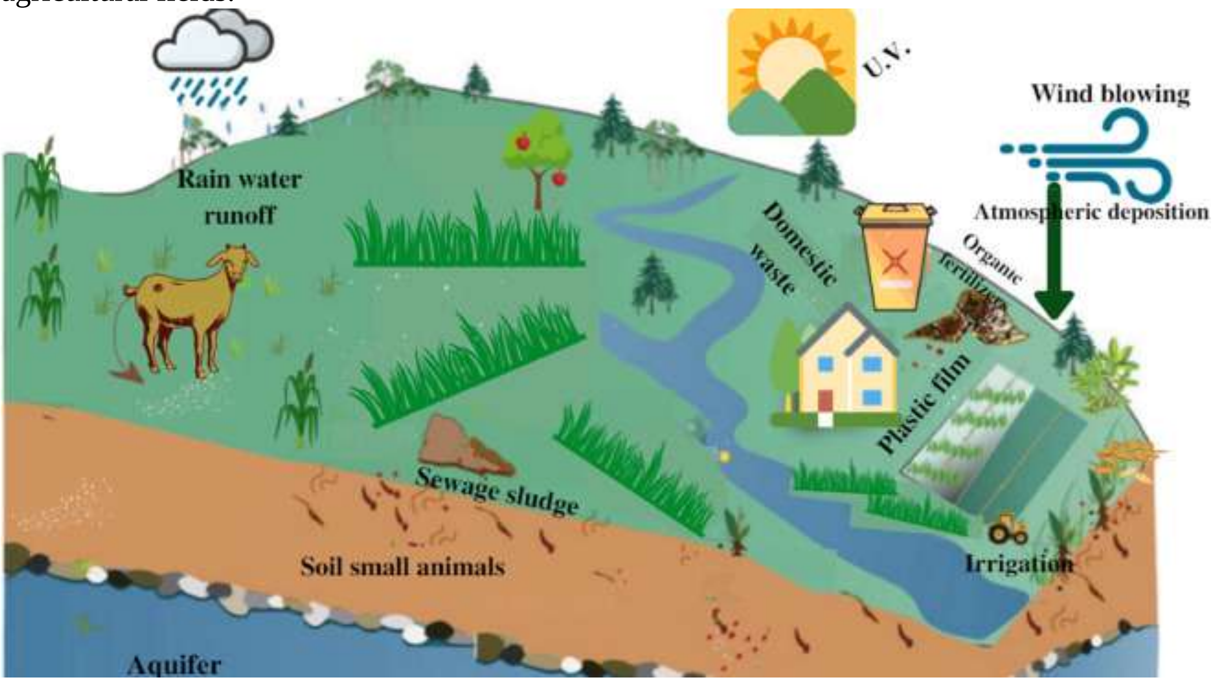

Figure 2. MPs mobility influencing factors in soil agro-ecosystems (Uwamungu et al. 2022)

Impacts on Soil Health

Once plastics have entered the soil systems, soils act as temporary sink (Blasing and Amelung, 2018). However especially erosion processes can overcome retention. Consequently, soil becomes a source when plastic particles are transported via fluvial or aeolian processes (Weber et al., 2021; Weber and Bigalke, 2022). In general, it is known that microplastics are mobile within the soil systems (Nizzetto et al., 2016; Zhang et al., 2022b; Liu et al., 2018; Weber and Opp, 2020). Microplastics in soil can affect its physical, chemical, and biological properties, with consequences for ecosystem function and agricultural productivity. Previous studies indicated that microplastics in the soil can affect plants to varying degrees. The toxicity and adsorption capacity of microplastics can directly damage and clog plant roots, disrupt the normal function of plant organs, and indirectly affect plant growth by altering the soil physical and chemical properties and structure (Machado et al., 2019; Huang et al., 2022; Zhang et al., 2022b).

Microplastics in soil can affect its physical, chemical, and biological properties, with consequences for ecosystem function and agricultural productivity (Figure3).

1. Soil Structure and Water Retention

I. Microplastics alter soil porosity, disrupting water infiltration and retention.

II. This affects plant root systems and overall soil stability.

III. Fibrous plastics can bind soil particles, potentially causing compaction and reducing aeration.

2. Nutrient Cycling

I. Microplastics can absorb harmful pollutants like heavy metals and pesticides, concentrating toxins in the soil.

II. These contaminants disrupt nutrient availability and microbial processes vital for plant growth.

3. Impact on Soil Microorganisms

I. Soil microbiota, crucial for decomposition and nutrient cycling, may ingest microplastics, leading to physical blockages or toxic effects.

II. Changes in microbial diversity can ripple through the food web, impairing soil health and plant resilience.

4. Plant Growth and Productivity

I. Studies suggest microplastics can interfere with root development and nutrient uptake, reducing crop yields.

II. They may also influence the uptake of toxins by plants, raising concerns for food safety. Particulate plastics can be a vector for toxic trace-element uptake. If particulate plastics are in soil contaminated with Cd, the Cd will be more readily taken up than if the particulate plastics are not present. (Bradney et al., 2019).

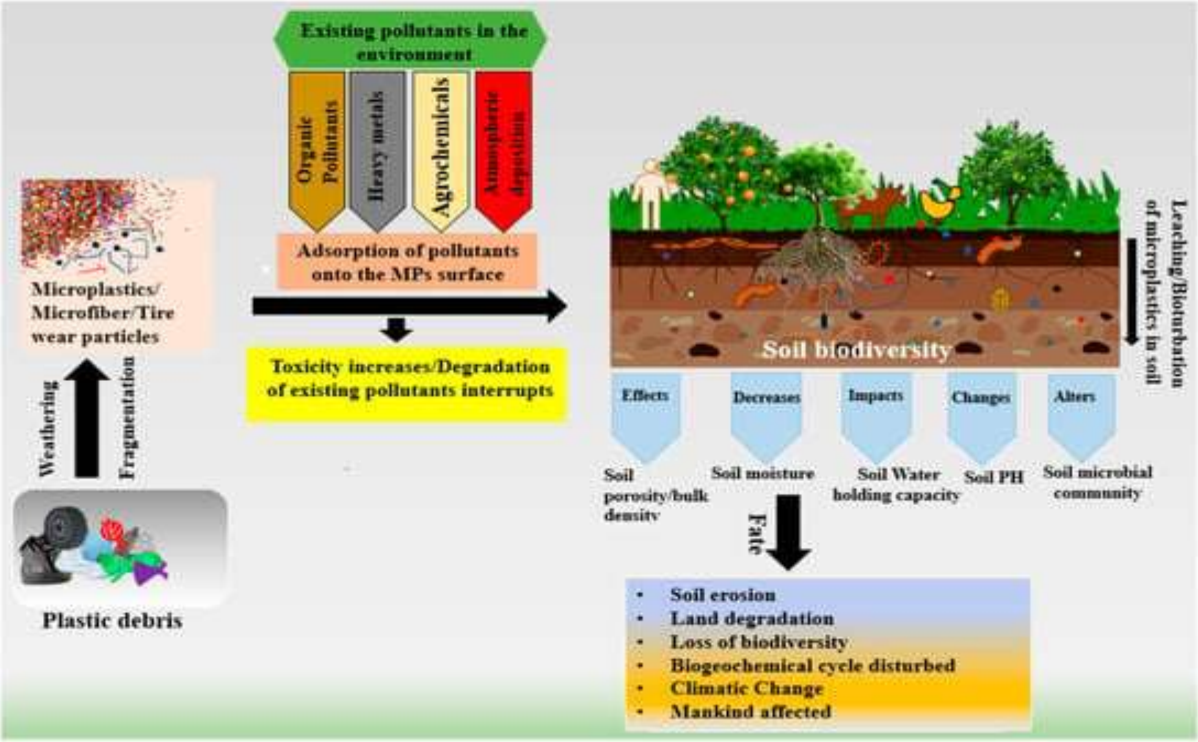

Figure 3. The fate and interactions of microplastics with existing co-contaminants in the soil and impacts on other ecological activities (Rai et al. 2023)

Potential Solutions

Potential sources of (micro)plastics and their migration in the continental region are given in Figure 4.

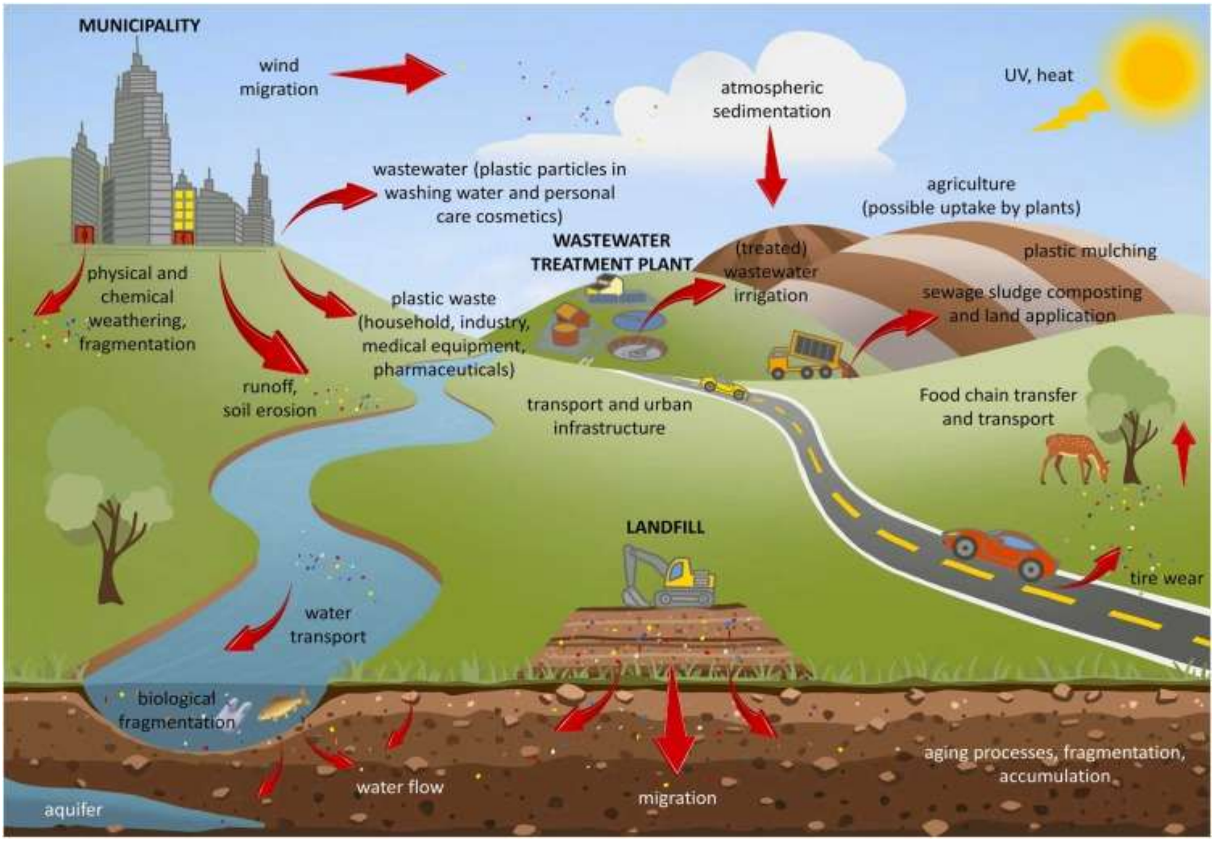

Figure 4. Potential sources of (micro)plastics and their migration in the continental region (Bodor et al 2024).

Addressing the issue requires a multi-pronged approach involving prevention, remediation, and policy:

1. Reducing Plastic Use in Agriculture
a) Transition to biodegradable alternatives for mulch films and other farm inputs.
b) Implement stricter guidelines for plastic additives in fertilizers and sludge.
2. Improving Waste Management
a) Enhance recycling infrastructure to prevent plastic leakage into the environment.
b) Encourage practices that minimize single-use plastics.
3. Innovative Remediation Techniques
a) Explore the use of fungi or bacteria capable of degrading microplastics in soils.
b) Develop advanced soil filtration and bioremediation technologies.

4. Legislation and Awareness
a) Governments must enforce regulations limiting microplastic pollution at its source.
b) Public campaigns can educate farmers and industries about sustainable pactices.

CONCLUSION

Microplastics in soil represent an emerging environmental crisis with profound implications for food security and ecosystem health. By addressing the root causes and implementing innovative solutions, humanity can mitigate this threat and work towards more sustainable land management practices. Safeguarding soil health is not just an environmental imperative; it is essential for the well-being of future generations.

REFERENCES

Blasing, M., Amelung, W., 2018. Plastics in soil: analytical methods and possible sources. Sci. Total Environ. 612, 422–435. https://doi.org/10.1016/j.scitotenv.2017.08.086.

Bodor, A., Feigl, G., Kolossa, B., Mészáros, E., Laczi, K., Kovács, E., & Rákhely, G. (2024). Soils in distress: The impacts and ecological risks of (micro) plastic pollution in the terrestrial environment. Ecotoxicology and Environmental Safety, 269, 115807.

Bradney, L., Wijesekara, H., Palansooriya, K.N., Obadamudalige, N., Bolan, N.S., Ok, Y.S., Rinklebe, J., Kim, K.-H., Kirkham, M.B., 2019. Particulate plastics as a vector for toxic trace-element uptake by aquatic and terrestrial organisms and human health risk. Environ. Int. 131, 104937. https://doi.org/10.1016/j.envint.2019.104937

Duis, K., Coors, A., 2016. Microplastics in the aquatic and terrestrial environment: sources (with a specific focus on personal care products), fate and effects. Environ. Sci. Eur. 28 (2). https://doi.org/10.1186/s12302-015-0069-y. (unpaged) (25 pages).

Huang, D., Wang, X., Yin, L., Chen, S., Tao, J., Zhou, W., Chen, H., Zhang, G., Xiao, R., 2022. Research progress of microplastics in soil-plant system: ecological effects and potential risks. Sci. Total Environ. 812, 11. https://doi.org/10.1016/j. scitotenv.2021.151487.

Hurley, R.R., Nizzetto, L., 2018. Fate and occurrence of micro(nano)plastics in soils: knowledge gaps and possible risks. Curr. Opin. Environ. Sci. Health 1, 6–11. https:// doi.org/10.1016/j.coesh.2017.10.006.

Kirkham, M.B., 2020. Water relations and cadmium uptake of wheat grown in soil with particulate plastics. In: Bolan, N.S., Kirkham, M.B., Halsband, C., Nugegoda, D., Ok, Y.S. (Eds.), Particulate Plastics in Terrestrial and Aquatic Environments. CRC Press, Taylor & Francis Group, Boca Raton, pp. 193–207.

Koutnik, V.S., Leonard, J., Alkidim, S., DePrima, F.J., Ravi, S., Hoek, E.M.V., Mohanty, S. K., 2021. Distribution of microplastics in soil and freshwater environments: global analysis and framework for transport modeling. Environ. Pollut. (Barking, Essex: 1987) 274, 116552. https://doi.org/10.1016/j.envpol.2021.116552.

Lechthaler, S., Waldschl¨ ager, K., Stauch, G., Schüttrumpf, H., 2020. The way of macroplastic through the environment. Environments 7 (10), 73. https://doi.org/ 10.3390/environments7100073.

Liu, M., Lu, S., Song, Y., Lei, L., Hu, J., Lv, W., et al., 2018. Microplastic and mesoplastic pollution in farmland soils in suburbs of Shanghai, China. Environ. Pollut. (Barking, Essex: 1987) 242 (Pt A), 855–862. https://doi.org/10.1016/j.envpol.2018.07.051.

Machado, A., Lau, C., Till, J., Kloas, W., Lehmann, A., Becker, R., Rillig, M., 2018. Impacts of microplastics on the soil biophysical environment. Environ. Sci. Technol. 52, 9656–9665. https://doi.org/10.1021/acs.est.8b02212.

Nizzetto, L., Bussi, G., Futter, M.N., Butterfield, D., Whitehead, P.G., 2016. A theoretical assessment of microplastic transport in river catchments and their retention by soils and river sediments. Environ Sci Process Impacts 18 (8), 1050–1059. https://doi. org/10.1039/c6em00206d

Piehl, S., Leibner, A., Loder, ¨ M.G.J., Dris, R., Bogner, C., Laforsch, C., 2018. Identification and quantification of macro- and microplastics on an agricultural farmland. Sci. Rep. 8 (1), 17950 https://doi.org/10.1038/s41598-018-36172-y.

Rai, M., Pant, G., Pant, K., Aloo, B. N., Kumar, G., Singh, H. B., & Tripathi, V. (2023). Microplastic pollution in terrestrial ecosystems and its interaction with other soil pollutants: a potential threat to soil ecosystem sustainability. Resources, 12(6), 67.

Uwamungu, J. Y., Wang, Y., Shi, G., Pan, S., Wang, Z., Wang, L., & Yang, S. (2022). Microplastic contamination in soil agro-ecosystems: A review. Environmental Advances, 9, 100273.

Wang, J., Liu, X., Li, Y., Powell, T., Wang, X., Wang, G., & Zhang, P. (2019). Microplastics as contaminants in the soil environment: A mini-review. Science of the total environment, 691, 848-857.

Weber, C.J., Bigalke, M., 2022. Opening space for plastics—why spatial, soil and land use data are important to understand global soil (micro)plastic pollution. Microplastics 1 (4), 610–625. https://doi.org/10.3390/microplastics1040042.

Weber, C.J., Opp, C., 2020. Spatial patterns of mesoplastics and coarse microplastics in floodplain soils as resulting from land use and fluvial processes. Environmental Pollution (Barking, Essex: 1987) 267, 115390. https://doi.org/10.1016/j. envpol.2020.115390.

Yu, Y., Velandia, M., Hayes, D.G., DeVetter, L.W., Miles, C.A., Flury, M., 2024. Biodegradable plastics as alternatives for polyethylene mulch films. Adv. Agron. 183, 121–192. https://doi.org/10.1016/bs.agron.2023.10.003.

Zhang, X., Chen, Y., Li, X., Zhang, Y., Gao, W., Jiang, J., et al., 2022b. Size/shapedependent migration of microplastics in agricultural soil under simulative and natural rainfall. Sci. Total Environ. 815, 152507 https://doi.org/10.1016/j. scitotenv.2021.152507.

TOPRAKLARDA MİKROPLASTİKLERİN TANIMLANMASI VE ANALİZİ
IDENTIFICATION AND ANALYSIS OF MICROPLASTICS IN SOILS

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Özet

Çeşitli yollarla toprağa karışan ve zamanla mikro hatta nano boyutlu parçacıklara dönüşen mikroplastiklerin, laboratuvar ortamında tespiti ve kimyasal bileşimlerinin belirlenmesi, mikroplastik kirliliği sorununun boyutlarının anlaşılması ve etkili çözüm stratejilerinin geliştirilmesi için büyük önem taşımaktadır. Topraktaki mikroplastiklerin analiz yöntemi, su ortamındaki sedimentlere benzer şekilde, örneklerden yoğunluk farkına göre plastiklerin ayrıştırılması, tanımlanması, sayısının belirlenmesi ve kimyasal bileşiminin belirlenmesi adımlarını takip etmektedir. Genel olarak, topraktaki mikroplastikleri ayırmak için toprak örnekleri kurutulur, elenir ve yoğunluk farklarından yararlanılarak hafif veya ağır parçacıklar ayrıştırılır. Örnekteki organik maddenin uzaklaştırılmasının ardından geriye kalan parçacıklar mikroskop altında incelenerek mikroplastiklerin morfolojik özellikleri ve miktarları tespit edilir. Daha sonra mikro-Fourier dönüşümlü kızılötesi (m-FT-IR) veya Raman spektroskopisi gibi tekniklerle kimyasal yapıları tespit edilir. Ancak, topraklardaki mikroplastiklerin karakterizasyonu konusundaki araştırmalar henüz oldukça yenidir ve toprağın karmaşık yapısından dolayı bu konuda araştırmacılar tarafından kabul görmüş standart bir yöntem tanımlanamamıştır. Bu durum, mikro ve nano plastiklerin çevresel etkilerinin daha iyi anlaşılmasını ve etkin müdahale yöntemlerinin oluşturulmasını geciktirmektedir. Kabul görmüş standart bir yöntemin olmaması, farklı araştırmacılar tarafından yapılan çalışma bulgularının doğrudan karşılaştırılmasını zorlaştırmakta ve hatta bazen imkânsız hale getirmektedir. Bu çalışmada, topraktaki mikroplastiklerin tespitinde kullanılan mevcut yöntemlerin temel prensipleri ve sınırlamaları tartışılmıştır.

Anahtar Kelimeler: Flotasyon, Yoğunluk ayrımı, Raman spektroskopisi, FTIR, Mikroplastik Kirliliği

Abstract

The detection and characterization of the chemical composition of microplastics, which enter soils through various pathways and eventually degrade into micro- or even nano-sized particles, are crucial for understanding the extent of microplastic pollution and developing effective mitigation strategies. The analysis method for microplastics in soils follows steps similar to those used for sediments in aquatic environments, including the separation of plastics based on density differences, their identification, quantification, and chemical characterization. Generally, soil samples are dried, sieved, and subjected to density separation to isolate light or heavy particles. After the removal of organic matter from the sample, the

remaining particles are examined under a microscope to determine the morphological characteristics and quantities of microplastics. Subsequently, chemical structures are identified using techniques such as micro-Fourier transformed infrared (m-FTIR) or Raman spectroscopy. However, research in microplastic characterization in soils is still in its infancy, and due to the complex nature of soil, no standardized method has yet been established by researchers. This limitation delays the comprehensive understanding of the environmental impacts of micro- and nano-plastics and the development of effective intervention strategies. The lack of an accepted standard method makes it difficult, and sometimes even impossible, to directly compare findings from studies conducted by different researchers. This study discusses the fundamental principles and limitations of the existing methods used for detecting microplastics in soils.
Keywords: Floating, Density separation, Raman spectroscopy, FTIR, Microplastic Pollution

Giriş

Mikro plastik kirliliği, ekvatordan kutuplara, denizden karaya kadar dünyanın her yerinde yaygın olarak bulunduğuna dair raporlar yayınlanmaktadır. Güncel tahminler, Avrupa'daki tarım arazilerine yıllık mikroplastik girişinin 63 ile 430.000 ton arasında değiştiğini, Kuzey Amerika'da ise bu rakamın 440 ile yaklaşık 300.000 ton arasında değiştiğini göstermektedir (Guo ve ark., 2020). Aynı zamanda, karasal ekosistemlerde bulunan mikroplastiklerin, okyanustakinden 4 ile yaklaşık 23 kat daha fazla bulunabileceği tahmin edilmektedir (Nizetto ve ark., 2016). Tarımsal ekosistemlerde, toprakların mikroplastik kirliliği ile ilgili araştırma sonuçları yayınlandıkça, etkilediği ekosistem hizmetleri üzerine etkileri daha iyi anlaşılmaya başlanmıştır. Atık su kullanımı, tarımsal faaliyetler ve çeşitli endüstriyel süreçler ile toprak ortamına ulaşan mikroplastikler, yüzey akışı, erozyon, biyotürbasyon ve suyun profil içerisindeki hareketi ile daha geniş bir alana yayılmaktadır (Qiu ve ark., 2023).

Araştırma sonuçları, toprakta biriken mikroplastiklerin, topraktaki fiziksel, kimyasal ve biyolojik süreçleri etkileyerek toprak ekosisteminin bütünlüğünü tehdit edebileceğini ortaya koymuştur (Zhao ve ark., 2022; Hoang ve ark., 2024; Aralappanavar ve ark., 2024). Toprakta bulunan mikro ve nano mikroplastiklerin boyutları ve fizikokimyasal özellikleri nedeniyle topraktaki çeşitli canlılar (fauna, mikroorganizmalar) ve bitkiler tarafından kolaylıkla alınabilmekte ve besin zinciri boyunca taşınabilmektedir. Bu durum, toprakta yaşayan organizmalarda; ölüm, büyüme ve gelişme gerilemesi, beslenme bozuklukları, endokrin sistem bozulmaları, bağışıklık sistemi zayıflaması ve genetik hasar gibi çeşitli olumsuz etkilere yol açabilmektedir. Son yapılan çalışmalar, mikro ve nano plastiklerin besin zinciri boyunca hareket ederek daha üst trofik seviyelere ulaşabileceğini ve bu sayede ekosistem üzerindeki etkilerinin daha da artabileceğini göstermektedir (Liang ve ark., 2023).

Toprağın sağladığı ekosistem hizmetlerine etkisi ile ilgili araştırma raporları yayınlanmış olmasına rağmen karasal mikroplastik kirliliğinin gerçek boyutu halen belirsizliğini korumaktadır. Bunun başlıca nedeni, topraktaki mikroplastikleri tespit etmek için kabul görmüş analitik araçların eksikliğidir. Toprağın farklı boyutlarda mineral ve organik maddeler içermesi ve katı bir analiz bileşeninin yine katı bir numune içinde izlenmesinin zorluğu, topraklarda etkili bir mikroplastik analizi için kapsamlı bir yöntemin henüz geliştirilememiş olmasının temel nedenleridir. Bu derlemede, özellikle tarım arazilerinde mikroplastik kirliliği çalışmalarında, örneklerin araziden alınması, laboratuvar ortamına taşınması, analize hazırlanması ve analizi edilmesi aşamalarında yaygın olarak kullanılan yöntemlerin temel prensipleri ve varsa sınırlamalarına ilişkin bilgiler özetlenmiştir.

Mikroplastik Çalışmalarında Toprak Örnekleme ve Analize Hazırlanma Aşamaları

Mikroplastik kirliliği çalışmalarında ilk ve en kritik aşama, arazi koşullarında doğru ve temsili toprak örneklerinin alınmasıdır. Araziden alınacak toprak örneklerinin miktarı, araştırmanın hedefleri, örnekleme alanının özellikleri, arazinin kullanım geçmişi ve laboratuvarda mikro plastikleri tanımlamak ve analiz etmek için kullanılacak yöntem ve cihazlara bağlı olarak değişkenlik göstermektedir (Chia ve ark., 2023). Mikroplastik analizlerinde toplanan toprak örneği miktarının az olması genellikle daha uygun ve pratiktir. Çoğu araştırmacı, analiz öncesi işlemlerden sonra sadece küçük bir miktar toprak kullanarak aynı sonuçlara ulaşabilmektedir. Örneğin, 100 gram gibi küçük bir toprak örneği bile birçok analiz için yeterli olabilir. Bu durum, hem ekonomik avantaj sağlamakta hem de laboratuvar çalışmalarını kolaylaştırmaktadır. Ancak, örnek miktarının azalması her zaman avantajlı olmayabilir. Örneğin, mikroplastiklerin yoğunluğunun çok düşük olduğu düşünülen ortamlarda, daha kesin sonuçlar elde etmek için daha büyük miktarlarda toprak örneği alınması gerekebilir. Ayrıca, farklı boyutlardaki mikro plastikleri ayırmak veya analiz etmek için farklı miktarlarda örnekler kullanılması gerekebilir.

Toprak örneklerinin yeterli veya doğru alanlardan alınmaması, analiz sonuçlarının güvenilirliğini olumsuz etkileyebilir. Yanlış örnek alma veya örnek hazırlama süreçleri, topraktaki mikroplastik miktarının gerçek değerden farklı olarak belirlenmesine neden olabilir (Hyde ve ark., 2019). Bu durum, hem mikroplastik kirliliğinin boyutlarının yanlış değerlendirilmesine hem de alınacak önlemlerin etkinliğinin azalmasına yol açabilir (Chia ve ark., 2023). Bu nedenle, toprak örneği alınacak yerin, araştırma bölgesini temsil etmesi, erişilebilir olması ve mikroplastik kirliliğinin olası kaynaklarını belirlemeye yardımcı olacak nitelikte seçilmesi, toprak mikroplastik varlığını doğru bir şekilde analiz etmek için büyük önem taşır (Li, 2019). Topraklarda mikroplastik kirliliği çalışmaları planlandığında, belirli bir alandan toprak örneği toplamadan önce aşağıda belirtilen üç önemli konuya dikkat edilmelidir. **Birinci olarak**, araştırma alanı içinde mikroplastik birikimi ve birikme şekli önemli ölçüde farklılık gösterebileceğinden mikroplastiklerin mekânsal değişkenliği göz önünde bulundurulmalıdır. Bu nedenle, örnekleme noktalarının seçimi, mekânsal dağılımı yansıtmalı ve küçük mesafelerde bile önemli dalgalanmalar olabileceğini hesaba katmalıdır. **İkinci olarak**, örnekleme alanının yönetim geçmişi hakkında yeterli bilgi edinilmelidir. Alanda farklı uygulamaların olduğu bölümler için alt örnekleme yapılmalıdır. **Üçüncü olarak**, örnekleme için toprak türü, bitki örtüsü ve arazi özellikleri açısından homojen alanlar tercih edilmelidir. (Chia ve ark., 2022).

Mikroplastik kirliliği araştırmalarında toprak örneklemesi yaparken, belirli alanlardan örneklerin alınmasından kaçınılmalıdır. Arazilerin sınırlarından, yüksek makine trafiği olan bölgelerden, su birikintilerinden, eski tarım alanlarından ve hayvan barınakları gibi yerlerden örnek alınmaması tavsiye edilmektedir. Belirtilen alanlarda örnekleme yapılması, topraktaki mikroplastiklerin doğal dağılımını yansıtmayan sonuçlara neden olabileceğinden, bu tür alanlardan uzak durmak gerekmektedir.

Toprakta mikroplastik kirliliğini araştıran çalışmaların önemli bir kısmında, özellikle toprak işleme yapılmayan alanlarda, toprak örnekleme derinliği yüzeyin ilk 20 cm'si ile sınırlı kalmıştır. Yüzey toprağında mikroplastik belirlenmesi, bölgesel kirlilik seviyesini belirlemek için uygun olsa da, toprak profilindeki dikey dağılım hakkında bilgi edinmek mümkün olmayacaktır. Zira, topraktaki mikroplastik miktarı derinlikle birlikte değişebilmektedir. Bu nedenle, daha kapsamlı bir değerlendirme için alt toprak katmanlarından da örnek alınması gerekmektedir. Bu durum, mikroplastiklerin toprakta nasıl hareket ettiğini ve yeraltı suyuna ulaşma potansiyelini anlamak için oldukça önemlidir (Cha ve ark., 2023).

Mikroplastik çalışmalarında, toprak örneklerinin saklama ve kurutma sıcaklığı konusunda standart bir uygulama bulunmamaktadır. Örneklerin taşınması ve saklanması için −20 °C ile oda sıcaklığı arasında değişen farklı sıcaklıklar rapor edilmiştir. Ancak bu sıcaklık tercihleri, mikroplastik analizinden çok, yapılması planlanan diğer analizler ile ilgili olduğu anlaşılmaktadır. Örneklerin kurutulması, mikroplastiklerin ayrıştırılmasını kolaylaştırdığı için önemlidir. Genel olarak, oda sıcaklığında yapılan çalışmalar, ekonomik ve güvenilir sonuçlar sunmaktadır. Kurutma işlemi sırasında yaklaşık 60 °C sıcaklık, mikroplastiklerin bozulmasını

önlediğinden önerilmektedir. Bununla birlikte, toprak örneklerinin açıkta kurutulması, havadaki plastiklerin bulaşma riski nedeniyle tavsiye edilmemektedir (Nuelle ve ark., 2014).
Toprak örneklerinin doğru şekilde muhafaza edilmesi ve mikroplastikler ile kontamine olmaması, çalışma sonuçlarının güvenirliliği için oldukça önemlidir. Toprak örneklerinin alüminyum kutular veya cam şişeler gibi plastik olmayan kaplarda saklanması, kontaminasyon riskini azaltır (Chia ve ark., 2022).

Mikroplastiklerin Topraktan Ayrıştırılması ve Çıkarılması

Genel olarak, mikroplastiklerin ayrıştırılmasındaki ilk adımda, toprak örneği içerisindeki taş, bitki kökü gibi büyük parçacıklar elenerek uzaklaştırılır. İkinci adımda, farklı yoğunluklara sahip olan mikroplastikler ve toprak parçacıkları birbirinden ayrıştırılır. Ancak, yoğunluk ayrımı öncesi ve sonrası organik maddelerin uzaklaştırılması gerekmektedir (Zhang ve ark. 2022).
Toprak örneklerindeki mikroplastik analizi öncesi hazırlık sürecinde dikkat edilmesi gereken önemli noktalar bulunmaktadır. Tarım toprakları, çeşitli organik ve inorganik maddelerin karışımı olan karmaşık bir yapıya sahiptir. Bu nedenle, analiz öncesi yapılması gereken işlerin amacı toprak içerisindeki mikroplastiklerin diğer organik ve inorganik maddelerden ayrıştırılması ve saf hale getirilmesidir. Toprak örneklerindeki büyük parçacıkların (taş, bitki kalıntıları vb.) uzaklaştırılması için öncelikle kaba bir ayrıştırma işlemi yapılır. Daha sonra, 5 mm'lik bir elek kullanarak daha büyük parçacıklar ayrılır. Ancak, daha küçük boyutlu mikroplastikleri incelemek isteyen bazı araştırmacılar, tüm toprak örneğini daha ince gözenekli eleklerden geçirerek daha detaylı bir analiz yapmaktadır. Genel olarak, çelik veya demirden yapılmış ve 20 ila 500 µm arasında gözenek büyüklüğüne sahip elekler tercih edilmektedir. Bu sayede, farklı boyutlardaki mikroplastikler hakkında daha fazla bilgi elde etmek mümkün olmaktadır (Junhao ve ark., 2021). Bununla birlikte, toprakta mikroplastiklerin miktarını belirlemek için standartlaştırılmış bir ekstraksiyon ve tanımlama yöntemi bulunmamaktadır. Literatürde çeşitli yöntemler tanımlanmıştır, ancak bu yöntemlerde örnekleme, ayrıştırma, organik maddenin uzaklaştırılması ve tanımlama aşamaları için farklı prosedürler içermektedir.

Yoğunluk Ayrımı

Yoğunluk ayrımı, çeşitli boyutlarda mikroplastiklerin, kaba parçacıklardan küçük parçacıklara kadar, ayrıştırılmasında etkili olduğu için toprak örneklerindeki mikroplastiklerin tespiti ve karakterizasyonunda en yaygın kullanılan yöntemdir (Katsumi ve ark., 2022). Toprak parçacıklarının yoğunluğunun (2.60-2.70 g cm^{-3}) mikroplastiklere (0.80-1.40 g cm^{-3}) göre daha yüksek olması, uygun bir sıvı ortamında, mikroplastiklerin yüzeye çıkarak toprak parçacıklarından ayrılmalarına neden olmaktadır. Düşük yoğunluklu polietilen (LPDE) ve polipropilen (PP) kökenli plastikler, deiyonize suda dahi kolaylıkla yüzeye çıkarken, daha yüksek yoğunluklu plastikler için deiyonize suya kıyasla yoğunluğu yüksek olan doymuş sodyum klorür (NaCl: 1.2 g cm^{-3}) gibi tuz çözeltileri, düşük maliyeti ve daha az toksik olması nedeniyle yoğunluk ayrımı için kullanılmıştır (Liu ve ark., 2018).
Sodyum klorür gibi tuzlar, düşük yoğunluklu PP ve LPDE gibi plastikler için etkili olsa da, yüksek yoğunluklu plastikler için yeterli olmamaktadır. Toprak örneklerinden yüksek yoğunluklu polietilen tereftalat (PET), polivinil klorür (PVC), polimetil metakrilat (PMMA) gibi plastikleri ayırmak oldukça zor bir işlemdir. Bu plastiklerin yoğunluğu, toprak parçacıklarına oldukça yakın olduğu için, onları ayırmak için daha yoğun çözeltiler kullanmak gerekmektedir (Liu ve ark., 2018). Kalsiyum klorür ($CaCl_2$), çinko bromür ($ZnBr_2$), sodyum iyodür (NaI), sodyum bromür (NaBr) ve çinko klorür ($ZnCl_2$) gibi daha yoğun doymuş tuz çözeltilerinin kullanımının, ekstraksiyon verimliliğini arttırabileceği bildirilmektedir. Ancak özellikle kalsiyum iyonunun toprak organik maddesinin kümelenmesine neden olmasının, sonraki aşamalarda mikroplastiklerin tespitini zorlaştırabileceği ifade edilmiştir. Bu durumda, NaI ve gibi daha yüksek yoğunluklu (1.80 g cm^{-3}) bir çözeltinin kullanımı tavsiye ediliyor

olmasına rağmen, NaI'nin maliyetinin yüksekliği ve uzun işlem süresi kullanımını sınırlandırmaktadır. Yüksek yoğunluklu ayırma çözeltisinin geri dönüşüm oranı, NaCl'inkinden çok daha yüksektir. Süspansiyon ortamının seçimi, geri kazanım oranı, fiyatı ve çevresel etkisine bağlı olarak yapılmalıdır (Scheurer ve ark., 2018; Han ve ark., 2019).

Yoğunluk ayırma işlemi, partiküller arasındaki etkileşimi azaltarak ayrışmayı kolaylaştıran ultrasonikasyon gibi fiziksel yöntemlerle desteklenerek plastiklerin ayırma işlemi daha etkin hale getirilebilmektedir. Ayrıca, yoğunluk ayrımı yönteminin etkinliği, plastik türüne, boyutuna ve şekline göre değişebilir. Örneğin, düzensiz şekilli veya yüzeyinde adsorpsiyonu yüksek olan mikroplastikler, diğerlerine göre daha zor ayrılabilir. Bu nedenle, farklı plastik türlerini içeren örneklerde, farklı yoğunluktaki sıvılar ve farklı ultrasonik işlem süreleri kullanılarak optimizasyon yapılması gerekebilir (Liu ve ark., 2018).

Elektrostatik Ayrıştırma

Toprak örneklerinde bulunan mikroplastiklerin doğru, kolay ve uygun maliyetli yöntemlerle ayırılması, bu konudaki bilimsel çalışmalar için temel bir gereksinimdir. Toprak örneklerinden mikro plastikleri ayırmak için kullanılan güvenilir yöntemlerden biri de elektrostatik ayırmadır. Bu yöntem, topraktaki minerallerin ve plastiklerin elektriksel iletkenlik farkından yararlanır. Plastikler, minerallere göre daha az iletken olduğu için, dışarıdan uygulanan bir elektriksel akım sayesinde ortamdaki diğer partiküllerden ayrıştırılabilir. Bu sayede, toprak örneğindeki mikroplastiklerin büyük bir kısmı kayıp olmadan ayrıştırılabilir. Özellikle daha büyük boyutlu mikroplastiklerin ayrıştırılmasında etkili olan bu yöntem, hızlı ve basit olması nedeniyle tercih edilmektedir. Ancak, bu yöntemin küçük boyutlu mikroplastikler veya nanopartiküller üzerindeki etkinliği henüz tam olarak bilinmemektedir (Felsing ve ark., 2018; Enders ve ark., 2020).

Yağ ile Ayrıştırma

Mikroplastiklerin lipofilik özelliklerinden yararlanılarak geliştirilen yağ ekstraksiyon yöntemi, yoğunluk ayırma yöntemine göre daha yüksek verimlilik sağlamaktadır (Crichton ve ark., 2017). Genel olarak yoğunluk yönteminin daha hafif mikroplastikler için tercih edilmesi gerektiği belirtilirken, yağ ekstraksiyon yöntemi, yoğunluk arttıkça azalan ayırma verimliliğine bir çözüm olarak sunulmaktadır (Zhao ve ark., 2024).

Bu yöntemde, Crichton ve ark. (2017) yedi farklı polimer türü için %90-100 arasında geri kazanım oranı elde edilmiştir. Yağ ekstraksiyonu ile mikroplastiklerin ayrıştırılması, tuz çözeltisi ile yapılan yoğunluk ayrımına göre daha basit, daha kolay ve daha ekonomik bir yöntem olarak öne çıkmaktadır. Ancak, bu işlemde kullanılan yağın FTIR analizlerinde sorun oluşturması nedeniyle ekstraksiyon sonrası etanol ile yıkama işlemi gerekmektedir.

Yağ ekstraksiyon yöntemi, aynı zamanda farklı tarım topraklarındaki mikroplastiklerin ayrıştırılmasında da etkili bir seçenek sunmaktadır. Çin'deki sekiz tipik tarım toprağında yapılan bir çalışmada, Zhao ve ark. (2024) bu yöntemle polietilen tereftalat (PET), PP, polistiren (PS) ve polietilen türündeki dört mikroplastiği topraklardan başarılı bir şekilde ayrıştırmıştır. Elde edilen ekstraksiyon oranları %83.33 ile %100 arasında değişmiştir. Bu yöntem ile ilgili olarak, yüksek yoğunluklu mikroplastikler için yağ ekstraksiyon yönteminin uygulanmasının uygun olduğu, ancak işlem sonrası kalan yağın temizlenmesinin önemli olduğu vurgulanmaktadır. Bununla birlikte, Zhao ve ark. (2024) laterit topraklardaki PET mikroplastiklerin yağ yöntemiyle ayrıştırılmasında, yoğunluk yönteminin ise PP mikroplastiklerin ayrıştırılmasında başarı oranlarının düşük olduğu bildirilmiştir. Bu durum, laterit topraklardaki demir ve alüminyum iyonlarının mikroplastiklerin ayrıştırılma oranlarını etkilemesi ile ilişkili olması açıklanmıştır.

Organik Maddenin Uzaklaştırılması

Organik madde, mikroplastikler ile benzer yoğunluğa sahip olduğundan, mikroplastiklerin toprak örneklerinden ayrıştırılmasını oldukça zorlaştırmaktadır. Organik madde, hem düşük yoğunluğu hem de mikroplastiklerin yüzeyine yapışarak spektroskopik analizleri engelleyebilmesi nedeniyle, mikroplastik analizindeki en önemli zorluklarından biridir. Bu nedenle, hidrojen peroksit, güçlü asitler veya bazlar gibi kimyasallar ile organik maddenin parçalanmasına gereksinim duyulmaktadır (Hurley ve ark., 2018).

Hidrojen Peroksit (H_2O_2) ve Fenton Reaktifi ile Organik Maddenin Uzaklaştırılması

Hidrojen peroksit (H_2O_2), güçlü oksidasyon özelliği sayesinde organik maddelerin ayrıştırılmasında sıkça kullanılan bir kimyasal maddedir. Özellikle mikroplastik araştırmalarında, numunelerdeki organik maddelerin uzaklaştırılması ve böylece mikroplastiklerin daha net bir şekilde gözlemlenmesi için kullanılmaktadır. Çoğu araştırmada, hidrojen peroksitin mikroplastiklere zarar vermediği bildirilmiş olmasına rağmen, Rist ve ark. (2017) uzun süreli uygulamalarının bazı polimerlerin fiziksel özelliklerini değiştirebileceğini ortaya koymuştur. Özellikle, hidrojen peroksite maruz kalan mikroplastiklerin daha küçük, ince ve şeffaf hale geldiği ve bu durumun mikroplastiklerin tanımlanması ve boyutlandırılmasını zorlaştırdığı ifade edilmiştir. Bu nedenle, hidrojen peroksidin oksidasyon verimliliğini artırmak için Fenton reaktifi kullanılması tavsiye edilmiştir. Fenton reaktifi, hidrojen peroksitin demir (Fe^{2+}) katalizör ile birleştirilmesiyle elde edilir. Bu kombinasyon, güçlü hidroksil radikalleri üreterek organik bileşenleri hızlı ve verimli bir şekilde oksitler. Ayrıca, düşük maliyeti ve kolay uygulanabilirliği, çevresel mikroplastik araştırmalarında tercih edilmesini sağlamaktadır. Hurley ve ark. (2018), Fenton reaktifinin toprak ve çamurdaki organik maddeleri etkin bir şekilde uzaklaştırdığını ve mikroplastiklere zarar vermediğini belirtmişlerdir. Bununla birlikte, hidrojen peroksit uygulamalarında yüksek sıcaklıkların, bazı polimerlerin termal bozunmasına neden olabileceğini belirten Hurley ve ark. (2018), Fenton reaktifi kullanıldığında sıcaklığın belirli bir sınırın üzerinde tutulmaması gerektiğini vurgulamışlardır. Aksi takdirde, şiddetli reaksiyonlar nedeniyle sıcaklık artışı ve mikroplastiklerin bozulması gibi istenmeyen sonuçların ortaya çıkabileceğine dikkat çekilmiştir.

Alkali Çözeltiler ile Organik Maddeni Uzaklaştırılması

Mikroplastik analizler öncesinde, mikroplastiklerin ayrıştırılması amacı ile alkali çözeltiler (KOH ve NaOH gibi) kullanımı da yaygın bir yöntemdir. Ancak, bazı araştırmacılar (Dehaut ve ark., 2016), yüksek konsantrasyonlu alkali çözeltilerin (10 M NaOH) bazı polimerlerin (naylon, PVC, PE, PET, PC) fiziksel özelliklerini değiştirdiğini, hatta bozulmalara neden olabileceğini belirtmişlerdir. Munno ve ark. (2018), yüksek konsantrasyonlu KOH çözeltilerinin mikroplastiklerin rengini değiştirdiğini ve geri kazanım oranlarını etkileyebileceğini belirtmiştir.

Asidik Çözeltiler ile Organik Maddenin Uzaklaştırılması

Mikroplastik analizlerinde organik maddelerin uzaklaştırılması için asit sindirimi yöntemi kullanılmaktadır. Özellikle HNO_3 ve HCl gibi güçlü asitler, organik maddeyi etkili bir şekilde parçalayabilmektedir. Ancak, bu yöntemin MP'lerin bütünlüğünü bozma riski bulunmaktadır (Zhao ve ark., 2024). Bu nedenle, mikroplastik analizlerinde asit sindirimi yerine, mikroplastiklere daha az zarar veren alternatif yöntemlerin tercih edilmesi önerilmektedir.

Mikroplastiklerin Tanımlanması

Örneklerin hazırlanması, temizlenmesi ve kimyasal işlemlerden geçirilmesi gibi aşamaların ardından mikroskopi, spektroskopi ve kromatografi gibi farklı yöntemlerle mikroplastiklerin miktarı, şekli, boyutları ve kimyasal bileşenleri incelenmektedir. Ancak mikroplastiklerin boyut, şekil ve kimyasal yapılarındaki çeşitlilik, bu analizleri oldukça zorlaştırmaktadır. Her yöntemin kendine özgü avantaj ve dezavantajları olduğu için genellikle birden fazla yöntem bir arada kullanılmaktadır. Bu süreçte karşılaşılan en büyük zorluk, küçük boyutlu ve farklı türdeki mikroplastikleri doğru bir şekilde tanımlamak ve miktarlarını tespit etmektir (Junhao ve ark., 2021).

Mikroskop Kullanımı ile Mikroplastiklerin Tanımlanması

Toprak örneklerinden mikroplastikler ayrıldıktan sonra, mikroskop altında yapılan karakterizasyon, maliyeti düşük ve kullanımı kolay bir yöntem olmasına karşın kullanıcı öznelliği nedeniyle küçük parçacıkların yanlış tanımlanmasına ya da gözden kaçmasına yol açabilir. Geleneksel mikroskopların kullanımı ile 200 nm boyutuna kadar olan mikroplastikler gözlemlenebilmekte, ancak daha küçük parçacıklar için taramalı elektron mikroskobuna (SEM) gereksinim duyulmaktadır. Elektron mikroskop pahalı bir cihaz olduğundan, Nile Red boyama tekniğinin mikroplastiklerin tanımlanmasını zenginleştirebileceği ifade edilmiştir.

Nile Red Boyama Tekniği ile Mikroplastiklerin Tanımlanması

Nile Red (NR) boyama yöntemi, topak örneklerinde mikroplastiklerin hızlı ve etkili bir şekilde tespit edilmesini sağlayan bir floresan teknik olarak öne çıkmaktadır. NR, hidrofobik yapısı sayesinde mikroplastiklerin yüzeyindeki polimerlerle güçlü bir şekilde etkileşime girer. Bu yöntem, mikroplastiklerin toprak ortamından izole edilmesi sonrası uygulanır. Öncesinde yapılan ayrım işlemleri, hem mikroplastiklerin diğer maddelerden ayrılmasını kolaylaştırır hem de boyama sırasında yanlış pozitif sonuçların önüne geçilmesini sağlar. Bu yöntemde kullanılan özel boyalar, mikroplastiklere bağlanarak onları floresan hale getirir ve böylece mikroskop altında kolayca gözlemlenebilirler (Sturm ve ark., 2023).

NR boyası, genellikle düşük polar çözücülerde çözülerek mikroplastiklere uygulanır. Isı ve mekanik işlemler, boyanın polimer zincirlerine daha etkili bir şekilde nüfuz etmesini sağlayarak tespit hassasiyetini artırır. Boyama işleminin ardından NR ile işlenmiş mikroplastikler, floresan mikroskop altında belirli uyarma ve emisyon dalga boylarında analiz edilir. Bu yöntemle boyanmış mikroplastikler, floresan özellikleri sayesinde farklı renklerde görsel olarak tespit edilebilir ve otomatik görüntü işleme teknikleriyle sayılabilir. NR boyasıyla yapılan analizler, mikroplastiklerin şekil, boyut ve polimer türleri hakkında bilgi sunabilmektedir. Ancak NR boyaması, bazı organik maddelerin de floresan özellik göstermesi nedeniyle ek doğrulama teknikleri gerektirebilir. Bu nedenle FTIR veya Raman spektroskopisi gibi ileri analiz yöntemleri, NR ile boyanan parçacıkların gerçekten mikroplastik olduğunu doğrulamak için sıklıkla kullanılır. NR yöntemi, mikroplastiklerin tespiti ve çevresel etkilerinin anlaşılmasında düşük maliyetli ve zaman kazandıran bir çözüm sunar (Shruti ve ark., 2022).

Sturm ve ark. (2023), bir Alman atıksu arıtma tesisinden bir yıl boyunca alınan numunelerde mikroplastik ölçümü yaparak, NR yönteminin etkinliğini test etmiştir. Çalışmanın en çarpıcı sonuçlarından biri, NR türevlerinin standart NR'ye kıyasla mikroplastik tespitinde üç kat daha fazla verim sağladığını ortaya koymasıdır. Bu iyileştirme, özellikle polar polimerlerin daha iyi tespit edilmesine olanak tanımış ve manuel yerine otomatik parçacık sayımı ile sürecin doğruluğu ve karşılaştırılabilirliği artırılmıştır. Örneğin, atıksu arıtma tesisi örneklerinde, NR türevleri ile otomatik sayım yöntemi kullanıldığında, günlük mikroplastik tahliyesi 10.409 parçacık/kişi seviyesinden 27.211 parçacık/kişi seviyesine yükselmiştir. Bu sonuçlar, NR'nin toprakta dahil olmak üzere farklı ortamlardaki mikroplastik analizlerinde önemli bir potansiyele sahip olduğunu ve standartlaştırılmış protokollerin geliştirilmesi gerektiğini vurgulamaktadır.

Mikroplastiklerin Polimer Yapılarının Tespiti

Fourier Dönüşümlü Kızılötesi Spektroskopisi (FTIR) ve Raman spektroskopisi, mikroplastiklerin analizi için kullanılan en yaygın ve gelişmiş yöntemler arasında yer almaktadır. Bu teknikler, örnek içerisindeki polimerleri diğer maddelerden ayırt edebilme yeteneğine sahiptir ve bu tekniklerin kullanımı ile polimer türleri doğru bir şekilde belirlenebilmektedir.

Fourier Dönüşümlü Kızılötesi Spektroskopisi (FTIR)

FTIR Spektroskopisi (FTIR) yöntemi, bir numunenin kızılötesi ışınımı absorplama veya iletme özelliklerini ölçerek, numunenin kimyasal bileşimi ve mevcut mikroplastik türü hakkında bilgi sağlamaktadır. Polimerlerin kimyasal yapısına özgü absorpsiyon bantlarını belirlemek için kullanılmaktadır. Oldukça küçük miktarda numuneye gereksinim duyan bu yöntem, özellikle ince film şeklindeki mikroplastiklerde veya partikül boyutları 10 µm'den büyük olan örneklerde oldukça etkili ve hızlıdır. FTIR, hem polimer türünü belirleyebilir hem de kimyasal bileşimler hakkında detaylı bilgi sunmaktadır (Elert ve ark., 2017; Andoh ve ark., 2023).

Mikroplastiklerin tanımlanmasında FTIR yönteminin bazı sınırlamaları bulunmaktadır. Özellikle farklı plastik türlerinin karışımlarını ve çok küçük mikroplastik parçacıklarını tespit etmekte zorluk yaşanabilmektedir. Bu sınırlamaları aşmak için Mikro-FTIR geliştirilmiştir. Mikro-FTIR, 20 µm boyutuna kadar küçültülmüş partiküllerin tespitine olanak tanıyarak daha küçük mikroplastiklerin analizi için etkili bir çözüm sunmaktadır. Bu gelişmiş teknik, numunelerdeki mikroplastiklerin daha ayrıntılı ve hassas bir şekilde karakterize edilmesini mümkün kılarak, geleneksel FTIR'nin eksik kaldığı alanlarda araştırmacılara önemli avantajlar sağlamaktadır (Andoh ve ark., 2023).

. Raman Spektroskopisi

Raman spektroskopisi, bir lazer kaynağıyla polimer moleküllerinin saçılım özelliklerini inceleyerek kimyasal yapıyı analiz eder. FTIR'ye göre numune hazırlama gereksinimi daha azdır ve daha küçük boyutlu partikülleri (örneğin, 1 µm'ye kadar) tespit edebilir. Raman, genellikle FTIR ile birlikte kullanılarak, farklı polimer türlerinin daha geniş bir yelpazede tanımlanmasını sağlar. Ayrıca, Raman yöntemi renkli polimerlerde daha etkilidir çünkü renk pigmentlerinin FTIR'de oluşturduğu gürültüyü aşabilir.

Raman ve FTIR yöntemleri farklı avantajlar sunmaktadır. Ancak araştırma sorularına bağlı olarak bu yöntemler tercih edilmelidir. Raman spektroskopisinin çalışma süresi, FTIR'den daha uzun olmasına rağmen, bu yöntem, partikül şekli, boyutu veya kalınlığından bağımsızdır ve analiz sonuçlarını etkileyebilecek bu tür parametrelerden etkilenmez. Siyah partiküller, FTIR'de kızılötesi radyasyonu yüksek ölçüde absorpladığı için genellikle tanımlanamayan spektrumlara neden olurken, Raman yöntemi suya ve atmosferik CO_2'ye karşı duyarsızdır. Ancak, organik maddelerin veya polimerlerdeki pigmentlerin neden olduğu arka plan floresansı Raman spektrumlarını bozabilir ve bu durum, özellikle yüksek organik madde içeren toprak örneklerinde sorun yaratabilir (Möller ve ark., 2020).

Sonuçlar ve Öneriler

Topraklarda mikroplastiklerin tespiti ve analizi, çevresel mikroplastik kirliliğinin boyutlarının anlaşılmasında ve etkin müdahale yöntemlerinin geliştirilmesinde kritik bir öneme sahiptir. Ancak, toprak matrisinin karmaşıklığı ve mikroplastiklerin boyut, şekil ve yoğunluk gibi farklı özellikleri nedeniyle bu alanda standart bir yöntem henüz geliştirilememiştir. Mevcut yöntemler, yoğunluk ayrımı, spektroskopik analizler (FTIR ve Raman), yağ ekstraksiyonu ve elektrostatik ayırma gibi çeşitli tekniklere dayanmakta, ancak her biri kendi içinde sınırlılıklar taşımaktadır. Özellikle, topraktaki organik ve inorganik bileşenlerin mikroplastiklerin ayrıştırılması ve tanımlanmasını zorlaştırdığı tespit edilmiştir. Bu durum, farklı çalışmalarda elde edilen sonuçların karşılaştırılabilirliğini sınırlandırmakta ve toprak mikroplastik kirliliği konusundaki genel bilgi birikimini geciktirmektedir.

Gelecekteki çalışmalarda, mikroplastik analizlerinde kullanılabilecek daha hassas, düşük maliyetli ve zaman tasarrufu sağlayan yöntemlerin geliştirilmesi büyük önem taşımaktadır. Özellikle, Nile Red boyama gibi floresan tabanlı teknikler ile FTIR ve Raman spektroskopisinin otomasyon süreçlerine entegre edilmesi, hem hassasiyeti artıracak hem de kullanıcı öznelliğini azaltacaktır. Ayrıca, mikroplastiklerin ayrıştırılmasında kullanılan çözeltilerin çevre dostu ve ekonomik alternatiflerle değiştirilmesi, laboratuvar süreçlerini kolaylaştıracaktır. Son olarak, mikroplastik analizinde uluslararası standartların belirlenmesi ve bu standartlara uygun protokollerin geliştirilmesi, farklı çalışmalar arasında karşılaştırılabilirliğin sağlanması açısından kritik bir adım olacaktır. Bu hedeflere ulaşmak için multidisipliner yaklaşımlar ve uluslararası iş birliklerinin teşvik edilmesi gerekmektedir.

Kaynaklar

Andoh, C. N., Attiogbe, F., Ackerson, N. O. B., Antwi, M., & Adu-Boahen, K. (2023). Fourier Transform Infrared Spectroscopy: An analytical technique for microplastic identification and quantification. Infrared Physics & Technology, 105070. https://doi.org/10.1016/j.infrared.2023.105070

Aralappanavar, V. K., Mukhopadhyay, R., Yu, Y., Liu, J., Bhatnagar, A., Praveena, S. M., ... & Sarkar, B. (2024). Effects of microplastics on soil microorganisms and microbial functions in nutrients and carbon cycling–A review. Science of the Total Environment, 171435.

Cha, J., Lee, J. Y., & Chia, R. W. (2023). Microplastics contamination and characteristics of agricultural groundwater in Haean Basin of Korea. Science of the Total Environment, 864, 161027. https://doi.org/10.1016/j.scitotenv.2022.161027

Chia, R. W., Lee, J. Y., Cha, J., & Rodríguez-Seijo, A. (2024). Methods of soil sampling for microplastic analysis: a review. Environmental Chemistry Letters, 22(1), 227-238. https://doi.org/10.1007/s10311-023-01652-9

Chia, R. W., Lee, J. Y., Jang, J., & Cha, J. (2022). Errors and recommended practices that should be identified to reduce suspected concentrations of microplastics in soil and groundwater: a review. Environmental Technology & Innovation, 28, 102933. https://doi.org/10.1016/j.eti.2022.102933

Crichton, E. M., Noël, M., Gies, E. A., & Ross, P. S. (2017). A novel, density-independent and FTIR-compatible approach for the rapid extraction of microplastics from aquatic sediments. Analytical Methods, 9(9), 1419-1428. https://doi.org/10.1039/c6ay02733d

Dehaut, A., Cassone, A. L., Frère, L., Hermabessiere, L., Himber, C., Rinnert, E., ... & Paul-Pont, I. (2016). Microplastics in seafood: Benchmark protocol for their extraction and characterization. Environmental pollution, 215, 223-233. https://doi.org/10.1016/j.envpol.2016.05.018

Elert, A. M., Becker, R., Duemichen, E., Eisentraut, P., Falkenhagen, J., Sturm, H., & Braun, U. (2017). Comparison of different methods for MP detection: what can we learn from them, and why asking the right question before measurements matters?. Environmental Pollution, 231, 1256-1264. https://doi.org/10.1016/j.envpol.2017.08.074

Enders, K., Tagg, A. S., & Labrenz, M. (2020). Evaluation of electrostatic separation of microplastics from mineral-rich environmental samples. Frontiers in Environmental Science, 8, 112. https://doi.org/10.3389/fenvs.2020.00112

Felsing, S., Kochleus, C., Buchinger, S., Brennholt, N., Stock, F., & Reifferscheid, G. (2018). A new approach in separating microplastics from environmental samples based on their electrostatic behavior. Environmental Pollution, 234, 20-28. https://doi.org/10.1016/j.envpol.2017.11.013

Guo, J. J., Huang, X. P., Xiang, L., Wang, Y. Z., Li, Y. W., Li, H., ... & Wong, M. H. (2020). Source, migration and toxicology of microplastics in soil. Environment international, 137, 105263. https://doi.org/10.1016/j.envint.2019.105263

Hoang, V. H., Nguyen, M. K., Hoang, T. D., Ha, M. C., Huyen, N. T. T., Bui, V. K. H., ... & Nguyen, D. D. (2024). Sources, environmental fate, and impacts of microplastic contamination in agricultural soils: A comprehensive review. Science of The Total Environment, 175276.

Hurley, R. R., Lusher, A. L., Olsen, M., & Nizzetto, L. (2018). Validation of a method for extracting microplastics from complex, organic-rich, environmental matrices. Environmental science & technology, 52(13), 7409-7417. https://doi.org/10.1021/acs.est.8b01517

Hyde, K., Ma, W., Obal, T., Bradshaw, K., Carlson, T., Mamet, S., & Siciliano, S. D. (2019). Incremental sampling methodology for petroleum hydrocarbon contaminated soils: volume estimates and remediation strategies. Soil and Sediment Contamination: An International Journal, 28(1), 51-64. https://doi.org/10.1080/15320383.2018.1529736

Katsumi, N., Nagao, S., & Okochi, H. (2022). Addition of polyvinyl pyrrolidone during density separation with sodium iodide solution improves recovery rate of small microplastics (20–150 μm) from soils and sediments. Chemosphere, 307, 135730. https://doi.org/10.1016/j.chemosphere.2022.135730

Liang, Y., Cao, X., Mo, A., Jiang, J., Zhang, Y., Gao, W., & He, D. (2023). Micro (nano) plastics in plant-derived food: Source, contamination pathways and human exposure risks. TrAC Trends in Analytical Chemistry, 165, 117138. https://doi.org/10.1016/j.trac.2023.117138

Liu, M., Lu, S., Song, Y., Lei, L., Hu, J., Lv, W., ... & He, D. (2018). Microplastic and mesoplastic pollution in farmland soils in suburbs of Shanghai, China. Environmental pollution, 242, 855-862. https://doi.org/10.1016/j.envpol.2018.07.051

Möller, J. N., Löder, M. G., & Laforsch, C. (2020). Finding microplastics in soils: a review of analytical methods. Environmental science & technology, 54(4), 2078-2090. https://doi.org/10.1021/acs.est.9b04618

Munno, K., Helm, P. A., Jackson, D. A., Rochman, C., & Sims, A. (2018). Impacts of temperature and selected chemical digestion methods on microplastic particles. Environmental toxicology and chemistry, 37(1), 91-98. https://doi.org/10.1002/etc.3935

Nizzetto, L., Futter, M., & Langaas, S. (2016). Are agricultural soils dumps for microplastics of urban origin?. Environ. Sci. Technol. 2016, 50, 20, 10777–10779. https://doi.org/10.1021/acs.est.6b04140

Nuelle, M. T., Dekiff, J. H., Remy, D., & Fries, E. (2014). A new analytical approach for monitoring microplastics in marine sediments. Environmental pollution, 184, 161-169. https://doi.org/10.1016/j.envpol.2013.07.027

Rist, S., Baun, A., & Hartmann, N. B. (2017). Ingestion of micro-and nanoplastics in Daphnia magna–Quantification of body burdens and assessment of feeding rates and reproduction. Environmental pollution, 228, 398-407. https://doi.org/10.1016/j.envpol.2017.05.048

Qiu, Y., Zhou, S., Zhang, C., Chen, L., Qin, W., & Zhang, Q. (2023). Vertical distribution and weathering characteristic of microplastics in soil profile of different land use types. Science of The Total Environment, 905, 166902. https://doi.org/10.1016/j.scitotenv.2023.166902

Scheurer, M., & Bigalke, M. (2018). Microplastics in Swiss floodplain soils. Environmental science & technology, 52(6), 3591-3598. https://doi.org/10.1021/acs.est.7b06003

Shruti, V. C., Pérez-Guevara, F., Roy, P. D., & Kutralam-Muniasamy, G. (2022). Analyzing microplastics with Nile Red: Emerging trends, challenges, and prospects. Journal of hazardous materials, 423, 127171. https://doi.org/10.1016/j.jhazmat.2021.127171

Sturm, M. T., Myers, E., Schober, D., Korzin, A., & Schuhen, K. (2023). Development of an inexpensive and comparable microplastic detection method using fluorescent staining with novel nile red derivatives. Analytica, 4(1), 27-44. https://doi.org/10.3390/analytica4010004

Xu, G., Cheng, H., Jones, R., Feng, Y., Gong, K., Li, K., ... & Zhang, L. (2020). Surface-enhanced Raman spectroscopy facilitates the detection of microplastics< 1 μm in the environment. Environmental science & technology, 54(24), 15594-15603.

Yang, L., Kang, S., Wang, Z., Luo, X., Guo, J., Gao, T., ... & Zhang, Y. (2022). Microplastic characteristic in the soil across the Tibetan Plateau. Science of the Total Environment, 828, 154518. https://doi.org/10.1016/j.scitotenv.2022.154518

Zhang, S., Li, Y., Chen, X., Jiang, X., Li, J., Yang, L., ... & Zhang, X. (2022). Occurrence and distribution of microplastics in organic fertilizers in China. Science of the Total Environment, 844, 157061. https://doi.org/10.1016/j.scitotenv.2022.157061

Zhao, S., Zhang, Z., Chen, L., Cui, Q., Cui, Y., Song, D., & Fang, L. (2022). Review on migration, transformation and ecological impacts of microplastics in soil. Applied Soil Ecology, 176, 104486.

Zhao, X., Liu, Z., Zuo, J., Cai, L., Liu, Y., Han, J., & Zhang, M. (2024). Comparison of Oil Extraction and Density Extraction Method to Extract Microplastics for Typical Agricultural Soils in China. Agronomy, 14(6), 1193. https://doi.org/10.3390/agronomy14061193

MOLECULAR HYDROGEN AS A REGULATOR IN PLANT GROWTH

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ABSTRACT
Usable agricultural lands are decreasing day by day due to climate change. The efficient use of agricultural lands will be of great importance in the future. The increasing world population shows that we will need more food. Increasing food demand indicates that we need new agricultural production methods that increase the quality and yield of products while not leaving residue in the product. Molecular hydrogen which is a selective scavenger of reactive oxygen species is an antioxidant, signal molecule, nontoxic and harmless. Molecular hydrogen-rich water is applicable because it can be easily obtained with methods such as nanobubbles, hydrogen saturation, and production with magnesium alloys. Molecular hydrogen can regulate plant growth by repairing damage in plants under stress, promoting seedling growth, development, and photosynthetic efficiency. Exogenous HRW application on plant roots up-regulates the salt tolerance-related gene expression, improves H^+-transport activity maintains the Na^+/K^+ balance, diminishes oxidant damage, reduces osmotic stress, and therefore promotes root growth. HRW also triggers the elongation of hypocotyls and roots in plants by mediating the level of endogenous hormones. Molecular hydrogen application is a safe method and promises hope in the production of agricultural products because it does not leave residues.
Keywords: Molecular Hydrogen, Root elongation, Seedling growth

INTRODUCTION
The world's population increased by approximately 3.6 billion between 1950 and 2000. This increase is expected to continue until the 2050s, reaching approximately 9.1 billion. The current world population growth rate is approximately 1.2%, corresponding to 77 million people per year (UN, 2001). To meet the food needs of this increasing world population, a 60% increase in food production is needed (Porter vd., 2014). It is estimated that an annual productivity increase of 2.4% is required to meet the demand resulting from population growth. However, the 1.6% increase rate remains below expectations (Kim vd., 2019). Evaluation of experience in increasing the production of crops by using higher amounts of agrochemicals suggests that this procedure is likely to cause greater environmental damage and further deteriorate food and water quality (Clark vd., 2002). New methods are needed to efficiently obtain agricultural products that can meet the nutritional needs of the increasing world population and animals. It is also important that these new methods do not negatively affect the nutritional content of the product and do not leave any additives in the product.
Molecular hydrogen (H_2) is a low molecular weight, non-polar, and electrochemically neutral substance that acts as an effective antioxidant and cytoprotective agent. Research on its use in both the food chain and agriculture has begun to gain momentum. In plants, H_2 can be used as

a seed conditioning agent during seed germination and planting, in the final stages of plant development and reproduction, in post-harvest processing, and as a food additive(Russell vd., 2024). Oxidative stress and subsequent cell and tissue damage can result from a multitude of factors, including environmental challenges (e.g. drought, pollution, increased soil salinity), human intervention (e.g. fertilizers, pesticides, paraquat), and natural aging (e.g. cellular degradation, microbial degradation). These factors can affect the growth, yield, and nutrient content of crops. In addition, oxidative damage can lead to rapid deterioration of crop quality, causing lipid oxidation, discoloration, and changes in both the nutritional profile and flavor of crops (Alwazeer ve Çiğdem, 2022; Russell vd., 2024).

H_2 has emerged as an important bioregulator that modulates various physiological processes that are enhanced under abiotic stress in plants, including the regulation of salinity and drought stress in rice or Arabidopsis and paraquat exposure in alfalfa(Jin vd., 2013; Zeng vd., 2013). In this regard, numerous studies are confirming the benefits of adding H_2 to the feed water of seeds, seedlings, and maturing plants. Here, H_2 provided as hydrogen-enriched rich water (HWW) has been shown to increase crop vigor and yield (Hu vd., 2021; Liu vd., 2024; X. Wang vd., 2023).

HYDROGEN ENRICHED WATER (HRW) PREPARATION METHODS

At standard pressure (1 atm) and ambient temperature (25 °C), the saturation of hydrogen water is about 1.6 mg/L (Alwazeer vd., 2021), and this saturation is difficult to achieve. To solve the problem of fast escape velocity, researchers have proposed several different supply methods. Hydrogen-enriched rich water (HZS)(Alwazeer, 2024), hydrogen-rich nano bubble water (HNZ)(M. Li vd., 2024), ammonia borane ($NH_3.BH_3$)(Zhao vd., 2021), magnesium hydride (MgH_2)(L. Li vd., 2020), and nanomaterials (Y. Wang vd., 2021) have been used to increase the release time of hydrogen, improve the residence time of hydrogen, and achieve the biological effect of hydrogen (R. Wang vd., 2024).

Hydrogen-Enriched Water (HRW)

The most common method of providing hydrogen is using hydrogen-enriched water (HRW). The preparation of HRW is a relatively simple method. Hydrogen is added to water to produce a hydrogen-saturated solution with a concentration of (1.6 ppm, 0.8 mM) in water (Alwazeer, 2024). Since the equipment for producing HRW is different, the concentration of HRW is also different. In addition, the methods for determining the hydrogen concentration are different. Therefore, it is a difficult process to determine the exact concentration of HRW in each study.

Nanububble-HRW

Hydrogen nano bubble water (HNW) has been developed to increase the retention time and biological activity of hydrogen in water (L. Li vd., 2021). HNW is produced by a nano hydrogen bubble water generator. The diameter of nanobubbles is less than 500 nm and has high internal pressure and a large surface area with a negative charge. These properties of nanobubbles are thought to contribute to the better dissolution of H_2 and mean that the processing time of H_2 can be extended (Hancock vd., 2021).

Magnesium Hydride and Nanomaterials

Magnesium hydride (MgH_2) in special formulations or coatings can release H_2 into the solution for a longer and more permanent time. The use of MgH_2 as a hydrogen donor leaves magnesium as well as the chemical coating used to passivate the reaction as a by-product. This can lead to excessive magnesium uptake by plants, which can cause adverse reactions. In addition, the hydrolysis of magnesium hydride will produce hydroxides that can improve the pH value in the system and have a negative effect on agricultural products. There are also suggestions here to use some organic acids to solve the pH problem (L. Li vd., 2020). Similarly, nanomaterials have a larger specific surface area, which some researchers use to store hydrogen and increase the supply time and efficiency. It has been reported that hollow mesoporous silica nanoparticles loaded with aminoborane (AB@hMSN) are a hydrogen-releasing nanomaterial that can continuously provide hydrogen for long periods of time in plants. AB@hMSN exhibits high hydrogen transport capacity and more persistent hydrogen release behavior in mildly acidic environments (Y. Wang vd., 2021).

Molecular hydrogen regulates plant development

In a study investigating the role and mechanism of HRW in cucumber defense response against chilling stress, the application of 50% saturated HRW to the roots of cucumber seedlings eliminated the damage caused by chilling stress. Growth and development indicators such as plant height, stem arch diameter, leaf area, dry weight, fresh weight, and root length increased under HRW application (X. Wang vd., 2023). Additionally, preharvest irrigation with hydrogen-rich water (HRW) increased the yield of daylily buds (Hu vd., 2021). HNW irrigation significantly increased Chinese cabbage yield by 32.70±12.15%. It also significantly increased single plant weight, height, maximum leaf length, and width (Liu vd., 2024). In a separate study with HNS, molecular hydrogen application in the form of hydrogen nanobubble water increased the length, width, and thickness and 1000-grain weight of brown/coarse rice and white rice compared to ditch water irrigation in small-scale field trials (total planting area ~150 m2)(Cheng vd., 2021). Undergrowth chamber and field conditions, H_2-treated soils improved the growth performance of spring wheat, canola, barley, and soybean (non-symbiotic) compared to untreated or air-pretreated soils. Barley and spring wheat plants grown in H_2-treated soil had 15 to 48% greater dry weight at 4 and 7 weeks of age. Shoot numbers of 7-week-old plants in H_2-treated soils were 36 and 48% greater, respectively. Soil exposed to H_2 improved plant growth (Dong vd., 2003). It has been reported that HRW application on Chinese cabbage and alfalfa seedlings reduced the inhibitory effects of cadmium (Cd) on seedling growth differently. In addition, HZS applied to alfalfa seedlings without using any chemicals increased the seedling growth rate by 9.9% and 16.7% (Dai vd., 2017; Wu vd., 2015). It has been observed that HRW application reduces Al-induced inhibition of alfalfa seedling root elongation in different ways, causing a 10% increase in root elongation under non-stress conditions, reducing Al toxic accumulation and improving seedling growth(Chen vd., 2014). In a different study, HZS treatment significantly increased the fresh weight, hypocotyl, and root length of mung bean seedlings. HZS promotes the growth of seedlings by regulating growth hormones and stimulating the elongation of hypocotyl and root cells (Wu vd., 2020).

CONCLUSION

The use of molecular hydrogen in agriculture can contribute to improving the nutritional content of products and increasing their yield, food safety, and environmental friendliness. With climate change, both the yield and nutritional content of products are negatively affected. Various chemicals are used to eliminate these negativities. However, these chemicals leave waste in both water resources and food. To eliminate these negativities, alternative methods are needed instead of traditional methods. When the studies that have been added to the literature so far are examined, it is thought that molecular hydrogen can be an alternative method due to its effects on products and its properties.

REFERENCES

Alwazeer, D. 2024. "Use of hydrogen extraction in the food industry". Reference Module in Chemistry, Molecular Sciences and Chemical Engineering (2. baskı). Elsevier Inc.

Alwazeer, D., Çiğdem, A. 2022. "Use of the Molecular Hydrogen in Agriculture Field". Turkish Journal of Agriculture-Food Science and Technology, 10(1), 14–20.

Alwazeer, D., Liu, F. F. C., Wu, X. Y., Lebaron, T. W. 2021. "Combating Oxidative Stress and Inflammation in COVID-19 by Molecular Hydrogen Therapy: Mechanisms and

Perspectives". Oxidative Medicine and Cellular Longevity, 2021.
Chen, M., Cui, W., Zhu, K., Xie, Y., Zhang, C., Shen, W. 2014. "Hydrogen-rich water alleviates aluminum-induced inhibition of root elongation in alfalfa via decreasing nitric oxide production". Journal of Hazardous Materials, 267, 40–47.
Cheng, P., Wang, J., Zhao, Z., Kong, L., Lou, W., Zhang, T., … Shen, W. 2021. "Molecular hydrogen increases quantitative and qualitative traits of rice grain in field trials". Plants, 10(11).
Clark, T., Harris, C. A., Tomerlin, J. R. 2002. "The regulation of pesticides in Europe–Directive 91/414". Journal of environmental monitoring, 4(2), 28N-31N.
Dai, C., Cui, W., Pan, J., Xie, Y., Wang, J., Shen, W. 2017. "Proteomic analysis provides insights into the molecular bases of hydrogen gas-induced cadmium resistance in Medicago sativa". Journal of Proteomics, 152, 109–120.
Dong, Z., Wu, L., Kettlewell, B., Caldwell, C. D., Layzell, D. B. 2003. "Hydrogen fertilization of soils - Is this a benefit of legumes in rotation?". Plant, Cell and Environment, 26(11), 1875–1879.
Hancock, J. T., Lebaron, T. W., May, J., Thomas, A., Russell, G. 2021. "Molecular hydrogen: Is this a viable new treatment for plants in the UK?". Plants, 10(11), 1–16.
Hu, H., Li, P., Shen, W. 2021. "Preharvest application of hydrogen-rich water not only affects daylily bud yield but also contributes to the alleviation of bud browning". Scientia Horticulturae, 287(May), 110267.
Jin, Q., Zhu, K., Cui, W., Xie, Y., Han, B., Shen, W. 2013. "Hydrogen gas acts as a novel bioactive molecule in enhancing plant tolerance to paraquat-induced oxidative stress via the modulation of heme oxygenase-1 signalling system". Plant, Cell and Environment, 36(5), 956–969.
Kim, W., Iizumi, T., Nishimori, M. 2019. "Global patterns of crop production losses associated with droughts from 1983 to 2009". Journal of Applied Meteorology and Climatology, 58(6), 1233–1244.
Li, L., Liu, Y., Wang, S., Zou, J., Ding, W., Shen, W. 2020. "Magnesium Hydride-Mediated Sustainable Hydrogen Supply Prolongs the Vase Life of Cut Carnation Flowers via Hydrogen Sulfide". Frontiers in Plant Science, 11(December), 1–13.
Li, L., Yin, Q., Zhang, T., Cheng, P., Xu, S., Shen, W. 2021. "Hydrogen nanobubble water delays petal senescence and prolongs the vase life of cut carnation (Dianthus caryophyllus l.) flowers". Plants, 10(8).
Li, M., Zhu, G., Liu, Z., Li, L., Wang, S., Liu, Y., … Shen, W. 2024. "Hydrogen Fertilization with Hydrogen Nanobubble Water Improves Yield and Quality of Cherry Tomatoes Compared to the Conventional Fertilizers". Plants, 13(3).
Liu, Z., Chen, G., Yang, E., Li, L., Zeng, Y., Cheng, X., … Shen, W. 2024. "Hydrogen-based irrigation increases yield and improves quality of Chinese cabbage by enhancing nutrient composition and antioxidant capabilities". Horticulture Environment and Biotechnology, (0123456789).
Porter, J. R., Xie, L., Challinor, A. J., Cochrane, K., Howden, S. M., Iqbal, M. M., … Travasso, M. 2014. "Food security and food production systems".
Russell, G., Nenov, A., Hancock, J. T. 2024. "How Hydrogen (H 2) Can Support Food Security : From Farm to Fork".
UN. 2001. "World population prospects" (C. 2). United Nations, Department of International, Economic and Social Affairs.
Wang, R., Yang, X., Chen, X., Zhang, X., Chi, Y., Zhang, D., … Zhou, P. 2024. "A critical review for hydrogen application in agriculture: Recent advances and perspectives". Critical Reviews in Environmental Science and Technology, 54(3), 222–238.
Wang, X., An, Z., Liao, J., Ran, N., Zhu, Y., Ren, S., … Fan, H. 2023. "The Role and

Mechanism of Hydrogen-Rich Water in the Cucumis sativus Response to Chilling Stress". International Journal of Molecular Sciences, 24(7).
Wang, Y., Lv, P., Kong, L., Shen, W., He, Q. 2021. "Nanomaterial-mediated sustainable hydrogen supply induces lateral root formation via nitrate reductase-dependent nitric oxide". Chemical Engineering Journal, 405(September 2020), 126905.
Wu, Q., Su, N., Cai, J., Shen, Z., Cui, J. 2015. "Hydrogen-rich water enhances cadmium tolerance in Chinese cabbage by reducing cadmium uptake and increasing antioxidant capacities". Journal of Plant Physiology, 175, 174–182.
Wu, Q., Su, N., Huang, X., Ling, X., Yu, M., Cui, J., Shabala, S. 2020. "Hydrogen-rich water promotes elongation of hypocotyls and roots in plants through mediating the level of endogenous gibberellin and auxin". Functional Plant Biology, 47(9), 771–778.
Zeng, J., Zhang, M., Sun, X. 2013. "Molecular Hydrogen Is Involved in Phytohormone Signaling and Stress Responses in Plants". PLoS ONE, 8(8), 1–10.
Zhao, G., Cheng, P., Zhang, T., Abdalmegeed, D., Xu, S., Shen, W. 2021. "Hydrogen-rich water prepared by ammonia borane can enhance rapeseed (Brassica napus L.) seedlings tolerance against salinity, drought or cadmium". Ecotoxicology and Environmental Safety, 224, 112640.

NANOSELÜLOZUN KALSİYUM SÜLFAT ESASLI KOMPOZİT ÜRETİMİNDE KULLANIMI
UTILIZATION OF NANOCELLULOSE IN CALCIUM SULFATE BASED COMPOSITE PRODUCTION

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ÖZET
Giriş ve amaç: Nanoselüloz (NS), son yıllarda kompozit malzeme teknolojisinde önemli bir yere sahip olmuştur. Bu malzeme, özellikle polimer kompozitlerin güçlendirilmesi ve performanslarının artırılması amacıyla kullanılmaktadır. Nanoselüloz, yüksek mekanik dayanım ve düşük yoğunluk gibi özellikleri sayesinde, geleneksel malzemelere alternatif olarak öne çıkmaktadır. Nanoselülozun kompozitlerde kullanımı, özellikle otomotiv ve inşaat sektörlerinde büyük bir potansiyele sahiptir. Nanoselüloz, doğal polimerik yapısı sayesinde birçok endüstride, özellikle kompozit malzeme uygulamalarında önemli bir yer edinmiştir. Bu çalışmada nanoselülozun kalsiyum sülfat esaslı kompozitlere entegre edilerek yükseltilmiş döşeme sistemleri için üretilen kompozit levhanın özelliklerinin iyileştirilmesi amaçlanmıştır.
Materyal ve Metod: Mekanik liflendirme süreçlerine tabi tutulan ağırtılmış ham selülozdan elde edilen nanofibrillenmiş selüloz kalsiyum sülfat esaslı kompozit karışımının içerisine ağırlıkça toz bağlayıcının %1, 3, 5, 10 ve 15 oranlarında katılmıştır. Hazırlanan karışımlar drenajlı preste sıkıştırılarak kompozit levhalar üretilmiştir. 1 gün sonra 24 saat süresince fırında kurutulan levhalardan alınan örnekler üzerinde yoğunluk, sertlik, nem düzeyi, statik yük taşıma kapasitesi ve eğilme dayanımı deneyleri gerçekleştirilmiştir.
Sonuçlar: Nanoselüloz miktarına bağlı olarak yoğunluk, nem ve sertlik değerlerinde anlamlı bir değişimin meydana gelmediği, ancak statik kırılma yükü ve eğilme dayanımı değerlerinde artışların meydana geldiği görülmüştür.
Anahtar Kelimeler: Nanoselüloz, Kalsiyum Sülfat, Kompozit, Eğilme dayanımı, Yoğunluk.

ABSTRACT
Introduction and purpose: Nanocellulose (NC) has become an important part of composite material technology in recent years. This material is used especially for the reinforcement of polymer composites and to increase their performance. Nanocellulose stands out as an alternative to traditional materials thanks to its properties such as high mechanical strength and low density. The use of nanocellulose in composites has a great potential especially in the

automotive and construction sectors. Nanocellulose has gained an important place in many industries, especially in composite material applications, thanks to its natural polymeric structure. In this study, it is aimed to improve the properties of composite boards produced for raised floor systems by integrating nanocellulose into calcium sulfate-based composites.
Material and Method: Nanofibrillated cellulose obtained from weighted raw cellulose subjected to mechanical fibrillation processes was added to the calcium sulfate-based composite mixture at 1, 3, 5, 10 and 15% of powder binder by weight. The prepared mixtures were compressed in a drained press and composite boards were produced. Density, hardness, moisture level, static loading and bending strength tests were performed on samples taken from the sheets dried in the oven for 24 hours after 1 day.
Results: It was observed that there was no significant change in density, moisture and hardness values depending on the amount of nanocellulose, but there were increases in static breaking load and bending strength values.
Keywords: Nanocellulose, Calcium Sulfate, Composite, Bending strength, Density.

GİRİŞ

Kompozit üretiminde cam veya karbon elyaf takviyesi yanında özellikle son yıllarda biyolojik kaynaklardan elde edilen liflerin kullanımı önemli ölçüde artmıştır. Biyolojik olarak parçalanabilir, petrol bazlı olmayan, düşük CO_2 emisyonlu ve düşük çevresel, hayvan, insan sağlığı ve güvenliği risklerine sahip, yenilenebilir ve sürdürülebilir kaynaklardan üretilen ürünlere talep giderek artmaktadır. Doğal selüloz bazlı malzemeler (odun, kenevir, pamuk, keten, vb.) orman ürünleri toplumumuz tarafından kağıt, tekstil, vb. gibi dünya çapındaki endüstrilerde binlerce yıldır mühendislik malzemeleri olarak kullanılmıştır ve, bugün de kullanımı devam etmektedir [1].

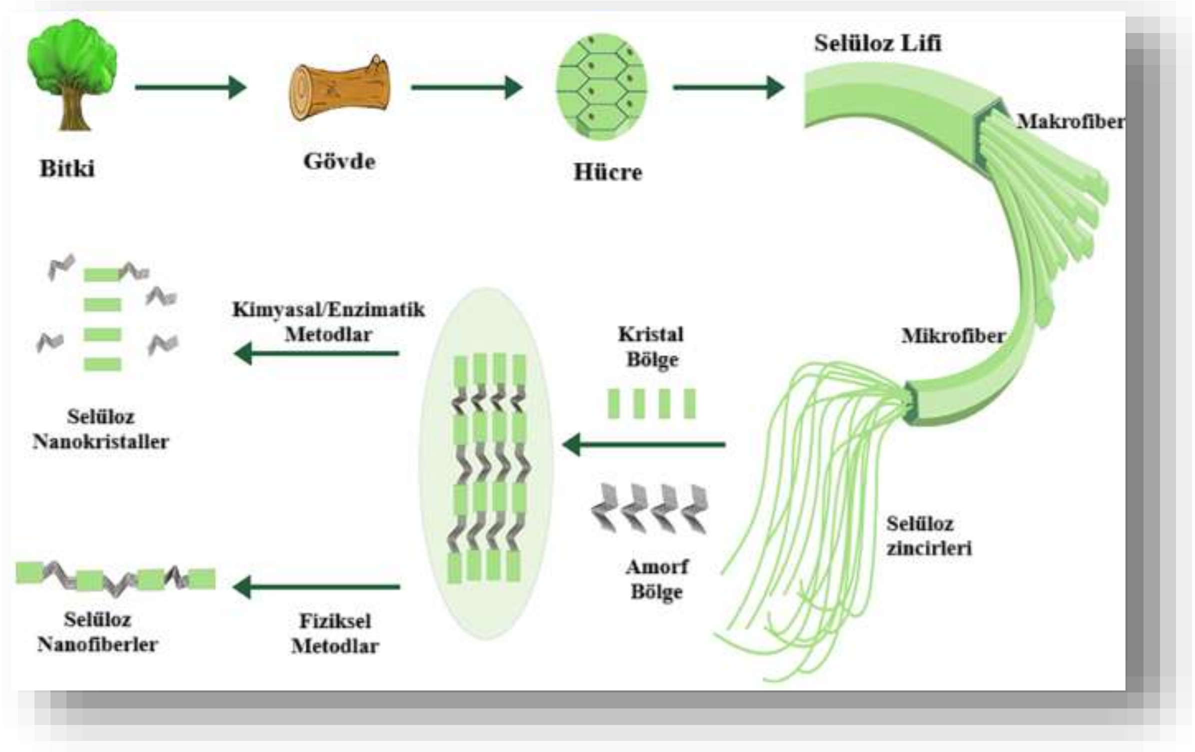
Çimentolu kompozitlerin performansını ve sürdürülebilirliğini arttırmaya yönelik nanosilika ve karbon nanotüpler (CNT'ler) gibi nanomalzemeler uzun yıllardır kullanılmaktadır. Selüloz yalnızca yeni bir nanomalzeme değil, aynı zamanda dünyadaki en bol bulunan organik madde ve doğal olarak hidrofilik bir polimerdir [2]. Bol miktarda bulunan, yenilenebilir ve sürdürülebilir bir katkı maddesi olan selüloz, çevresel etkileri azaltırken çimento ve alçı esaslı matrislerin performansını iyileştirebilir [3].

Son yapılan çalışmalarda NS'lerin çimentolu kompozitlerde bir takviye ürünü olarak kullanıldığını göstermektedir [4]. Lekshmi ve arkadaşları yaptıkları çalışmada [58], çimento harcı için takviye olarak sisalden elde ettikleri %3,3 ağırlıkta NS kullanılmıştır. NS takviyeli harçlar için mikro selülüz takviyeli harçlara kıyasla eğilme mukavemetinde %26'lık ve elastik modülde %42'lik bir artış meydana geldiğini belirtmektedirler [5] .

Nanoselüloz, yüksek mekanik dayanım, düşük yoğunluk ve biyolojik kökenli olmaları gibi özellikleri sayesinde, geleneksel malzemelere alternatif olarak öne çıkmaktadır. Nano selüloz, yüksek yüzey alanı, yüksek mukavemet ve hafifliği sayesinde başka bir hidrolik bağlayıcı olan alçı matrisli kompozitlerin de takviye malzemesi olarak kullanılabileceği, elde edilen alçı matrisli kompozitlerin mekanik, fiziksel ve kimyasal özelliklerini önemli ölçüde iyileştirebileceği düşünülmektedir [6] .

Selüloz; yaklaşık $1,5x10^{12}$ tonluk biyokütle [7] ile dünya üzerinde en yaygın bulunan, tükenmez organik polimer olan bir ham madde kaynağıdır [8]. Bitkilerin önemli bir bileşeni olan selüloz, elastisiste modülü 145 GPa, çekme dayanımı 7,5 GPa civarında, nispeten düşük yoğunluk (1,6 g/cm^3) ve yüksek en boy oranı (3–5 nm genişliğinde, 50–500 nm uzunluğunda) olduğundan olağanüstü mekanik özelliklere sahiptir [9].

Doğal kaynaklardan elde edilen selüloz yapılar; fiberlerin en/boy oranı, morfolojisi, boyutları, kristallik derecesi gibi özelliklerine göre farklı şekillerde isimlendirilmektedir. Boyut ve morfolojilerine göre selüloz; selüloz mikrofibril-SMF (MFC: micro fibrillated cellulose), selüloz mikrokristal-SMK (MCC: micro crystalline cellulose), nanofibril selüloz-SNF (NFC: nano fibrillated cellulose) ve nanokristalin selüloz-SNK (NCC: nano crystalline cellulose) olarak sınıflandırılabilmektedir (Şekil 1) [10].



Şekil 1. Bitkilerden nanoselüloz hazırlanmasının şematik gösterimi [11]

Nanoselülozun en yaygın formları selüloz nanofibrilleri (CNF), selüloz nanokristalleridir (CNC) . CNC genellikle kısa, çubuk şeklinde parçacıklara sahipken, CNF parçacıkları tipik olarak daha uzun, daha esnektir ve sıklıkla dallıdır. CNC genellikle filmler [12] ve bariyerler gibi şeffaf uygulamalar için kullanılırken, CNF genellikle takviye uygulamaları ve viskozite modifikasyonu için kullanılır[13] [14] .

Selülozik biyokütlelerden elde edilen CNF'lerin genişlikleri 100-140 nm arasında olurken, uzunlukları ise 3000 nm'ye kadar ulaşmaktadır. CNC ile kıyaslandığında kristalinite dereceleri düşüktür ve daha amorf bir yapıya sahiptir [15].

Kaplama, otomobil ve yapı malzemeleri, sağlık ve katkı maddesi üretimi gibi çeşitli uygulamalarda kullanılan CNF yüksek özgül yüzey alanı, mukavemeti, en boy oranı; boyutsal kararlılığı, kimyasal işlevselliği, termal kararlılığı ve optik özellikleriyle ön plana çıkmaktadır. CNF'nin yüksek yoğunluğa sahip oluşu, elektriksel iletkenliğini de düşürdüğünden dielektrik malzeme olarak kullanıma uygundur [16][17].

Ülkemizde mevcut durumda bina içi düzenlemeleri içeren yılda yaklaşık 750.000m² yükseltilmiş döşeme projesi gerçekleşmektedir. Yükseltilmiş döşeme sistemleri; kablolama, ısıtma, soğutma ve havalandırma tesisatlarının zeminde yoğun olarak kullanıldığı mekanlarda gerek duyulan tüm estetik ve fonksiyonel koşulları sağlayan sistemlerdir.

Kablolar sistemin altında bırakılan boşlukta gizlenebildiği gibi, gerek duyulduğunda defalarca müdahale imkânı yarattığı için mekanların yerleşim planında kullanıcıya serbestlik sağlamaktadır (Şekil 2).

Şekil 2. Yükseltilmiş döşeme sistemi

Nanoselülozun kompozitlerdeki kullanımı, çevresel sürdürülebilirlik, mekanik dayanım ve enerji verimliliği gibi birçok alanda önemli avantajlar sunmaktadır. Nanoselülozun çeşitli türleri ve uygulama alanları, bu malzemenin potansiyelini daha da artırmakta ve gelecekteki araştırmalar için geniş bir alan sağlamaktadır [18]. Bu bağlamda, nanoselülozun kompozit malzemelerdeki rolü, hem akademik hem de endüstriyel açıdan büyük bir ilgi görmektedir. Çalışma kapsamında nanoselüloz takviyeli kalsiyum sülfat esaslı kompozit üretimi ve nano selülozun elde edilen kompozitin mekanik ve fiziksel özelliklerine etkileri araştırılmıştır [19].

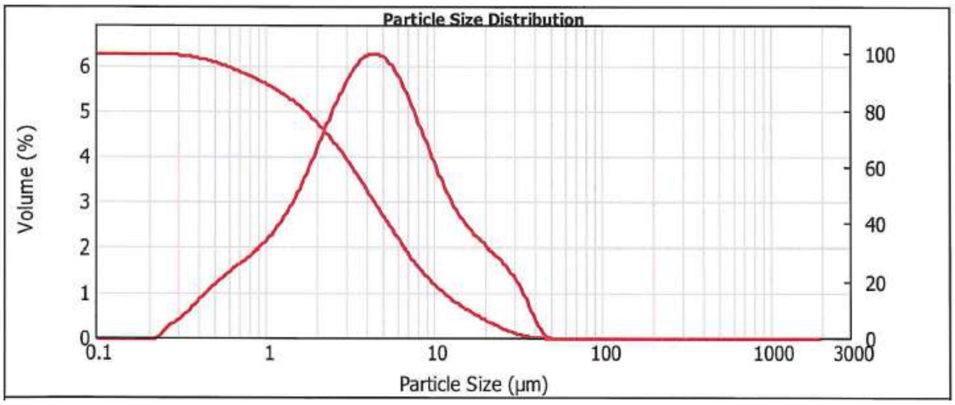
MATERYAL VE YÖNTEM

Kompozit malzeme üretim sürecinde Matris malzemesi olarak; TS EN 13279-1 [20]standardına uygun olarak üretilen ve DALSAN Alçı firmasından temin edilen alçı kullanılmıştır.

Kullanılan matris malzemesine ait fiziksel özellikler Tablo 1'de, tane boyut dağılımları ise Şekil 3'te görülmektedir.

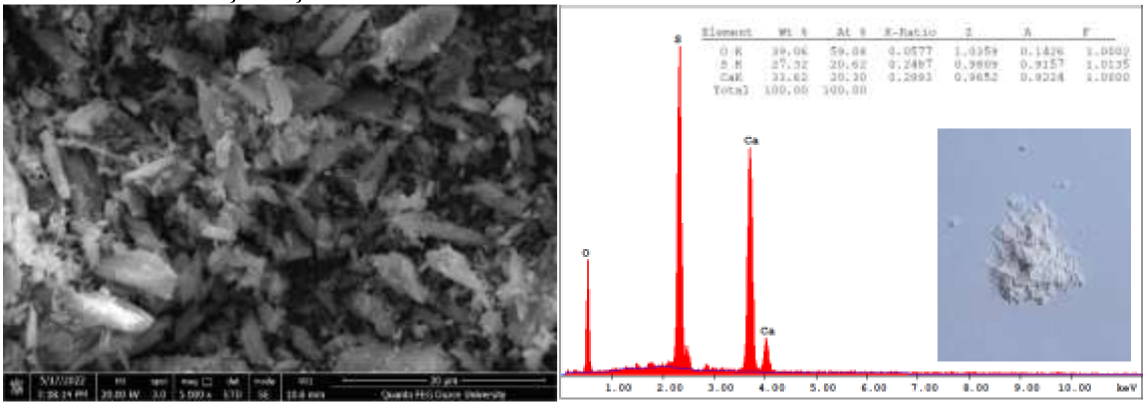
Tablo 1. Matris malzemesine ait mekanik ve fiziksel özellikler

Özellik	**Değerler**
Su / Alçı oranı	7 - 7,5 lt suya 10 kg alçı
Priz başlangıç süresi	> 8 dakika
Donma süresi	30 dakika
Basınç dayanımı (en az)	100 kgf/cm^2 (4x4 blok)
Eğilmede çekme dayanımı (en az)	45 kgf/cm^2 (4x4x16 blok)
200 mikron elekten geçen (en az)	%99,5
100 mikron elekten geçen (en az)	%95
Gevşek birim hacim ağırlığı (toz)	750-800 kg/m^3
Kuru Birim hacim ağırlığı	1050-1100 kg/m^3
Yangına tepki	A1



Şekil 3. Alçıya ait tane boyut analizi grafiği

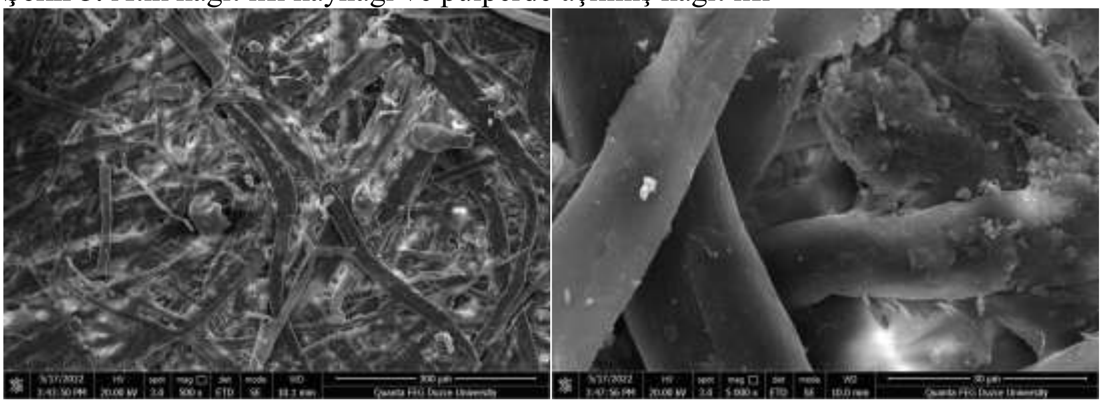
Kullanılan alçıya ait tane boyut dağılımı incelendiğinde tane boyutlarının 0,2-50 mikron aralığında değişim gösterdiği ortalama tane boyutunun 5 mikron olduğu, Alçının %80 inin 0,6-30 mikron aralığında tane boyutuna sahip olduğu görülmektedir. Ayrıca alçıya ait SEM ve EDS analizi sonuçları Şekil 4'te verilmektedir.



Şekil 4. SEM ve EDS analizi sonuçları

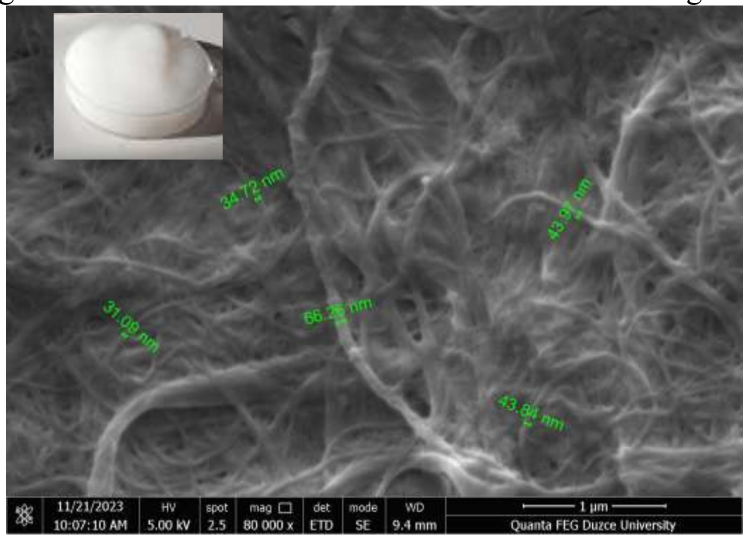
Kompozit üretimlerinde takviye malzemesi olarak 1. sınıf atık oluklu kartonlardan elde edilen selülozlar kullanılmaktadır. Yüksek kesafet pulperinde açılan %10 luk konsantrasyondaki selüloz hamuru kompozit üretiminde kullanılmıştır. Atık kağıt kaynağı ve pulperde açılmış durumdaki atık kağıt liflerinin görününümü Şekil 5'te, atık kağıt lifine ait SEM görüntüleri ise Şekil 6'da görülmektedir.

Şekil 5. Atık kağıt lifi kaynağı ve pulperde açılmış kağıt lifi



Şekil 6. Atık kağıt lifine ait SEM görüntüleri

Kalsiyum sülfat esaslı kompozit karışımlarında Fiber Kimya A.Ş. Firması tarafından ağırtılmış ham selülozdan mekanik liflendirme ile üretilen yüksek fibrilasyon düzeyine sahip nanoselüloz (nano fibrillenmiş selüloz) kullanılmıştır. %2 konsantrasyona sahip sulu süspansiyon formunda olan nanoselüloz kompozit karışımlarına alçı ağırlığının %1, 3, 5, 10 ve 15 i oranlarında katılmıştır. Jel formundaki nanoselüloza ait SEM görüntüsü Şekil 7'de görülmektedir. Nano selülozun 10-50 nanometre aralığında farklı çaplara sahiptir.



Şekil 7. Nanoselüloza ait SEM görünümü

Kompozit üretimlerinde ayrıca atık alçı tozu, su ve priz geciktirici kimyasal katkı malzemesi kullanılmıştır. Tablo 2'de karışım oranları belirtilen kompozit üretimi Şekil 7'de görülen üretim prosesleri sonrasında kürleme sürecine tabi tutulmuştur. Üretilen kompozit levha ve bu levhalardan alınan örnekler üzerinde deneysel çalışmalar gerçekleştirilmiştir.

Tablo 2. Nanoselüloz takviyeli kompozit karışım tablosu

SN	Malzeme	Referans	%1 NS	%3 NS	%5 NS	%10 NS	%15 NS
1	Alçı	40	40	40	40	40	40
3	Alçı tozu	5	5	5	5	5	5
4	Su	50	50	50	50	50	50
5	Kağıt hamuru	4,5	4,5	4,5	4,5	4,5	4,5
6	Priz geciktirici	0,5	0,5	0,5	0,5	0,5	0,5
7	Nanoselüloz (%2)	0,0	0,4	1,2	2,0	3,9	5,9

Şekil 7. Kalsiyum sülfat esaslı atık kağıt lifi ve nanoselüloz takviyeli kompozit levha üretim prosesi.

Elde edilen kompozit karışımları üzerinde üretim sürecinde baskı süresi, levha kalınlığı, preste ve fırında atılan su miktarı gibi özellikleri, üretilen kompozit numuneleri üzerinde ise nem miktarı, TS EN 12825 [21] standardına göre statik yük taşıma kapasitesi, eğilme dayanımı deneyleri ve SEM analizi gerçekleştirilmiştir (Şekil 8).

Şekil 8. Üretilen kompozit numuneler üzerinde gerçekleştirilen deneyler

BULGULAR VE TARTIŞMA

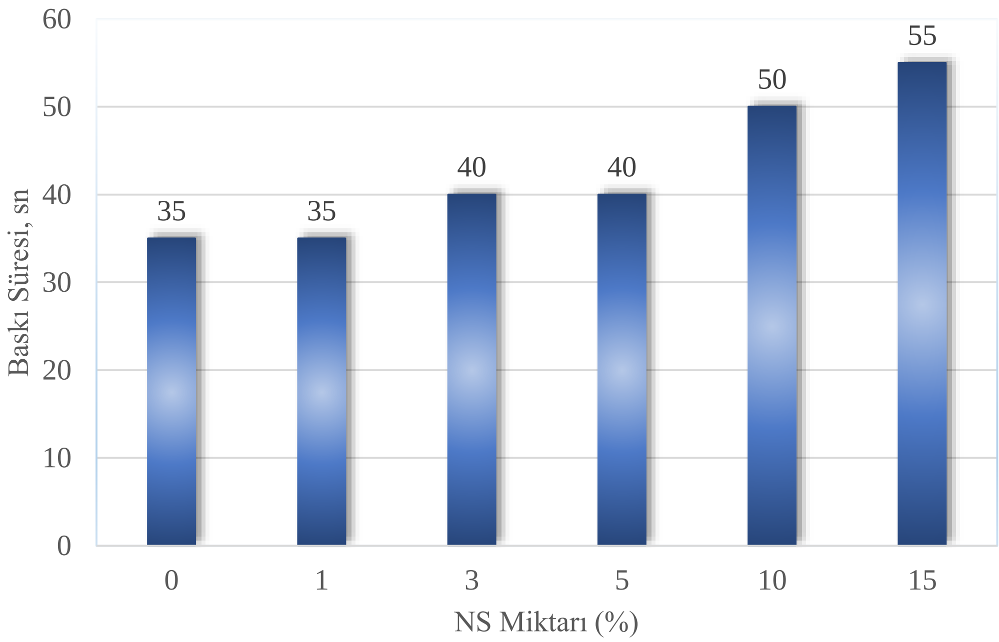
Farklı NS takviyeli olarak üretilen kalsiyum sülfat matrisli kompozit örnekler üzerinde üretim sürecinde ve elde edilen örnekler üzerinde gerçekleştirilen yoğunluk, nem miktarı, statik yük taşıma kapasitesi ve eğilme dayanımı gibi deneysel çalışmalardan elde edilen sonuçlar Tablo 3'te verilmiştir.

Tablo 3. Kompozit karışımlarından ve üretilen numunelerden elde edilen veriler

NS Miktarı (%)	Baskı Süresi, (sn)	Levha Kalınlığı (mm)	Preste atılan su miktarı (%)	Fırında atılan su miktarı (%)	Yoğunluk (kg/m³)	Nem Miktarı (%)	Kırılma Yükü, (N)	Eğilme Dayanımı, (MPa)
	35	36	33	7	1666,6	21	3582	8,15
1	35	36	34	8	1680,2	22	3621	8,47
3	40	36	33	8	1684,8	21	3670	8,54
5	40	38	32	8	1675,7	22	3844	9,22
10	50	36	33	9	1680,2	21	3865	9,75
15	55	37	33	8	1671,1	21	3914	8,96

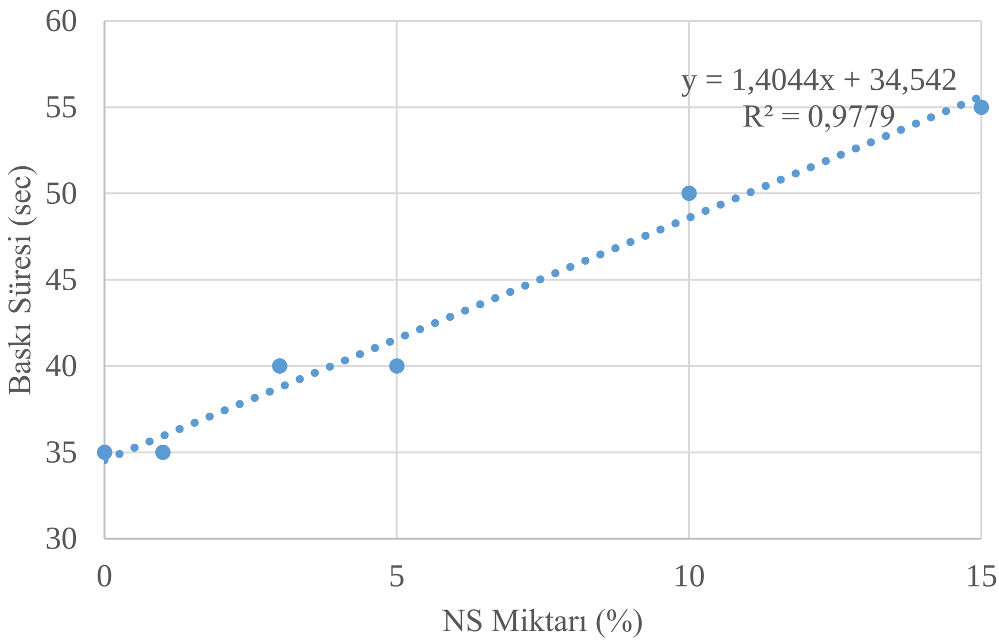
Baskı Süresi ve Preste Atılan Su Miktarı

Kompozit karışımları presleme süresince eşit levha kalınlığını sağlayacak şekilde basınca maruz bırakılmıştır. Levha üretim sürecinde ölçülen baskı sürelerine ait bar grafik Şekil 9'da, NS miktarı ile baskı süresi arasındaki ilişkiyi açıklayan grafik ise Şekil 10'da verilmiştir.



Şekil 9. Levha üretim sürecinde ölçülen baskı süreleri

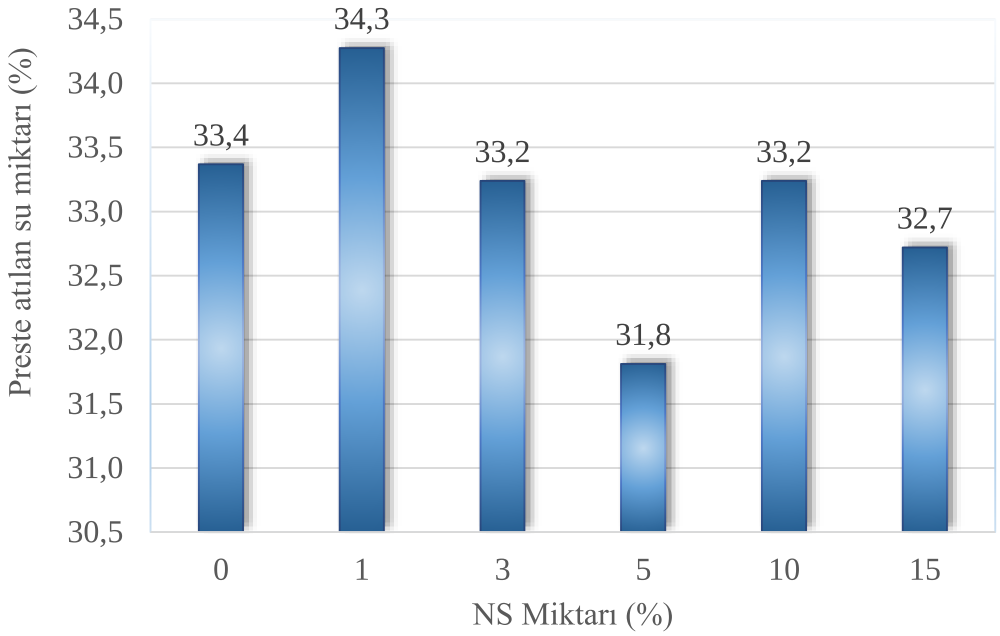
Baskı sürelerinin NS miktarına bağlı olarak değişiklik gösterdiği, takviye edilen NS miktarı arttıkça baskı sürelerinin de uzadığı görülmektedir.%1 oranında NS takviyeli kompozit karışımlarında baskı süresinde herhangi bir artış meydana gelmezken, %3, 5, 10 ve 15 oranında NS takviyeli kompozit karışımlarında baskı sürelerinin referans numuneye göre sırasıyla 14, 14, 42 ve 57 oranında artış gösterdiği tespit edilmiştir.



Şekil 10. NS miktarı ile baskı süreleri arasındaki ilişki grafiği

NS miktarı ile baskı süreleri arasında 1. Dereceden Y=a+bX model denklemi ile açıklanabilen doğrusal bir ilişki olduğu, ilişkiyi açıklayan model denklemin Y = 1,4044x + 34,542 olduğu tespit edilmiştir. Hidrofilik bir yapıya sahip olan NS bünyesinde tutulan suyun pres sırasında atılabilmesi için baskı süresini arttırdığı görülmektedir.

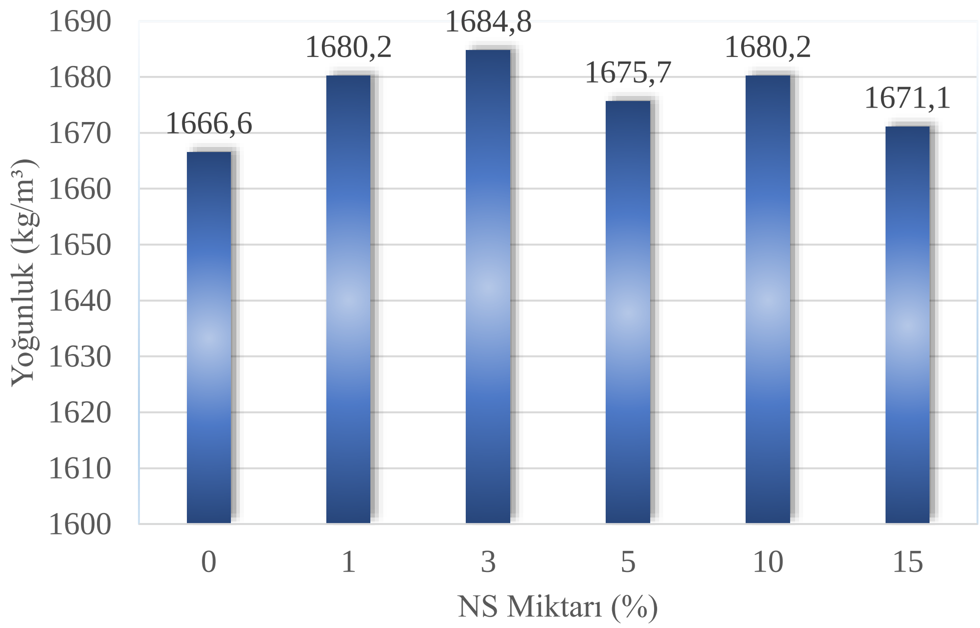
Diğer taraftan preste atılan su miktarına dair elde edilen ölçümlere ait sonuçlar Şekil 11'de verilmiştir. Preste atılan su miktarları incelendiğinde referans numuneye göre farklılıklar olduğu görülse de %4'ten daha küçük farkların ortaya çıktığı tespit edilmiştir. NS takviyeli kompozitlerin üretim prosesinde preste atılan su miktarları bakımından anlamlı bir farkın olmadığı görülmektedir.



Şekil 11. Preste atılan su miktarlarına ait bar grafik

Yoğunluk

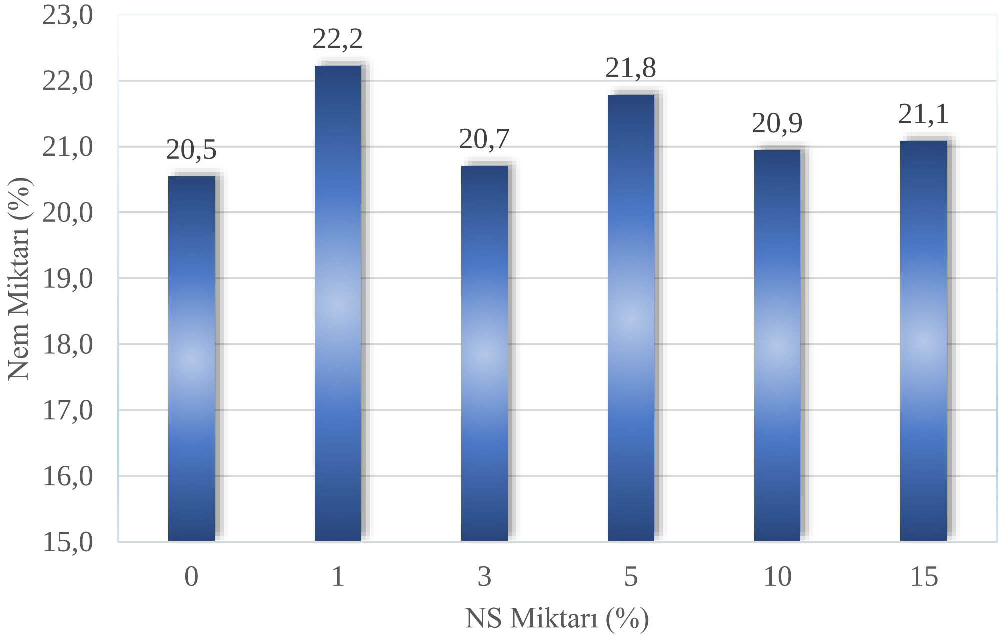
Sertleşmiş kompozit levhalar üzerinde gerçekleştirilen yoğunluk ölçümlerine ait ortalama yoğunluk değerlerini gösteren bar grafik Şekil 12'de görülmektedir. NS takviye miktarına bağlı olarak yoğunluk değerlerinde anlamlı bir farkın olmadığı, yoğunluk değerlerinin referans numuneye göre %1'in altında kalan küçük farklılıkların ortaya çıktığı tespit edilmiştir.



Şekil 12. Ortalama yoğunluk değerlerine ait bar grafik

Nem Miktarı

NS takviyeli kalsiyum sülfat matrisli kompozitler üzerinde gerçekleştirilen nem miktarı ölçümlerine ait ortalama nem miktarları Şekil 13'te görülmektedir.

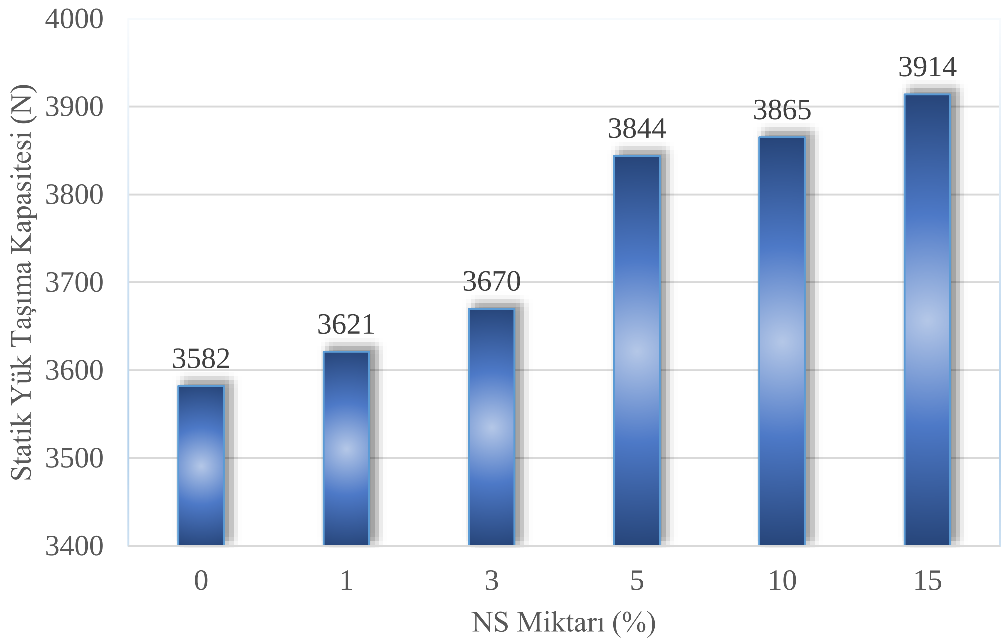


Şekil 13. Ortalama nem miktarı değerlerine ait bar grafik

Kürlenmiş kalsiyum sülfat levhalar üzerinde ölçülen nem miktarı değerlerinde referans numuneye göre sırasıyla %8, 1, 6, 2 ve 3 oranında değişimlerin meydana geldiği, NS miktarındaki artışa bağlı olarak, kurutma prosesi sonrası bünyede tutulan nem miktarında %1 ve %5 oranındaki takviye oranları dışında anlamlı bir değişimin meydana gelmediği görülmüştür.

Statik Yük Taşıma Kapasitesi

Sertleşmiş kompozit levhalar üzerinde statik yük taşıma kapasitesi deneyinden elde edilen ortalama kırılma yüklerine ait bar grafiği Şekil 14'te görülmektedir. Elde edilen sonuçlar incelendiğinde NS takviye miktarına bağlı olarak statik yük taşıma kapasitesi değerlerinde önemli değişimlerin meydana geldiği görülmektedir.

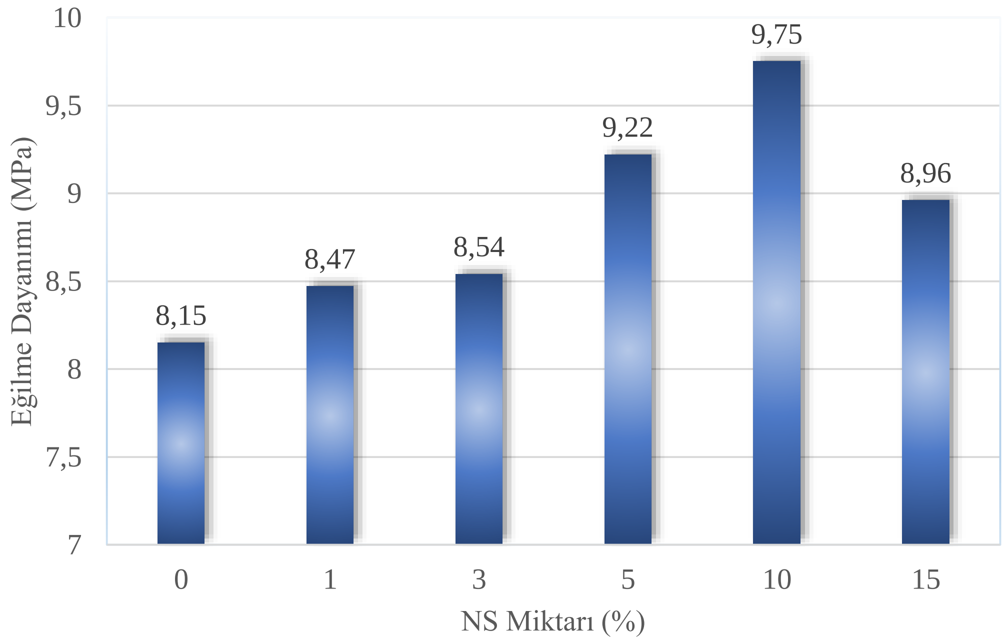


Şekil 14. Ortalama statik yük taşıma kapasitesi değerlerine ait bar grafik

Statik yük taşıma kapasitelerinin NS miktarındaki artış ile doğru orantılı olduğu, en küçük değerlerin referans numunede meydana geldiği, en büyük değerlerin ise %15 NS takviyeli kompozitlerde meydana geldiği, referans numuneye göre sırasıyla %1, 2, 7, 8 ve 9 oranlarında artışların meydana geldiği tespit edilmiştir.

Eğilme Dayanımı

Kompozit örnekler üzerinde TS EN 13279-2 standardına uygun olarak gerçekleştirilen eğilme dayanımı deneyi sonucunda elde edilen ortalama eğilme dayanımı değerlerine ait bar grafik Şekil 15'te görülmektedir. Elde edilen değerler incelendiğinde NS takviye miktarına bağlı olarak eğilme dayanımlarında önemli değişimlerin meydana gelmektedir.



Şekil 15. Ortalama eğilme dayanımı değerlerine ait bar grafik

Kompozitler levhalardan kesilen örnekler üzerinde gerçekleştirilen eğilme deneyinden elde edilen değerler incelendiğinde, NS takviye miktarındaki artış ile %10'a kadar doğru orantılı olduğu, en küçük eğilme dayanımının referans numunede meydana geldiği, en büyük dayanımın ise %10 NS takviyeli kompozitte meydana geldiği, eğilme dayanımı değerlerinin referans numuneye göre sırasıyla %4, 5, 13, 20, 10 oranlarında eğilme dayanımı değerlerinin attığı tespit edilmiştir. NS takviyesi ile eğilme dayanımlarının %20 ye varan oranlarda bir iyileşme sağlandığı görülmüştür.

SONUÇ VE ÖNERİLER

Nanoselülozun kalsiyum sülfat esaslı kompozitlere takviye edilerek yükseltilmiş döşeme sistemleri için üretilen kompozit levhanın özelliklerinin iyileştirilmesi amacıyla, mekanik liflendirme süreçlerine tabi tutulan ağırtılmış ham selülozdan elde edilen nanofibrillenmiş selüloz kalsiyum sülfat esaslı kompozit karışımının içerisine ağırlıkça toz bağlayıcının %1, 3, 5, 10 ve 15 oranlarında katılmıştır. Hazırlanan karışımlar preste sıkıştırılarak kompozit levhalar üretilmiştir. Üretilen kompozit levhalar üzerinde, baskı süresi, yoğunluk, nem miktarı, statik yükleme ve eğilme dayanımı deneyleri gerçekleştirilmiştir.

NS takviyeli kalsiyum sülfat esaslı yükseltilmiş döşeme üretiminde kullanılan kompozit levhalar üzerinde gerçekleştirilen deneysel çalışmalar sonucunda elde edilen veriler değerlendirildiğinde; %2 lik sulu konsantrasyon formundaki NS'nin kompozit karışımının içerisine disperse edilmesinde herhangi bir zorluk yaşanmamıştır.

NS takviye edilen karışımların hedeflenen kalınlıktaki levha üretimi yapılabilmesi için gerekli olan presleme süresinde %50 ye varan artışların meydana geldiği, kurutma prosesi sonrası ölçülen nem miktarlarında ve yoğunluk değerlerinde anlamlı bir farklılığın olmadığı, NS takviyesi ile statik yükleme kapasitesi değerlerinde %9'a varan oranlarda artışların sağlandığı, NS takviyesi ile eğilme dayanımlarında ise %20 ye varan oranlarda bir iyileşme sağlandığı görülmüştür.

Doğal kaynaklardan elde edilen ve sürdürülebilir nitelikteki selüloz liflerinin yapı malzemeleri üretim süreçlerinde kullanım potansiyelinin oldukça yüksek olduğu, özellikle eğilme dayanımı açısından kritik önem taşıyan yükseltilmiş döşeme sistemleri, duvar ve asma tavan panel üretimleri, çimentolu lif levha üretimi ve alçı kartonpiyer üretimleri gibi farklı ürünlerin mekanik ve fiziksel özelliklerinin iyileştirmesinde kullanılabileceği değerlendirilmektedir.

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KAYNAKLAR

[1] K. Oksman and R. J. Moon, "Chapter 7 Characterization of Nanocomposites Structure," in Handbook of Green Materials, World Scientific, 2014, pp. 89–105.

[2] C. De Maria, P. Correia, and M. F. De Souza, "Mechanical Strength and Thermal Conductivity of Low-Porosity Gypsum Plates 2 . Materials and Methods," vol. 12, no. 1, pp. 95–99, 2009.

[3] R. J. Moon, A. Martini, J. Nairn, J. Youngblood, A. Martini, and J. Nairn, Cellulose nanomaterials review : structure , properties and nanocomposites. 2011.

[4] C. Correia, S. Francisco, R. Soares, and H. Savastano, "Nanofibrillated cellulose and cellulosic pulp for reinforcement of the extruded cement based materials," Constr. Build. Mater., vol. 160, pp. 376–384, 2018, doi: 10.1016/j.conbuildmat.2017.11.066.

[5] M. S. Lekshmi, S. Vishnudas, and K. R. Anil, "Lignocellulosic materials as reinforcement and replacement for binders in masonry mortar," Constr. Build. Mater., vol. 282, p. 122607, 2021, doi: 10.1016/j.conbuildmat.2021.122607.

[6] O. A. Hisseine, W. Wilson, L. Sorelli, B. Tolnai, and A. Tagnit-hamou, "Nanocellulose for improved concrete performance : A macro-to-micro investigation for disclosing the effects of cellulose filaments on strength of cement systems," Constr. Build. Mater., vol. 206, pp. 84–96, 2019, doi: 10.1016/j.conbuildmat.2019.02.042.
[7] N. Yüzer and D. Oktay, "Nano Selüloz Malzemelerin Çimento Esaslı Sistemlerde Kullanımı," pp. 113–134, 2023.
[8] O. Faruk, A. K. Bledzki, H. Fink, and M. Sain, "Biocomposites reinforced with natural fibers : 2000 – 2010," Prog. Polym. Sci., vol. 37, no. 11, pp. 1552–1596, 2012, doi: 10.1016/j.progpolymsci.2012.04.003.
[9] J. Kim et al., "Review of Nanocellulose for Sustainable Future Materials," vol. 2, no. 2, pp. 197–213, 2015, doi: 10.1007/s40684-015-0024-9.
[10] A. P. Becerril, The Influence Of Cellulose Nanocrystals On Performance And Transport Propertıes Of Cementıtıous, no. December. 2020.
[11] F. Zhang, R. Shen, N. Li, X. Yang, and D. Lin, "Nanocellulose : An amazing nanomaterial with diverse applications in food science," Carbohydr. Polym., vol. 304, no. September 2022, p. 120497, 2023, doi: 10.1016/j.carbpol.2022.120497.
[12] Q. Liao, H. Liu, Z. Chen, Y. Zhang, and R. Xiong, "Flexible and ultrathin dopamine modified MXene and cellulose nanofiber composite films with alternating multilayer structure for superior electromagnetic interference shielding performance," no. 3, 2023.
[13] S. Suresh, D. R. Salem, and R. K. Sani, Spectroscopy, microscopy and other techniques for characterization of bacterial nanocellulose and comparison with plant-derived nanocellulose. Elsevier Inc.
[14] Yanting Xu; Zhenzeng Wu; Ao Li; Nairong Chen; Jiuping Rao; Qinzhi Zeng, "Nanocellulose Composite Films in Food Packaging Materials : A Review," pp. 1–28, 2024, doi: https://doi.org/10.3390/polym16030423.
[15] B. Poyraz, A. Tozluoğlu, Z. Candan, A. Demir, M. Yavuz, and Ü. Büyuksarı, "TEMPO-treated CNF Composites : Pulp and Matrix Effect," vol. 19, no. 1, pp. 195–204, 2018, doi: 10.1007/s12221-018-7673-y.
[16] T. Xu et al., "Advanced Nanocellulose-Based Composites for Flexible Functional Energy Storage Devices," 2021, doi: 10.1002/adma.202101368.
[17] X. Huang, C. Wang, X. Ao, C. Li, and L. Yang, "Preparation and Properties of Cellulose Nanofiber-Reinforced Ionic Conductive Hydrogels Sensor," vol. 64, no. 6, pp. 765–774, 2022, doi: 10.1134/S0965545X22700420.
[18] Y. Terao, T. Yoshimura, and D. Kuroki, "Application of Cellulose Resin Composite," no. 3, pp. 1–7, 2023.
[19] J. A. Shatkin, V. Advisors, T. Wegner, T. Bilek, F. Service, and J. Cowie, "Market projections of cellulose nanomaterial-enabled products -Part 1: Applications," no. May, 2014, doi: 10.32964/TJ13.5.9.
TS EN 12825, Yükseltilmiş döşeme sistemleri, Turkish Standard, Mart 2003.
TS_EN_13279_2, Gypsum binders and gypsum plasters - Part 2: Test methods, Turkish Standard, Nisan 2014
[20] TS_EN_13279_2, Gypsum binders and gypsum plasters - Part 2: Test methods, Turkish Standard, Nisan 2014.
[21] TS EN 12825, Yükseltilmiş döşeme sistemleri, Turkish Standard, Mart 2003.

INVESTIGATION OF BIOHYDROGEN PRODUCTION POTENTIAL OF WOOD SAWDUST WASTE

AHŞAP TALAŞ ATIĞININ BİYOHİDROJEN ÜRETİM POTANSİYELİNİN ARAŞTIRILMASI

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ABSTRACT

Introduction and Purpose: The near depletion of non-renewable fuels and their negative environmental effects have increased interest in biofuels. Among biofuels, biohydrogen possesses the advantages of having H_2O as a by-product of combustion, being non-toxic, and being obtained by using wastewater/waste rich in carbohydrates. This study aims to determine the potential of biological hydrogen production through the dark fermentation method in batch bioreactors using mixed bacteria and wood sawdust waste at pH values of 4.5 and 4.0 under operating conditions.

Materials and Methods: Anaerobic batch bioreactors with a volume of 120 mL, designed to prevent the growth of phototrophic microorganisms, were used. In the study, mixed bacteria obtained from the anaerobic reactor of a biological wastewater treatment plant were heat pretreated at 100±1 ºC for 55 minutes. The bioreactors were capped to contain pretreated mixed bacteria, nutrient composition, and wood sawdust waste. After this process, nitrogen gas was given into the bioreactors for 4 minutes. Thus, oxygen was removed from the contents of the bioreactors. Bioreactors were operated in a 160 rpm shaker incubator in a dark room at 38±1 ºC. Gas sampling was carried out using a gas-tight glass syringe. Gas analysis was performed in a gas chromatography device. Calibration was performed with high-purity hydrogen, carbon dioxide, and methane gas.

Results and Discussion: No gas production was observed in the first hours in bioreactors operated at different pH values. Biohydrogen production was determined at the eighth hour in the bioreactors. After this hour, hydrogen production increased in the bioreactors and reached maximum hydrogen production. The study indicates that different pH values affect biohydrogen production.

Conclusion: Maximum biohydrogen production was determined as 2181.10^{-4} mL and 1161.10^{-4} mL in the bioreactor operated at pH values of 4.5 and 4.0, respectively. In addition, it was determined that biohydrogen production was better in the bioreactor operated at a pH value of 4.5. In conclusion, biohydrogen production was detected in all bioreactors operated at different pH values using wood sawdust waste.

Key Words: Wood Sawdust Waste; Biohydrogen Production; Bioreactor

ÖZET

Giriş ve Amaç: Yenilenebilir olmayan yakıtların tükenmek üzere olması ve bu yakıtların çevreye olumsuz etkileri, biyoyakıtlara ilgiyi arttırmıştır. Biyoyakıtlardan biyohidrojen, yanma yan ürününün H_2O olması, toksik olmaması ve karbonhidrat bakımından zengin atıksu/atık kullanılarak elde edilme avantajlarına sahiptir. Bu araştırmada, kesikli biyoreaktörlerde, karışık bakteriler ve ahşap talaş atığı kullanılarak, 4.5 ve 4.0 pH değeri

işletim koşullarında karanlık fermantasyon yöntemiyle biyolojik hidrojen üretim potansiyelinin belirlenmesi amaçlanmıştır.
Materyal ve Yöntem: 120 mL hacimli, fototrofik mikroorganizmaların gelişimini önleyecek şekilde tasarlanmış anaerobik kesikli biyoreaktörler kullanılmıştır. Araştırmada, biyolojik atık su arıtma tesisi anaerobik reaktöründen temin edilen karışık bakterilere, 100±1 ºC'de 55 dakika ısıl ön işlem uygulanmıştır. Biyoreaktörlerin ön işleme tabi tutulmuş karışık bakteri, besin bileşimi ve ahşap talaş atığı içeriği olacak şekilde kapakları kapatılmıştır. Bu işlem sonrası, biyoreaktörlerin içerisine 4 dakika azot gazı uygulanmıştır. Böylece, biyoreaktörlerin içeriğinden oksijen uzaklaştırılmıştır. Biyoreaktörler, 38±1 ºC sıcaklığa sahip karanlık odada işletilmek üzere 160 rpm çalkalayıcı inkübatörde işletilmiştir. Gaz örneklemesi, gaz sızdırmaz cam şırınga aracılığıyla yapılmıştır. Gaz analizi, gaz kromatografi cihazında gerçekleştirilmiştir. Yüksek saflıkta hidrojen, karbondioksit ve metan gazı ile kalibrasyon yapılmıştır.
Araştırma Bulguları ve Tartışma: Farklı pH değerinde işletilen biyoreaktörlerde, ilk saatlerde gaz üretimi olmadığı saptanmıştır. Biyoreaktörlerde sekizinci saatte biyohidrojen üretimi olduğu tespit edilmiştir. Bu saat sonrası biyoreaktörlerde, hidrojen üretimi artmış ve maksimum hidrojen üretimine ulaşılmıştır. Araştırma, farklı pH değerlerinin biyohidrojen üretimini etkilediğini göstermektedir.
Sonuç: 4.5 ve 4.0 pH değerinde işletilen biyoreaktörde maksimum biyohidrojen üretimi sırasıyla 2181.10^{-4} mL ve 1161.10^{-4} mL olarak saptanmıştır. Buna ilaveten, 4.5 pH değerinde işletilen biyoreaktörde biyohidrojen üretiminin daha iyi olduğu belirlenmiştir. Dolayısıyla, ahşap talaş atığı kullanılarak, farklı pH değerlerinde işletilen biyoreaktörlerin tamamında biyohidrojen üretimi tespit edilmiştir.
Anahtar Kelimeler: Ahşap talaş atığı; Biyohidrojen üretimi; Biyoreaktör

GİRİŞ

Enerji talebi, bireylerin yaşam tarzındaki değişikliklerle ilişkili olarak artmaktadır (Singh vd., 2021). Dünyada, yenilenebilir olmayan yakıtların tükenmek üzere olması ve bu yakıtların çevre üzerinde olumsuz etkileri birleştiğinde, çevre dostu alternatif enerji kaynaklarına verilmesi gereken önem artmıştır (Cui vd., 2010). Enerji geleceğinin yenilenebilir enerji olduğu bildirilmiştir. Dünyada, iklim değişikliğinin temel nedenlerinden birinin fosil yakıtların yakılması olduğu kabul edilmektedir. Bu nedenle, biyoyakıt üretimine ilişkin sürdürülebilir ve çevre dostu enerji kaynakları odaklı araştırmalara önem verilmektedir. Biyoyakıtlardan biyohidrojen, yanma yan ürününün H_2O olması ve toksik olmaması gibi avantajlar nedeniyle çevre dostu sürdürülebilir enerji kaynaklarından biri olarak rapor edilmiştir (Badawi vd., 2023). Biyoyakıt üretiminde endüstriyel, kentsel, tarımsal ve orman endüstrisi atıkları gibi çeşitli atıklar kullanılmaktadır. Bu atıkların, biyoyakıt üretiminde kullanımı hem atık yönetimine hem de biyoenerji üretimine katkı sağlamaktadır.
Biyohidrojen (i) fotofermantasyon, (ii) dolaylı biyofotoliz, (iii) doğrudan biyofotoliz, (iv) karanlık fermantasyon ve (v) hibrid sistem yöntemiyle üretilmektedir. Bu yöntemlerden karanlık fermantasyon, karbonhidrat bakımından zengin substratlar kullanılarak, anaerobik bakterilerle karanlıkta biyolojik hidrojen üretimidir. Bu substratlar kolay erişilebilir ve düşük maliyetlidir. Glikoz, galaktoz, ksiloz, sakaroz içerikli materyaller ve organik kökenli atıklar genel olarak hidrojen üretimi amacıyla kullanılmaktadır. Biyolojik hidrojen üretimi ham madde tipi, biyoreaktör işletim koşulları, spesifik bakteri veya karışık bakteri tipi gibi faktörlerden etkilenmektedir (Ananthi vd., 2024; Ayodele vd., 2023).
Bu araştırmada, kesikli biyoreaktörlerde, karışık bakteriler ile ahşap talaş atığının ön işleme tabi tutulmadan 4.5 ve 4.0 pH değeri işletim koşullarında kullanılarak, karanlık fermantasyon yöntemiyle biyolojik hidrojen üretim potansiyelinin belirlenmesi amaçlanmaktadır.

MATERYAL VE YÖNTEM

Biyoreaktörlerin İçeriği ve İşletimi

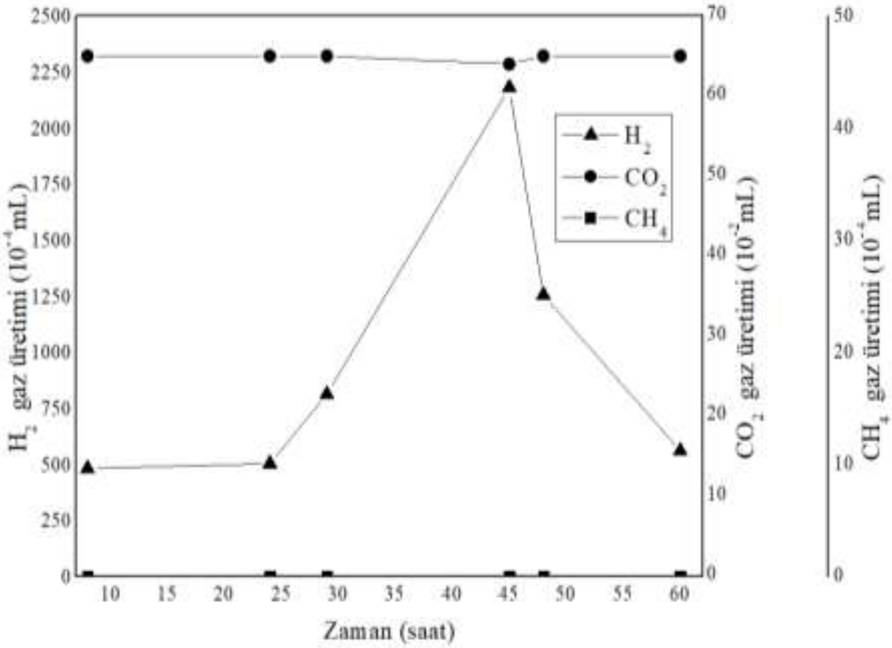
Araştırmada, fototrofik mikroorganizmaların gelişimini önleyecek şekilde tasarlanmış 120 mL hacimli anaerobik kesikli biyoreaktörler kullanılmıştır. Biyoreaktör kurulumları öncesi, biyolojik atık su arıtımını gerçekleştiren bir atık su arıtma tesisi anaerobik reaktöründen karışık mikroorganizma temin edilmiştir. Karışık mikroorganizma, biyoreaktörlere takviye edilmeden önce, 55 dakika 100±1 ºC'de ısıl ön işleme tabi tutulmuştur. Biyoreaktörlerin besin bileşimi $Na_2MoO_4.2H_2O$ 14.4 mg L^{-1}, $CuCl_2.H_2O$ 10 mg L^{-1}, $FeCl_3.6H_2O$ 20 mg L^{-1}, $CoCl_2.6H_2O$ 21 mg L^{-1}, $ZnCl_2$ 23 mg L^{-1}, $NiSO_4$ 32 mg L^{-1}, $MnCl_2.4H_2O$ 30 mg L^{-1}, $MgSO_4.7H_2O$ 320 mg L^{-1}, $CaCl_2.2H_2O$ 500 mg L^{-1}, NH_4Cl 2500 mg L^{-1}, KH_2PO_4 250 mg L^{-1} olarak hazırlanmıştır (Fang vd., 2006; Dursun, 2024). 3 mm'den küçük partikül boyutlu lignoselülozik biyokütle tiplerinin hidrolizinin etkin ve erişilebilir olduğu bildirilmiştir (Barakat vd., 2014). Bu kapsamda, 3 mm'den küçük partikül boyutlu ahşap talaş atığı kullanılmıştır. Ön işleme tabi tutulmuş karışık bakteri, musluk suyuna takviye edilmiş besin bileşimi ve ahşap talaş atığından oluşan biyoreaktör bileşeni 90 mL olacak şekilde biyoreaktörlerin kapakları kapatılarak kurulumu tamamlanmıştır. Ardından, biyoreaktör içerisine 4 dakika azot gazı uygulanarak, biyoreaktör içeriğinden oksijen uzaklaştırılmıştır. Bu işlemler sonrası biyoreaktörler, 38±1 ºC sıcaklığa sahip karanlık odada işletilmek üzere 160 rpm çalkalayıcı inkübatörde işletilmiştir.

Analitik Metodlar

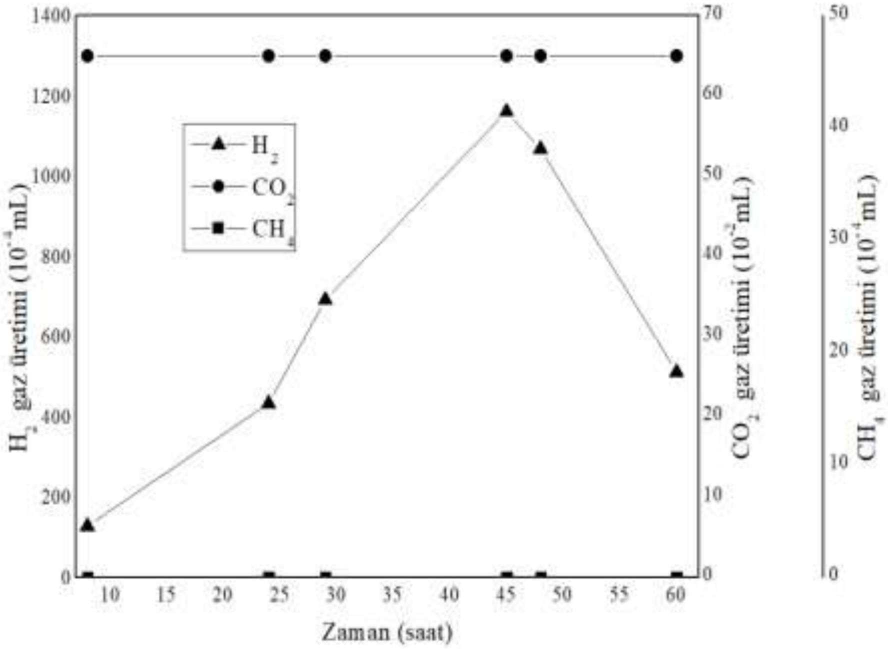
Gaz sızdırmaz musluklu cam şırınga aracılığıyla gaz örneklemesi yapılmıştır. Yüksek saflıkta hidrojen, karbondioksit ve metan gazı ile kalibrasyon yapılmış, kapiler kolon ve termal iletkenlik dedektörüne sahip gaz kromatografisinde (GC) gaz analiz edilmiştir. Analizde, taşıyıcı gaz olarak helyum kullanılarak, 230 ºC dedektör, 200 ºC enjeksiyon ve 35 ºC kolon sıcaklıklarında çalışılmıştır.

ARAŞTIRMA BULGULARI VE TARTIŞMA

Ön işleme tabi tutulmadan kullanılan 5 gr.ahşap talaşı/L'de 4.5 başlangıç pH değerinde işletilen biyoreaktörlerde ilk saatlerde gaz üretimi gerçekleşmediği saptanmıştır. Şekil 1'de sunulduğu üzere sekiz saatte 482.10^{-4} mL, yirmidört saatte 504.10^{-4} mL ve yirmidokuz saatte 813.10^{-4} mL hidrojen üretildiği tespit edilmiştir. Maksimum hidrojen üretiminin kırkbeş saatte 2181.10^{-4} mL olmasını takiben, bu saat sonrasında hidrojen üretimi azalan eğilim göstermiştir. 4.0 başlangıç pH değerinde, ön işleme tabi tutulmadan kullanılan 5 gr.ahşap talaşı/L'de işletilen biyoreaktörlerde ilk saatlerde gaz üretimi olmadığı belirlenmiştir. Biyoreaktörde sekiz saatte 128.10^{-4} mL, yirmidört saatte 434.10^{-4} mL ve yirmidokuz saatte 692.10^{-4} mL hidrojen, Şekil 2'de sunulduğu üzere saptanmıştır. Maksimum hidrojen üretimi, 1161.10^{-4} mL olarak kırkbeş saatte tespit edilmiştir. Bu saat sonrası hidrojen üretimi azalma eğilimi göstermiştir.



Şekil 1. 4.5 pH değeri işletiminde hidrojen gazı üretimi



Şekil 2. 4.0 pH değeri işletiminde hidrojen gazı üretimi

Aynı koşullarda, farklı (4.5 ve 4.0) pH değerlerinde işletilen biyoreaktörler incelendiğinde, her iki işletim koşulunda da biyohidrojen üretiminin gerçekleştiği, ancak 4.5 pH değerinde işletilen biyoreaktörde hidrojen üretiminin daha iyi olduğu belirlenmiştir. Bu araştırmadaki gibi ham maddeye ön işlem uygulanmadan doğrudan biyohidrojen üretim potansiyelinin incelendiği araştırmaların sayısı sınırlıdır. Biyohidrojen üretimi araştırmalarında, genel olarak spesifik veya karışık bakteriler kullanılmıştır. Spesifik bakterinin kullanıldığı Ivanova vd., (2009) tarafından yapılmış bir çalışmada, Caldicellulosiruptor saccharolyticus kullanılarak ön işlem görmemiş buğday samanının fermantasyon yoluyla biyohidrojen üretim potansiyeli incelenmiştir. 70 °C'de, 7.2 pH'da gerçekleştirilen araştırmada, %1 substrat konsantrasyonunun üzerinde substrat inhibisyonu olduğu saptanmıştır. %1 substrat konsantrasyonuna sahip kuru katı buğday samanı çalışmasında 44.68 L/kg kuru buğday samanı hidrojen verimi olduğu belirlenmiştir. Karışık bakterilerin kullanıldığı Alemahdi vd., (2015) tarafından yapılmış çalışmada da, ham pirinç samanı ve ısıl (100 °C'de 60 dakika) ön işlem uygulanmış aktif çamur kullanılarak biyohidrojen üretimi mezofilik (35 °C) koşullarda incelenerek, 14.22 NmL H_2/g VS hidrojen verimine ulaşılmıştır. Marone vd., (2012) tarafından ise, bitkisel atıkların kendi kendine fermantasyonu ve bitkisel atıklardan izole edilerek zenginleştirilmiş *Buttiauxella* sp. 4, *Rahnella* sp. 10 ve *Raoultella* sp. 47 hidrojen üretimini gerçekleştiren üç suş, hem ayrı ayrı hem de üç suşun birlikte kullanıldığı bakteriyel yapay konsorsiyumla karşılaştırılmıştır. 28 °C'de gerçekleştirilen çalışmada, tüm bakteriyel inokulümler de, kendi kendine fermentasyona kıyasla hidrojen üretim oranında önemli bir artış olduğu saptanmıştır. Yapay konsorsiyum inokulümü, 2.56 mL H_2/saat olarak en yüksek hidrojen üretimiyle sonuçlanmıştır. Biyohidrojen üretim potansiyelinin incelenmesine ilişkin araştırmalar genel olarak, biyoreaktör işletim koşulları, bakteri (spesifik veya karışık) tipi, ham madde (katı veya sıvı) formu ve tipinin önemli olduğunu göstermektedir.

SONUÇ

Araştırmada, ahşap talaş atığı kullanılarak, 4.5 ve 4.0 pH değerinde işletilen 120 mL hacimli anaerobik kesikli biyoreaktörlerde biyohidrojen üretim potansiyeli incelenmiştir. 4.5 ve 4.0 pH değerinde işletilen biyoreaktörde maksimum hidrojen üretimi sırasıyla 2181.10^{-4} mL ve 1161.10^{-4} mL olarak saptanmıştır. Buna ilaveten, 4.5 pH değerinde işletilen biyoreaktörde biyohidrojen üretiminin daha iyi olduğu belirlenmiştir. Dolayısıyla, farklı pH değerlerinde işletilen biyoreaktörlerin tamamında biyohidrojen üretimi tespit edilmiştir.

KAYNAKLAR

Alemahdi, N., Che Man, H., Rahman, N.A., Nasirian, N., Yang, Y. (2015). Enhanced mesophilic bio-hydrogen production of raw rice straw and activated sewage sludge by co-digestion. International Journal of Hydrogen Energy, 40(46), 16033-16044. https://doi.org/10.1016/j.ijhydene.2015.08.106

Ananthi, V., Ramesh, U., Balaji, P., Kumar, P., Govarthanan, M., Arun, A. (2024). A review on the impact of various factors on biohydrogen production. International Journal of Hydrogen Energy, 52, 33-45. https://doi.org/10.1016/j.ijhydene.2022.08.046

Ayodele, D.T., Ogunbiyi, O.D., Akamo, D.O., Otun, K.O., Akinpelu, D.A., Adegoke, J.A., Fapojuwo, D.P., Oladoye, P.O. (2023). Factors affecting biohydrogen production: Overview and perspectives. International Journal of Hydrogen Energy, 48(71), 27513-27539. https://doi.org/10.1016/j.ijhydene.2023.04.001

Badawi, E.Y., Elkharsa, R.A., Abdelfattah, E.A. (2023). Value proposition of bio-hydrogen production from different biomass sources. Energy Nexus, 10, 100194. https://doi.org/10.1016/j.nexus.2023.100194

Barakat, A., Mayer-Laigle, C., Solhy, A., Arancon, R.A.D., de Vriesa, H., Luque, R. (2014). Mechanical pretreatments of lignocellulosic biomass: towards facile and environmentally sound technologies for biofuels production. RSC Advances, 4, 48109-48127. DOI: 10.1039/C4RA07568D

Cui, M., Yuan, Z., Zhi, X., Wei, L., Shen, J. (2010). Biohydrogen production from poplar leaves pretreated by different methods using anaerobic mixed bacteria. International Journal of Hydrogen Energy, 35(9), 4041-4047. https://doi.org/10.1016/j.ijhydene.2010.02.035

Dursun, N. (2024). Biohydrogen production from Buckwheat residue using anaerobic mixed bacteria. Fermentation, 10(15), 1-16. https://doi.org/10.3390/fermentation10010015

Fang, H.H.P., Li, C., Zhang, T. (2006). Acidophilic biohydrogen production from rice slurry. International Journal of Hydrogen Energy, 31(6), 683-692. https://doi.org/10.1016/j.ijhydene.2005.07.005

Ivanova, G., Rákhely, G., Kovács, K.L. (2009). Thermophilic biohydrogen production from energy plants by Caldicellulosiruptor saccharolyticus and comparison with related studies. International Journal of Hydrogen Energy, 34(9), 3659-3670. https://doi.org/10.1016/j.ijhydene.2009.02.082

Marone, A., Massini, G., Patriarca, C., Signorini, A., Varrone, C., Izzo, G. (2012). Hydrogen production from vegetable waste by bioaugmentation of indigenous fermentative communities. International Journal of Hydrogen Energy, 37(7), 5612-5622. https://doi.org/10.1016/j.ijhydene.2011.12.159

Singh, T., Alhazmi, A., Mohammad, A., Srivastava, N., Haque, S., Sharma, S., Singh, R., Yoon, T., Gupta, V.K. (2021). Integrated biohydrogen production via lignocellulosic waste: Opportunity, challenges & future prospects. Bioresource Technology, 338, 125511. https://doi.org/10.1016/j.biortech.2021.125511

APPLICATION OF REMOTE SENSING METHODS IN AGRICULTURE

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ABSTRACT
Reflectance data is being used in agriculture more and more as satellite, aerial, and ground-based remote sensing technologies progress. This study examines several remote sensing techniques intended to preserve the environment and maximize the profitability of agricultural crop production. The study provides examples of how remote sensing data can be used to anticipate crop yields, evaluate plant nutritional needs and soil nutrient content, calculate plant water [20] demand, and control weeds.
Key words: crop irrigation, plant protection, agronomy, vegetation indices, and remote sensing.

Introduction
Remote sensing is the process of gathering information about items without actually touching them. The information carrier utilized in remote sensing is electromagnetic radiation, which moves in a vacuum at the speed of light as waves of various lengths. The wavelengths most suitable for remote sensing are visible light, shortwave, thermal infrared, near infrared, and microwave bands. Passive remote sensing sensors capture incident radiation that is reflected or emitted by the objects, whereas active sensors produce their own radiation that interacts with the target being studied and returns to the measuring device.

INDICES OF VEGETATION

Vegetation indices, which are unitless radiometric measurements, can be used to spectrally characterize the biophysical characteristics of plants. In the VIS, NIR, and SWIR wavelength ranges, they are computed as ratios or differences of two or more bands. A vegetation index is considered useful if it has a high correlation with plant biophysical parameters and is not sensitive to factors that interfere with the analysis of remote sensing data [12], such as soil background, relief, non-photosynthetic plant elements, atmosphere, viewing and illumination geometry, and so on. The most commonly used metric is the Normalized Difference Vegetation metric, which was first and is calculated as the ratio of the addition and difference of the reflectance in the red and near-infrared regions.

green parts of plants absorb red and blue light through chlorophyll and substantially reflect in the near-infrared spectrum due to scattering in the leaf mesophyll.The NDVI indicator is most commonly used to forecast the yields of farmed plants and to assess their condition, biomass, and developmental phases. Many attempts have been made to create other indices that might lessen the influence of the soil background and atmosphere on the outcomes of spectral measurements, and the NDVI has emerged as the most often used vegetation index.

The relationship between water stress and plant thermal characteristics is then explained by vegetation indices such as the Crop Water Stress Index [19], Surface Temperature, Water Deficit Index, and Stress Index [4]. Table 1 lists examples of vegetation indices used in particular agricultural applications that have been documented in the paper.

USE OF REMOTE SENSING IN AGRICULTURE

There are three types of remote sensing: satellite, aircraft, and ground-based. Spatial and spectral resolution should also be considered when evaluating a remote sensing system. The measurements of the smallest thing that can be recognized on the planet's surface are related to the spatial resolution, which specifies the pixel size of satellite or aerial photos that cover the planet's surface. The range of spectral bands in which a sensor may gather reflected radiation is reflected in its spectral accuracy.

Table 1. Vegetation indices discussed in paper

Index	Formulae	Application
Ratio vegetation index	RVI=NIR/RED	Estimating nitrogen status of winter wheat
Shortwave Infrared Water Stress Index	SIWSI=SWIR-NIR/SWIR+NIR	Indication of canopy wate
Advanced Normalised Vegetation Index	ANVI= NIR–BLUE/ NIR +BLUE	Mapping Ridolfia segetum patches in sunflower crop
Simple Ratio	SR=RED/NIR	Detection of pest infestation in regional scale
Chlorophyll index	CI=NIR/GREEN	Plant nitrogen status estimation
Damage sensitive spectral index	DSSSI=RED-NIR-BLUE-GREEN/ RED-NIR+BLUE-GREEN	Determine the pest damage on wheat
Effective Leaf Area Index	ELAI=-0.4+0.28NIR/RED	Winter oilseed rape yield prediction
Structure Insensitive Pigment Index	SIPI=NIR-BLUR/NIR-RED	Determine the pest damage on wheat
Green Normalized Difference Vegetation Index	GNDVI=NIR- GREEN/NIR+ GREEN	Corn yield predictions
Green Red Vegetation Index	GRVI=GREEN-RED/GREEN+RED	Estimation of damage caused by thrips
Optimized Soil Adjusted	OSAVI=NIR-RED/NIR-	Nitrogen status estimation of

Vegetation Index	RED+0.16	winter wheat
Normalized Difference Infrared Index	NDII=NIR-SWIR/NIR+SWIR	Detection of diurnal orchard canopy water content

Remote sensing based on the ground

Portable remote sensing devices are very useful for small-scale operational field oversight of biotic and abiotic stresses. Compared to satellite and aircraft remote sensing, this invention offers better temporal, spectral, and geographic resolutions. When compared to aeroplane and satellite-equipped sensors, which can be used to analyze considerably wider areas at a time, portable remote sensing's efficiency and frequently time-shortened nature limit its ability to scan confined locations. Identifying insect damage, predicting yield, weed control, moisture requirements, and plant nutritional needs are the most often studied issues in agricultural research utilizing field spectrometers.

REMOTE SENSING IN AIR

Unmanned Aerial Vehicles, which are aircraft controlled from a land control station, are gradually replacing manned aircraft, which are currently the main method used for airborne remote sensing. UAVs are often lightweight, slow-moving, low-cost aircraft that are perfect for gathering data remotely. UAVs currently fall into two primary categories: "fixed wing" and "rotatory wing." One benefit of fixed wing UAVs is their ability to fly for extended periods of time at high speeds with less complicated aerodynamics.

Some of them can take off and land without even a runway or launching device. One advantage of rotary wing UAVs is its ability to hover over a target and take off and land vertically. However, their flight range is limited because to their complicated mechanical design and low battery life.

UAVs provide a number of benefits, including the ability to obtain very high-resolution imagery, the ability to be used quickly and frequently, and flexibility in terms of altitude and operating scheduling. Individual plants, regions, voids, and designs throughout the terrains that have probably never been seen before can be observed thanks to this imaging. UAVs with a typical spatial resolution of 1–20 cm could help bridge the resolution gap between terrestrial platforms less than 1 cm and flying aircraft resolution of 0.2–2 m. With a spatial resolution of 1–20 cm and a swath width of 50–500 m, High resolution inputs required for site-specific crop management might be available via UAV platforms. Very high-resolution UAVs may also be employed in agronomic research, specialty crop management, and within-field variability studies. In recent years, various ultra-lightweight imaging systems weighing around 100 g have been created for use with UAVs. The ADC Micro is one of the lightest multispectral cameras on the market. It weighs 90 g and produces images in three wavelengths: green, red , and near-infrared.

Satellite photography

In the past, agricultural acreage estimation, general crop condition evaluation, and crop type classification have all made use of satellite imagery. Due to the limited spatial clarity of sensors, these applications were typically utilized across wide areas. However, more recent satellite sensors with finer resolutions are now enabling in-field evaluation of issues including hail damage, flooding, and drought stress.

The increasing number of satellite remote sensing applications does not negate the limitations of this technology. Changing weather conditions can have an impact on satellite imaging. Low-resolution satellite imagery is only useful for extensive research and might not be appropriate for small-scale farms. Additionally, higher-resolution satellites, such as QuickBird and ASTER, have longer revisit times, which limits their utility for any application that could need frequent photos. spacecraft are frequently placed in constellations, which are made up of a few synchronised spacecraft that overlap in ground coverage and are coordinated, in order to shorten the revisit time.

YIELD FORECASTING

Crop production forecasts using remote sensing have mostly relied on statistical-empirical correlations between vegetation indices and yield. When planning harvest, storage, transportation, and marketing operations, government organisations, commodities merchants, and producers greatly benefit from knowing the expected yield. Economic risk decreases with the speed at which this knowledge becomes available, leading to improved efficiency and higher returns on investments.

Remote sensing based on the ground

In a study on winter wheat, terrestrial spectra to predict yield at the start of the shooting stage. Numerous writers highlight the importance of plant growth in predicting yield. For instance, spectral assessments [14] conducted during the crop's full budding stage produced the best accurate production projections for winter oilseed rape. However, showed that wheat yields were best predicted when the plants entered the flowering stage, but the strongest correlation between the spectral data and the winter rape yield was achieved at the start of the flowering stage.

Several studies have demonstrated the value of NDVI index yield forecasting, however, RVI and ELAI indices also showed strong correlations with expected yield. Indices based on reflectance in green and near-infrared wavelengths had the strongest connection with yield before oilseed rape flowering. Indexes derived from reflectance in NIR wavelengths and their logarithmic modification showed to be more effective than non-transformed spectral data for yield predictions during rape flowering.

REMOTE SENSING IN AIR

Using parts of the VIS and NIR spectra multiple times during the development period, the use of aerial photos for predicting maize output has also been investigated. Crop production forecasting models can be greatly improved by using data from aerial remote sensing. Launay and Guerif developed a model that incorporates data from photos taken during the growing season. The root mean square error decreased from 20% to roughly 10% as yield predictions improved. The quantity and time of the photos, which determine the amount and kind of plant biophysical variables that may be assessed, determined how robust the model was. If remote sensing data were incorporated towards the end of the season, the model's predictions improved to 15% from 21% when yield evaluations were obtained for areas where the soil was not sufficiently defined. Additionally, the authors found that under extreme drought circumstances, the agricultural model was significantly less dependable.

Data gathered by a UAV platform can potentially be used to forecast yield. Swain and Zaman used an uncrewed aircraft to obtain multispectral photos in order to estimate the production of rice by utilizing a linear regression model showed a significant relationship ($R2=0.7$) between rice yield and spectral data.

Remote sensing via satellite

Crop yields were evaluated at the regional level using vegetation indices based on AVHRR/NOAA satellite imagery . The authors' model, which outlined relationships between satellite spectral data and Iow crop production, yielded substantial R2 values for soybean (0.8) and maize (0.8). Using AVHRR/NOAA pictures, the technology to examine grain development and production under Polish conditions. The authors developed a model that used evapotranspiration and LAI indices derived from AVHRR pictures to forecast wheat production with an error RMSE=12%.

Galvao investigated the feasibility of estimating soybean yield using satellite Hyperion hyperspectral pictures and found a strong connection ($r = 0.7$) between the weight of harvested seed and vegetation indicators [7]. Using an artificial neural network architecture, the model created by Li made it possible to predict maize and soybean yields at the local level using the MODIS sensor. The accuracy of the model is 85%. A modified version of the model

developed by Li was also used by Doraiswamy to investigate the feasibility of forecasting yields using MODIS satellite data.
Ground reflectance measurements were used to calibrate the model. Good agreement yields reported by the USDA-National Agricultural Statistics Service for maize and soybeans with differences of -3.12 and 6.62 percent were the results of the simulation.

PLANTS' NUTRITIONAL NEEDS

Remote sensing based on the ground

Techniques for ground-level remote sensing are also used to evaluate the nutritional needs of plants. Li demonstrated a positive linear connection between RVI and nitrogen [2] absorption in winter wheat of R2=0.60 and RMSE=30.5%, using a handheld radiometer that could measure the 325–1075 nm spectrum. The study conducted by Stroppiana used normalized difference indices, which are obtained by combining all possible wavelengths within the 350–2500 nm spectral region, to assess the plant nitrogen concentration in paddy rice.
Reflectance data in the visible portion of the spectrum 503 and 480 nm was used in that study to derive the best correlation (R2=0.65) between plant nitrogen levels and a normalized difference index. In a study on rice and wheat a strong association between canopy reflectance and leaf nitrogen buildup. When the ratio of reflectance at 810 nm to reflectance at 660 nm and the ratio of reflectance at 870 nm to reflectance at 660 nm were utilised in the computations, the best results were obtained R2=0.84 and 0.85. Gauging the reflectance using active sensors such as Crop Circle and Green Seeker used another method intended to assess nitrogen levels in an agricultural field. which have their own light source, in contrast to passive sensors. Typically, only two or three wavelengths are produced by active sensors. While the CropCircle model ACS-470 contains three measurement spectral channels and a set of NIR 770 nm and red 660 nm sensors, the GreenSeeker has an NIR 770 nm and a red 660 nm, while the CropCircle model ACS-470 offers three spectral channels for measurements and a collection of
The user can choose between interchangeable filters based on the application. The Yara N-sensor is more advanced than the GreenSeeker and CropCircle sensors and can collect spectral data in five single wavebands. For nitrogen fertilisation, this sensor has been effectively applied to corn, barley, triticale, sugarcane[18] and potatoes.

AIRBORNE

In order to differentiate between nitrogen-deficient and nitrogen-sufficient maize plots, reliability of ground level and airborne sensing approaches. This is an intriguing example of using airborne hyperspectral pictures for plant nutritional stress detection. Ground-level readings were obtained using SPAD, Dualex, and Multiplex sensors, while hyperspectral sensors Micro-Hyperspec VNIR imager were used to collect data in the air. 300 meters above the testing site, this camera captured radiance imagery in 260 bands in the 400–885 nm range. The study demonstrated that vegetation indices derived from aerial observations were just as accurate as those obtained using ground-level crop nitrogen status assessment equipment.
Goel provided extensive documentation on the application of airborne remote sensing in agriculture, confirming the technology's capacity to identify weed infestation and nitrogen deficit in maize. The study's goal was to ascertain the connection between the reflectance measured in the 72 VIS and NIR wavebands from 409 to 947 nm and spectral variations brought on by weeds in the crop and different fertiliser rates. The findings show that weed presence and plant nitrogen shortages have a major impact on maize reflectivity.
The growth stage seems to influence differences in other spectral regions, whether they were caused by weeds, nitrogen, or both. Thirty days after planting, sixty-six days after planting at the tasseling stage, and eighty-six days after planting at the full-grown stage, three airborne photos were obtained during the season. When maize was in the tasseling stage, weeds were most easily found. The effectiveness of the nitrogen status evaluations derived from

multispectral images captured by UAVs and data recorded using a ground-based platform was compared.

Remote sensing via satellite

There are also many instances of how satellite imagery is used to estimate the nitrogen status of crops. For instance, QuickBird satellite multispectral data could be utilized to accurately analyze the within-field spatial variability of maize's nitrogen status for in-season nitrogen management. reported similar findings, demonstrating that single band reflectance in red 640–720 nm and NIR 770–880 nm.

High resolution satellite pictures were helpful tools in managing nitrogen fertilization, and green 520–610 nm wavelengths and vegetation indices of NDVI, GNDVI, RVI, and OSAVI (Table 1) were strongly linked with wheat nitrogen status parameters.

REMOTE SENSING FOR DISEASE AND PEST DAMAGE DETECTION

GROUND-BASED

Plants can be identified using remote sensing data thanks to variations in their reflectance spectra caused by the presence and severity of pests and diseases. The spectral features of plants that are healthy and those that are infested differ greatly. Due to substantial absorption by photosynthetic pigments, a healthy leaf reflects very little light in the VIS range. In contrast, the spectral reflectance in the NIR bands is rather high and mostly governed by the dry matter and interior structure of the leaf.

When it came to identifying insect damage in crops, ground-based spectral reflectance proved to be quite useful. Genc used a handheld radiometer and the structure-insensitive pigment index and NDVI to accurately measure the pest damage to wheat. The Ranjitha investigation also revealed variations in reflectance between plants that were pest-damaged and those that were healthy. The study investigated three vegetation indices, and GRVI seemed to be the most susceptible to cotton damage from thrips.

Kumar used both field and lab spectroscopy to compare the spectral reflectance from healthy and infested mustard canopies in an investigation of aphid infestation. The findings indicated that there was a substantial correlation between aphid infestation and the spectral indices NDVI, RVI, AI, and SIPI , and that these indices may be used to detect aphid infestation in mustard. Yang studied the stress caused by greenbugs in wheat in a greenhouse. They discovered that spectral vegetation indices generated from wavelengths centered at 694 nm and 800 nm, as well as a waveband centered at 694 nm, were the most sensitive to wheat damaged by greenbugs. Riedell characterized the leaf reflectance spectra of wheat under stress from the Russian wheat aphid in a greenhouse using a handheld radiometer. They came to the conclusion that the normalized total pigment to chlorophyll a ratio index and leaf reflectance in the 625–635 nm and 680–695 nm ranges were reliable markers of chlorophyll loss brought on by aphid feeding. Mirik examined the link between aphid abundance and four vegetative indices [15] while taking into account the Russian wheat aphid.

The only reliable and statistically significant correlations between AI and Russian wheat aphid abundance across all fields were discovered in that study. The fact that AI outperforms NDVI, SIPI, and DSSI in detecting aphid abundance suggests that developing novel spectral indices could enhance pest detection using remote sensing. However, one should be mindful that field examination should be used in conjunction with remote sensing approaches to detect pest abundance.

Ashourloo provide an illustration of how to use spectral data to identify a plant disease. who looked at using vegetation indices based on information from a hyperspectral radiometer for identifying wheat leaf rust infestations. Based on reflectance at 605, 695, and 455 nm wavelengths, the authors created two indices, the Leaf Rust Disease Severity Index 1 and 2, both of which had high R2 values in relation to the disease severity (0.94 and 0.95, respectively).

Zhang used reflectance to find Phytophthora infesting in tomatoes. According to the study, the near infrared (NIR) spectrum, particularly between 700 and 1300 nm, was far more effective than the visible spectrum for identifying. infesting-caused illness symptoms. While the difference in the NIR area was greater than 10%, the difference in spectral reflectance between healthy and sick plants in the visible spectrum range was just 1.19%. Baranowski had comparable outcomes when they developed a hyperspectral approach for early identification of biotic stressors brought on by Alternaria alternative, an oilseed rape pathogen. The SWIR area between the water absorption bands 1470 and 1900 nm showed the largest spectral variations between the infected and uninfected portions of oilseed rape leaves.

AIRBORNE REMOTE SENSING

Choosing a sensor with the right spectral and spatial resolution is crucial when employing aerial photography to identify infected plants in agricultural crops. Mewes examined the efficacy of two hyperspectral cameras in identifying wheat plants infected with brown rust. The first camera recorded the reflected radiation in 498 channels in the 400–2500 nm range with a spectral resolution of 2.5–5.8 nm, while the second camera recorded the reflected radiation in 115 channels in the range of 383–839 nm with a spectral resolution of 5 nm.

Stronger correlations at longer NIR wavelengths were linked to the AISA-DUAL images' greater accuracy in identifying healthy and infested plants compared to the ROSIS images 84.32% and 80.33%. Due to lower atmospheric absorption and scattering of the signal reflected from the field surface, AISA images had a stronger AISA signal intensity and a higher spatial resolution 1.5 m and 2.0 m, respectively than ROSIS images, which were recorded from a higher altitude 2300 m and 2880 m, respectively. The acquired imagery data could be immediately compared because both sensors had the same Signal to Noise Ratio >500:1 and pictures were shot nearly simultaneously.

Glaser used hyperspectral images obtained with spatial resolutions ranging from 0.5 to 2.0 meters to accurately identify maize plots affected with corn rootworm. Plots infested with insects could be identified with classification accuracy of up to 99%, and this was higher for photos taken later in the season. The SR index (Table 1), which is the ratio of two bands in the VIS 648 nm and NIR 747 nm wavelengths, was used to determine the maximal separability between infested and uninfected maize.

When it comes to identifying plant diseases and pests, the spatial resolution of the image data is crucial. Compared to piloted aircraft platforms, UAVs can produce greater resolution photographs, leading to better outcomes. Garcia-Ruiz examined the efficacy of detecting citrus greening disease, which is caused by the motile bacteria .Sensor based on a UAV and a comparable imaging system installed on a piloted aircraft. The spatial resolutions of the two systems were 5.45 cm/pixel and 0.5 m/pixel, respectively.

Based on UAV-based datasets, classification accuracy of 67–85% was attained with little variation. from the findings of 61–74% derived from datasets based on aero planes. However, a comparison of false negative results obtained using data obtained via aero planes and UAVs, namely 7-32 and 28-45, respectively, showed that the first method was superior to the latter.

Remote sensing via satellite

Satellite images can also be used to observe the presence of pests and plant diseases in agricultural crops. Apan showed that orange rust disease in sugarcane may be identified using Hyperion satellite hyperspectral photography. Chen successfully identified severe take-all disease infestations in wheat [1] using Landsat multispectral imagery. In order to identify powdery mildew and leaf rust in winter wheat, Franke and Menz assessed high resolution QuickBird satellite multispectral imagery. The findings showed that multispectral pictures are only somewhat suited for differentiating early infection levels in wheat, but they are generally suitable for detecting infield heterogeneities in wheat vigour [9], especially for later stages of fungal infections.

Evaluation of Plant Water Requirements Using Ground-Based Remote Sensing

The creation of spectral indices to ascertain the water requirements of plants serves as another illustration of the potential of spectral measurements conducted at ground level. TIR remote sensing can be employed thermal data can be used to ascertain the current state of plant water supply because the temperature of a plant canopy is dependent on both the amount of heat stress and water availability. Plants exhibiting withering symptoms release increased longwave infrared radiation in response to water availability. The CWSI index was created to compare the thermal data over time and space.

The minimum and maximum variations between the air and plant canopy temperatures were used to normalize the canopy temperature .Mogensen, who employed spectral measurements for the regulation of oilseed rape plantations [16], remotely sensed data can also be utilized to identify when crop irrigation should begin. The Relative Reflectance Index and soil water content were found to be strongly correlated in the study. The ideal irrigation start date can be found using the RRI index, which is computed as the ratio of the reflectance index of the withered crops to that of the fully irrigated reference crop.

Aerial-based remote sensing

The canopy equivalent water thickness, or the weight of water per unit area of leaf, was directly calculated by Champagne using data from aircraft. The LAI of plants and their biomass, which are significant factors in many agricultural applications, are closely related to EWT. Broadleaf crops like beans, corn, canola and peas were well-predicted by the authors' model, which described the link between EWT and hyperspectral airborne photography data; however, wheat yielded subpar predictions [6].

Canopy water content, which is the total quantity of foliage water per unit ground area, is another indicator of plant water content that may be calculated using aerial photos. Although CWC is strongly related to plant water potential and relative water content, the latter is simpler to evaluate using optical remote sensing [13]. A number of techniques, including the NDWI and NDII indices, have been developed to estimate CWC from remotely sensed data.

Using continuous wavelet analysis on data from the Airborne Visible/Infrared Imaging Spectrometer collected in 224 bands from 365 to 2500 nm at a spectral resolution of 10 nm, Cheng investigated the daily and seasonal change of CWC in nut tree orchards. Three wavelet features at wavelengths of 1100 nm, 167 nm, and 2180 nm were shown to have a substantial correlation with CWC. When combined, these wavelet features produced the best wavelet model [5] and predicted CWC with an R2 of 0.84.

UAV platforms have shown great promise in managing water irrigation. The ability to fly at low altitudes eliminates the dirt background effect by enabling the acquisition of thermal images with great spatial resolution. Gago significantly improved the published water stress assessment over earlier studies by utilizing thermal image pixel resolution of 2.5 cm to produce R2=0.86 for the link between the CWSI index and plant water status in vines.

Remote sensing via satellite

Numerous investigations have demonstrated that precise measurements of plant water content may also be made at the satellite level. Using the NDWI, which was computed by combining two water absorption bands from the MODIS satellite sensor, centered at 860 nm and 1240 nm, Gao determined the amount of liquid water in plants. An additional index, Fensholt and Sandholt used SIWSI to track changes in the vegetative water content over time and space in rice paddy fields in China utilizing water absorption characteristics at 858 nm and 1640 nm [10].

In order to promote efficient water management and provide information on the total evaporative water demand for crops, satellite photos are especially helpful in estimating the vegetation water content over large agricultural areas. El-Magd and Tanton used a modified sensible heat flux technique using Landsat ETM satellite data to directly calculate ET. This technique can be used to calculate water use efficiency and is helpful for estimating agricultural water requirements.

GROUND-BASED REMOTE SENSING FOR WEED CONTROL

The application of handheld radiometers in agricultural crop weed management has been the subject of extensive research. Remote sensing for weed control entails identifying the type of weed or differentiating it from crop plants. Applying pesticide accurately to weed plants is sufficient, although distinguishing weeds from crops is less difficult than identifying weed species. Several vision systems have been employed to detect weeds in agricultural crops. The Weedseeker is one agricultural practice system that uses optical sensors to separate plants from soil.

However, it is more challenging to differentiate crop plants from weeds. Machine vision, which combines optics, electronics, mechanics, computer science, and image processing, is being tested for its ability to identify and differentiate weeds from crop plants more effectively. This approach allows one to distinguish between crop and weed plants by using automatic discriminant analysis based on information about plant color, saturation, shape, and texture. Burks showed that this method's accuracy ranged from 80 to 97%, which is extremely high. Identification of volunteer potatoes in maize and sugar beetroot crops was made possible by a combination of plant size, shape, and color data, and the differentiation between maize plants and weeds [3].

REMOTE SENSING IN AIR

Weed identification appears to be the most effective use of airborne remote sensing in pest management. For instance, Deguise successfully mapped weed patches in a canola field, and Lamb used hyper-spectral radiance data from an aerial sensor to demonstrate the detection of weeds in a triticale crop seedling stage [8]. The spectral bands centred at 675.98 and 685.17 nm in the red region and the NIR bands from 743.93 to 830.43 nm have good potential for discriminating between weed-free and weed-infested areas in maize, according to Goel, who also provide interesting information about detecting weed infestations with the aid of multispectral airborne remote sensors. Based on aerial photos, Peña investigated the potential use of UAVs to maximize herbicide application. 50 days after seeding, weeds [11] were identified with an accuracy of up to 91% thanks to high spatial resolution aerial images at extremely low altitudes 40 m.

Remote sensing via satellite

With ground resolutions of 2.44 and 1.64 meters, respectively, high-resolution multispectral satellites like QuickBird and GeoEye show potential in weed seedling identification. Comprehensive maps of the spread of Cirsium arvense in sugar beets throughout the cotyledon stage were created using QuickBird imaging. However, because the spectral characteristics of weeds and their background differ, low resolution NOAA-AVHRR 1100 m and moderate resolution satellites like SPOT 20 m or Landsat TM 30 m have proven to be helpful on a large scale for the detection and mapping of large clusters of weed [17].

CONCLUSIONS

The use of remote sensing in precision agriculture, which has been growing quickly in recent years, is frequently related to the examples given above. This farm management approach's primary goal is to maximize input returns while maintaining environmental stewardship. Precision agriculture's highly sophisticated technologies necessitate continuous access to comprehensive data describing the environmental circumstances in which this production occurs. Airborne and satellite photos at the field scale can provide such information.

Monitoring weed infestations and pest and plant disease damage is made easier by data gathered from satellite, aircraft, and ground levels, which enables prompt remediation. The capacity to employ remote sensing data to assess plant fertilization needs based on soil and crop nutrient content helps to improve the quality of produced seeds and fruits and boost yields, all of which are critical for increasing crop profitability. precise assessment of

During the field season, the nutritional needs of plants at key phases aid in fertilization optimization and minimize any potential negative effects related to off-site pesticide transportation. In order to control crop output in situations of water stress, remote sensing has also been used to evaluate the water requirements of plants and establish when irrigation should start.

However, the development of quantitative remote sensing applications for crop management requires the resolution of two significant issues. The first issue that needs to be addressed is the fluctuation in reflectance brought on by angles of solar irradiation, the direction in which sensors are seen, or the orientation of plant rows. The second issue is finding stress detection algorithms that work consistently across time and place that can distinguish between stress signals caused by pests, nutrients, and water and "noise" from soil and non-photosynthetically active plant material. For these objectives, more recent methods like spectrum mixing analysis may be employed. Recently, a fleet of 28 tiny observing satellites, each tens of centimeters in size, were launched into space by the Planet Labs firm.

The satellites are able to deliver remarkably high-resolution and high-frequency photographs of agricultural fields. The incorporation of remotely sensed parameters into decision support systems is another trend that has coincided with the growth of remote sensing. Decision support systems will be more reliable when remotely collected data is combined with current crop simulation models, which will also help modernize agricultural production management.

REFERENCES

[1]. Apan A., Held A., Phinn S., Markley J. (2004). Detecting sugarcane 'orange rust' disease using EO-1 Hyperion hyperspectral imagery. International Journal of Remote Sensing 25, 489–498.

[2]. Bagheri N., Ahmadi H., Alavipanah S.K., Omid M. (2012). Soil-line vegetation indices for corn nitrogen content prediction. International Agrophysics 26, 103–108.

[3]. Burks T.F., Shearer S.A., Heath J.R., Donohue K.D. (2005). Evaluation of neural network classifiers for weed species discrimination. Biosystems Engineering 91, 293–304.

[4]. Calderón R., Navas-Cortés J.A., Lucena C., Zarco-Tejada P.J. (2013). High-resolution airborne hyperspectral and thermal imagery for early detection of Verticillium wilt of olive using fluorescence, temperature and narrow-band spectral indices. Remote Sensing of Environment 139, 231–245.

[5]. Cheng T., Riaño D., Koltunov A., Whiting M.L., Ustin S.L., Rodriguez J. (2013). Detection of diurnal variation in orchard canopy water content using MODIS/ASTER airborne simulator (MASTER) data. Remote Sensing of Environment 132, 1–12.

[6]. Champagne C.M., Staenz K., Bannari A., McNairn H., Jean-Claude D. (2003). Validation of a hyperspectral curve-fitting model for the estimation of plant water content of agricultural canopies. Remote Sensing of Environment 87, 295–309.

[7]. Dąbrowska-Zielińska K., Ciołkosz A., Budzyńska M., Kowalik W. (2008). Monitorowanie wzrostu i plonowania zbóż metodami teledetekcji. Problemy Inżynierii Rolniczej 4, 45–54.

[8]. Deguise J. C., Staenz K., Lefebvre J. (1999). A hyperspectral data: weed detection. Fourth International Airborne Remote sensing Conference and Exhibition/21st Canadian Symposium on Remote Sensing, Ottawa, Ontario, Canada, 21-24 June.

[9]. Franke J., Menz G. (2007). Multi-temporal wheat disease detection by multi-spectral remote sensing. Precision Agriculture 8, 161–172.

[10]. Gao B.C. (1996). NDWI – A normalized difference water index for remote sensing of vegetation liquid water from space. Remote Sensing of Environment 58, 257–266.

[11]. Goel P.K., Prasher S.O., Landry J.-A., Patel R.M., Bonnell R.B., Viau A.A., Miller J.R. (2003). Potential of airborne hyperspectral remote sensing to detect nitrogen deficiency and weed infestation in corn. Computers and Electronics in Agriculture 38, 99–124.
[12]. Huete A., Justice C. (1999). MODIS Vegetation Index (MOD 13) Algorithm Theoretical Basis Document, Greenbelt: NASA Goddard Space Flight Center, http://modarch.gsfc.nasa.gov/MODIS/LAND/ #vegetation-indices, 129 pp.
[13]. Hunt E.R., Rock B.N., Nobel P.S. (1987). Measurement of leaf relative water content by infrared reflectance. Remote Sensing of Environment 22, 429–435.
[14]. Li F., Gnyp M.L., Jia L., Miao Y., Yu Z., Koppe W., Bareth G., Chen X., Zhang F. (2008a). Estimating N status of winter wheat using a handheld spectrometer in the North China Plain. Field Crop Research 106, 77–85.
[15]. Mirik M., Michels G.J., Kassymzhanova-Mirik S., Elliott N.C. (2007). Reflectance characteristics of Russian wheat aphid (Hemiptera: Aphididae) stress and abundance in winter wheat. Computers and Electronics in Agriculture 57, 123–134.
[16]. Mogensen V.O., Jensen C.R., Mortensen G., Thage J.H., Koribidis J., Ahmed A. (1996). Spectral reflectance index as an indicator of drought of field grown oilseed rape (Brassica napus L. European Journal of Agronomy 5, 125–135.
[17]. Peters A.J, Reed B.C., Eve M.D., McDaniel K.C. (1992). Remote-sensing of Broom Snakeweed (Gutierrezia sarthrae) with NOAA-10 spectral image processing. Weed Technology 6, 1015– 1020.
[18]. Singh I., Srivastava I.A., Chandna P., Gupta R. (2006). Crop sensors for efficient nitrogen management in sugarcane: Potential and constraints. Sugar Tech 8, 299–302.
[19]. Vidal A., Pinglo F., Durand H., Devaux-Ros C., Maillet A. (1994). Evaluation of a temporal fire risk index in mediterranean forests from NOAA thermal IR. Remote Sensing of Environment 49, 296–303.
[20]. Zarco-Tejada P.L.J., Rueda C.A., Ustin S.L. (2003). Water content estimation in vegetation with MODIS reflectance data and model inversion methods. Remote Sensing of Environment 85, 109–124.

VALUE ADDED IN GRAPES: PRODUCT EVALUATION METHODS AND GLOBAL COMPETITIVENESS

ÜZÜMDE KATMA DEĞER: ÜRÜN DEĞERLENDİRME ŞEKİLLERİ VE KÜRESEL REKABET

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ÖZET

Giriş ve Amaç: Dünya genelinde tarımsal üretim içinde üzüm, stratejik öneme sahip bir ürün olarak öne çıkmaktadır. Üzüm, doğrudan sofralık (taze) ve kuru üzüm olarak tüketilmesinin yanı sıra şarap, üzüm suyu, sirke ve şıra ürünlerinin üretimi ile de değerlendirilmektedir. Katma değer oluşturma süreçleri, hem yerel ekonomileri desteklemekte hem de küresel pazarda rekabet gücünü artırmaktadır. Bu çalışmanın amacı, üzüm üretimine katma değer sağlayan ürünlerin, küresel rekabetteki rolünü tartışmak ve Türkiye’nin dış ticaret potansiyelini zorluk ve fırsatlar bakımından değerlendirmektir.

Materyal ve Yöntem: Çalışmada, sektör raporları, üretim, ticaret ve tüketim istatistiklerinden elde edilen veriler kullanılmıştır. Türkiye’nin üzüm üretimi, ihracatı ve katma değerli ürün üretiminde oynadığı rol, diğer büyük üretici ülkeler ile karşılaştırılmıştır. Ayrıca, yerel düzeyde uygulanan inovasyon ve sürdürülebilir üretim uygulamalarının pazar payı üzerindeki etkisi incelenmiştir. Küresel rekabet için stratejik öneme sahip şarap üretimi ve organik üzüm yetiştiriciliği gibi alt sektörler de bu kapsamda ele alınmıştır.

Bulgular: Katma değer oluşturma sürecinde, Türkiye’nin Dünya çapında güçlü bir potansiyele sahip olduğu görülmüştür. Ancak bu potansiyelin değerlendirilmesinde, güvenilir ve yenilikçi yöntemlerle pazarlanabilir üretime odaklanılması gerekmektedir. Özellikle, taze üzümden elde edilen şarap, kuru üzüm, geleneksel ve organik ürünler gibi katma değeri yüksek ürünlere yönelim, ülke ihracatında önemli bir artış sağlayabilir. Türkiye’nin üzüm çeşitleri ve katma değerli üzüm ürünlerinin uluslararası düzeyde coğrafi işaret alması, küresel pazarda benzersiz bir avantaj sunabilir.

Tartışma ve Sonuç: Sonuç olarak, üzümde katma değer oluşturma süreçlerinin iyileştirilmesi, Türkiye’nin küresel pazarlarda daha etkin bir rol oynamasını sağlayabilir. Sürdürülebilir üretim teknikleri ve inovasyona öncelik verilmesi, sektörde uzun vadeli başarıya katkı sağlayacaktır. Bu bağlamda, üzüm üreticilerinin desteklenmesi ve sektörel iş birliklerinin artırılması büyük önem taşımaktadır.

Anahtar Kelimeler: Üzüm; Tüketim Şekilleri; Küresel Rekabet; Ticaret; Türkiye

ABSTRACT

Introduction and Purpose: Grapes hold strategic importance in global agricultural production. In addition to direct consumption as table grapes (fresh) and raisins, grapes are also utilized in the production of wine, grape juice, vinegar, and must. Value added processes support local economies and enhance competitiveness in global markets. This study aims to discuss the role of value added grape products in global competition and evaluate Türkiye's foreign trade potential in terms of challenges and opportunities.

Materials and Methods: Data from industry reports, production, trade and consumption statistics were utilized in this study. Türkiye's role in grape production, exports, and value-added product development was compared with other major producing countries. Additionally, the impact of locally implemented innovations and sustainable production practices on market share was examined. Sub-sectors of strategic importance for global competition, such as wine production and organic grape cultivation, were also considered.

Results: Türkiye has been identified as holding a strong potential globally in value added grape production. However, evaluation of this potential requires a focus on reliable and innovative methods for marketable production. Particularly, prioritizing high value products such as wine, raisins, and traditional or organic grape-based goods can significantly boost exports. International geographical indication of Türkiye's grape varieties and value-added grape products could offer a unique advantage in the global market.

Discussion and Conclusion: In conclusion, improving value added processes in grape production could enable Türkiye to play a more effective role in global markets. Prioritizing sustainable production techniques and innovation will support long-term success in the sector. Supporting grape producers and fostering sectoral collaborations are essential in this context.

Key Words: Grapes; Consumption Patterns; Global Competition; Trade; Türkiye

GİRİŞ

Bağcılık, asma bitkisinin ve temel ürünü olan üzümün yetiştiriciliğini ve değerlendirilmesini kapsayan bir tarımsal faaliyettir. Üzüm çok yönlü değerlendirilme şekilleriyle önemli ticaret hacmine sahiptir. Dünyada yetiştiriciliği yapılan üzüm çeşitlerinin büyük bir bölümü saf ve melez olarak *Vitis vinifera* L. asma türüne aittir. Türkiye *V. vinifera* L. türünün önemli gen merkezlerinden biri olması nedeniyle, gen kaynakları bakımından zengin, kadim medeniyetlere yurt olması nedeniyle de farklı değerlendirme yöntemlerinin geliştirildiği bir coğrafyadır. 1965 yılından bu yana devam eden "Türkiye Asma Genetik Kaynaklarının Belirlenmesi, Muhafazası ve Tanımlanması Üzerinde Araştırmalar" projesi kapsamında, Türkiye'nin tamamı taranarak 2024 yılı itibariyle 1.459 yerli ve 104 yabancı orjinli olmak üzere toplam 1.563 üzüm genotipi Tarımsal Araştırmalar ve Politikalar Genel Müdürlüğü (TAGEM)'ne bağlı Tekirdağ Bağcılık Araştırma Enstitüsüne ait Asma Arazi Gen Bankası'nda koruma altına alınmıştır. Ayrıca yedekleme amacıyla TAGEM'e bağlı Manisa Bağcılık Araştırma Enstitüsü'nde bir duplikasyon bağı bulunmaktadır. Bu kapsamda yapılan araştırma çalışmaları; Türkiye'nin milli değeri olan genetik kaynakların avantajlarının ortaya çıkarılması ve ıslah materyali olarak kullanılmasında önem taşımaktadır.

FAO (2024) verilerine göre 2022 yılında Dünya'da yaklaşık 6,7 milyon ha alanda 75 milyon ton yaş üzüm üretimi gerçekleşmiştir. Türkiye ise, 384.536 ha alan ve 4,2 milyon ton üretim ile Dünya bağ alanı ve yaş üzüm üretiminin % 6'sını karşılamaktadır (TÜİK, 2024a). Türkiye bağ alanı bakımından İspanya, Fransa, İtalya ve Çin'den sonra 5. sırada yer alırken, üzüm üretimi bakımından Çin, İtalya, Fransa, İspanya ve ABD'den sonra 6. sıradadır (FAO, 2024). Türkiye'de 2023 yılında üretilen 3.400.000 ton yaş üzümün % 53'ü sofralık, % 38'i kurutmalık ve % 9'u şaraplık-şıralık olarak değerlendirilmiştir (TÜİK, 2024a). Dünya kuru üzüm üretimi ve ihracatında lider konumda olan Türkiye, Dünya sofralık üzüm üretiminde Çin ve Hindistan'dan sonra 3. sıradadır. Ülkemizde üzüm, genel değerlendirme şekillerinin (sofralık, kurutmalık, şaraplık) yanı sıra; geleneksel ve yöresel ürünlere işlenmektedir. Üreticinin geçimini sağlamasında önemli bir rol oynayan ve üzümün değerlendirilme olanakları bakımından zengin olan bağcılık faaliyeti milli ekonomiye de katma değer sağlamaktadır. Bu çalışmada, katma değer sağlayan üzüm ürünlerinin üretimi, ihracat potansiyeli ve Türkiye'nin bu ürünlerle ilgili dış pazardaki rolü rakip ülkeler ile birlikte değerlendirilmiştir.

MATERYAL VE YÖNTEM

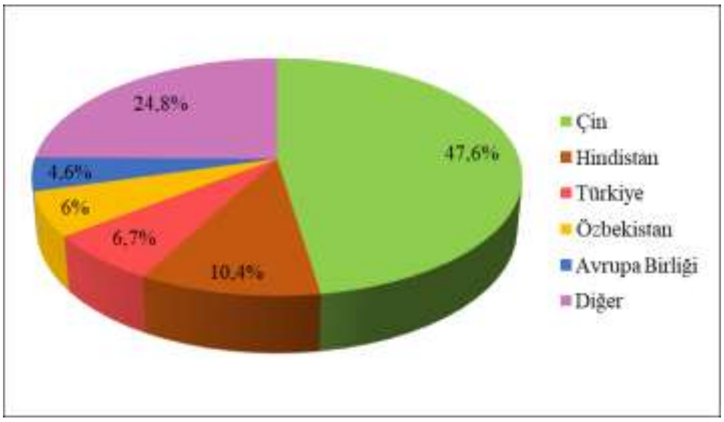
Çalışmada, istatistik veriler kullanılmıştır. Bu amaçla, Türkiye İstatistik Kurumu (TÜİK), Birleşmiş Milletler Gıda ve Tarım Örgütü (FAO), ABD Tarım Bakanlığı (USDA), Uluslararası Ticaret Merkezi (ITC), Uluslararası Bağcılık ve Şarapçılık Örgütü (OIV), Uluslararası Sert Kabuklu ve Kuru Meyveler Konseyi (INC) veri tabanları ve sektör raporlarından elde edilen bilgiler incelenmiştir. Türkiye'nin üzüm üretimi, ihracatı ve katma değerli ürün üretimindeki rolü, önemli üretici ülkeler ile karşılaştırılmıştır. Sürdürülebilir bağcılık uygulamaları ile ihracatta etkin olma potansiyelinin ve dış pazar payının artırılması yönünde değerlendirmeler yapılmıştır.

BULGULAR

Dünya'da ve Türkiye'de Üzümün Değerlendirilmesi

Sofralık Üzüm Üretimi

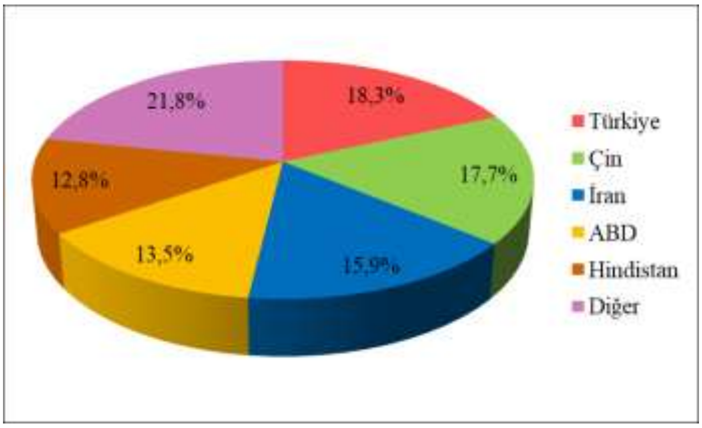
Dünya'nın önemli sofralık üzüm üretici ülkelerin üretim payları Şekil 1'de verilmiştir. Dünya sofralık üzüm üretimi 2023 yılında 28,1 milyon tona ulaşmıştır. Çin sofralık üzüm üretiminde 13,5 milyon ton ile lider konumda olup % 47,6 üretim payına sahiptir. 2. sırada yer alan Hindistan toplam üretimin % 10,4'ünü karşılamaktadır. Çin ve Hindistan'ın ardından Türkiye 3. sırada yer almaktadır. Türkiye 1,8 milyon ton üretim ile toplam üretimin % 6,7'sini oluşturmaktadır. Özbekistan ve Avrupa Birliği ise toplam üretimin % 10,6'sına sahiptir (USDA, 2024).



Şekil 1. Dünya'nın Önemli Sofralık Üzüm Üretici Ülkelerin Üretim Payları (%) (USDA, 2024)

Kuru Üzüm Üretimi

Dünya'nın önemli kuru üzüm üretici ülkelerin üretim payları Şekil 2'de verilmiştir. Yaklaşık 1,1 milyon ton Dünya kuru üzüm üretiminde Türkiye % 18,3'lük pay ile lider konumdadır. Türkiye'yi Çin (% 17,7), İran (% 15,9), ABD (% 13,5) ve Hindistan (% 12,8) izlemektedir (INC, 2024). Türkiye'de 2023 yılında 1.304.344 ton kurutmalık üzüm üretiminin 981.741 tonu çekirdeksiz kurutmalık ve 322.603 tonu çekirdekli kurutmalıktır. 2023/2024 üretim sezonunda 206.500 ton çekirdeksiz kuru üzüm rekoltesi söz konusudur (Manisa Ticaret Borsası, 2024).

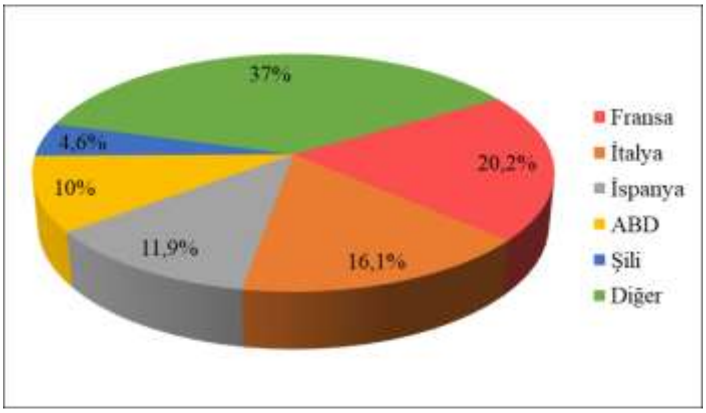


Şekil 2. Dünya'nın Önemli Kuru Üzüm Üretici Ülkelerin Üretim Payları (%) (INC, 2024)

Türkiye'nin ihracata yönelik üzüm üretiminde ilk sırada çekirdeksiz kuru üzüm yer almaktadır. Kuru üzüm ihracatında Sultani Çekirdeksiz çeşidi ilk sıradadır. Kuru üzüm üretimi ve ihracatında lider konumda olan Türkiye'de, yeni kurulan çekirdeksiz üzüm bağlarının tamamına yakınını Manisa Bağcılık Araştırma Enstitüsü tarafından geliştirilen Sultan 7 üzüm çeşidinden tesis edilmektedir. Sultani Çekirdeksiz çeşidinin önemli bir tipi olan Sultan 7, üretime kazandırılarak birim alandan verim artışları sağlanmış ve üreticiler tarafından yoğun talep görmektedir.

Şarap Üretimi

Dünya'nın önemli şarap üretici ülkelerin üretim payları Şekil 3'de verilmiştir. Dünya'da 2023 yılı şarap üretim miktarı yaklaşık 24 milyar litre olup, Fransa (% 20,2), İtalya (% 16,1), İspanya (% 11,9), ABD (% 10) ve Şili (% 4,6) Dünya şarap üretiminde en fazla paya sahip ilk 5 ülkedir. Türkiye'nin dünya şarap üretiminden aldığı pay %1'in altındadır (OIV, 2024). Türkiye'nin 2023 yılı şarap üretim miktarı 67 milyon litre'dir (TOB, 2024a).



Şekil 3. Dünya'nın Önemli Şarap Üretici Ülkelerin Üretim Payları (%) (OIV, 2024)

Avrupa ülkeleri (Fransa, İtalya, İspanya), ABD ve Avustralya gibi ülkelerde üretilen üzümün önemli bir kısmı şarap üretiminde kullanılmaktadır. Ülkemizde şaraplık-şıralık üzüm üretiminin yaklaşık % 20-25'i (yaklaşık 100.000 ton) şaraba işlenmekte olup, geri kalanı pekmez, pestil, sirke vb. yöresel ürünlerin yanında sumalık rakı üretiminde kullanılmaktadır.

Dünya'da ve Türkiye'de Üzüm ve Üzüm Ürünleri Dış Ticareti

Bağcılık ürünlerinin Dünya ticaretindeki büyüklüğü ve Türkiye'nin konumunu açıklayan Dünya ve Türkiye ticaretine ait değerler Çizelge 1'de verilmiştir. ITC (2024) istatistik verilerine göre üzüm ve üzüm ürünleri açısından Dünya'da yaklaşık 50,5 milyar $ büyüklüğünde bir ticari değer söz konusudur. Türkiye bu pazardan 681,8 milyon $ ile yaklaşık % 1,4 oranında pay alabilmektedir. Dünya'nın en büyük kuru üzüm üreticisi ve ihracatçısı olan Türkiye'nin Dünya kuru üzüm ihracatındaki payı % 33,2'dir. Kuru üzümü**,** % 1,5 ile sofralık üzüm ve % 1,4 ile geleneksel ürün niteliğindeki pekmez izlemektedir. Şarap ve üzüm suyu değerlendirme şekillerinde ise %1 oranı dahi yakalanamamaktadır. Dünya ihracat gelirleri sınıflandırıldığında, % 77 ile en fazla şarap, daha sonra % 18,4 ile sofralık üzüm ticareti en önemli paylara sahiptir. Türkiye'de ise, toplam ihracat gelirlerinde % 74,5 ile kuru üzüm ticareti öne çıkarken bunu % 20,4 ile sofralık üzüm ve % 3,7 ile şarap ticareti izlemektedir.

Çizelge 1. 2023 Yılı Dünya ve Türkiye Üzüm ve Üzüm Ürünleri İhracatı

Değerlendirme Şekli	İhracat Geliri (1000 $)		İhracat Geliri Payı (%)		Türkiye'nin Payı (%)
	Dünya	Türkiye	Dünya	Türkiye	
Sofralık Üzüm	9.268.699	139.288	18,4	20,4	1,5
Kuru Üzüm	1.531.900	508.209	3,0	74,5	33,2
Şarap	38.912.496	25.092	77,0	3,7	0,1
Pekmez	605.857	8.534	1,2	1,3	1,4
Üzüm Suyu	189.370	641	0,4	0,1	0,3
Toplam	50.508.322	681.764	100	100	1,4

Kaynak: ITC, 2024

Sofralık Üzüm İhracatı

Dünyada 2023 yılında yaklaşık 4,6 milyon ton sofralık üzüm ihracatı yapılmıştır. Peru, Dünya sofralık üzüm ihracatında 647.531 ton ile 1. sıradadır. Şili (503.937 ton), Çin (483.353 ton), İtalya (386.678 ton) ve Güney Afrika (318.126 ton) ise 2023 yılında en fazla ihracat yapan diğer ülkeler olmuştur. Türkiye 146.453 ton ihracat ile 9. sıradadır. Peru (1,7 milyar $), Hollanda (914 milyon $), İtalya (893 milyon $), Çin (814 milyon $) ve Şili (811 milyon $) ihracat değeri en yüksek ülkelerdir. Türkiye'de yaş üzüm olarak tüketilen sofralık üzümde 2023 yılında 1,8 milyon ton olan üretimin ihraç edilen kısmı sadece % 8'dir. Türkiye'nin sofralık üzüm dış pazarında Dünya sıralamasında geride kalma durumu; iç tüketimin yüksek olması, ihracata yönelik sofralık üzüm üretiminde kalite ve kalıntı sorunları ile ağırlıklı olarak tek çeşitle (Sultani Çekirdeksiz) pazarda yer alması, üretici ülkelerin büyük çoğunluğunun kuzey yarım kürede yer alması ve ABD'nin rekabetçi dış ticaret politikası izlemesi gibi nedenlerden kaynaklanmaktadır. 2023 yılında, yaklaşık 146 bin ton olan sofralık üzüm ihracatından 139 milyon $ gelir elde edilmiş olup ihraç birim fiyatı 951 $/ton'dur. Türkiye'nin sofralık üzüm ihraç birim fiyatının düşük olmasının temel nedeni ithalatçı ülkelerdeki pazar fiyatlarının düşük olmasıdır. Fiyatların düşük olmasında Türkiye'nin ağırlıklı olarak tek çeşitle dış pazarda bulunması ve ihracata yönelik kalite standartlarının karşılanamaması etkili olmaktadır. Türkiye'nin miktar olarak en fazla sofralık üzüm ihraç ettiği 5 ülke Çizelge 2'de verilmiştir. 2023 yılında ihraç edilen üzüm miktarının yarısından fazlası (% 56,2) Rusya Federasyonu'na yapılmıştır. Ukrayna (% 13,1), Polonya (% 5,7), Romanya (% 3,9) ve Belarus (% 3,3) en fazla ihracat yapılan diğer ülkelerdir (ITC, 2024).

Çizelge 2. Türkiye Sofralık Üzüm İhracatında Önemli Ülkelerin Payı (%)

Ülke/Yıl	2023
Rusya Federasyonu	56,2
Ukrayna	13,1
Polonya	5,7
Romanya	3,9
Belarus	3,3
Diğer	17,8

Kaynak: ITC, 2024

Kuru Üzüm İhracatı

Türkiye, 2023 yılı 277.081 ton kuru üzüm ihracatıyla Dünya'da lider ülkedir. Türkiye'den sonra Şili (70.992 ton), Güney Afrika (57.232 ton), Afganistan (53.066 ton) ve ABD (51.285 ton), en fazla kuru üzüm ihracatı yapan diğer ülkelerdir. İhracat değeri bakımından da Türkiye 508 milyon $ ile 1. sırada olup, Türkiye'yi, ABD (175 milyon $), Şili (143 milyon $), Güney Afrika (116 milyon $) ve Afganistan (105 milyon $) takip etmiştir. Türkiye'nin 2023 yılı ihraç birim fiyatı 1.834 $/ton'dur. Türkiye'nin en fazla kuru üzüm ihracatı gerçekleştirdiği ülkeler Çizelge 3'de incelendiğinde, İngiltere en büyük alıcı ülke (% 23,3) olmuştur. İngiltere'den sonra Hollanda (% 13,1), Almanya (% 11,5), İtalya (% 6,7) ve Fransa (% 5,9) en fazla ihracat yapılan diğer ülkelerdir (ITC, 2024).

Çizelge 3. Türkiye Kuru Üzüm İhracatında Önemli Ülkelerin Payı (%)

Ülke/Yıl	2023
İngiltere	23,3
Hollanda	13,1
Almanya	11,5
İtalya	6,7
Fransa	5,9
Diğer	39,5

Kaynak: ITC, 2024

Şarap İhracatı

Dünyada 2023 yılı şarap ihracat miktarı yaklaşık 10 milyar litre'dir. Toplam şarap ihracatının % 68'i İtalya, İspanya, Fransa, Şili ve Avustralya tarafından yapılmıştır (OIV, 2024). İhracat gelirleri sıralandığında; Fransa (12,9 milyar $), İtalya (8,4 milyar $), İspanya (3,2 milyar $), Şili (1,5 milyar $) ve Avustralya (1,4 milyar $) şeklindedir. Türkiye'de şarap, önemli bağcı ülkelerin aksine üzümün değerlendirme şekilleri arasında Dünya üretim ve ticaretinde oldukça geri planda kalmaktadır. Türkiye'nin 2023 yılı ihracat miktarı 6.635.000 litre, ihracat değeri 25.092.000 $ ve birim ihracat fiyatı 3.782 $/1000 litre olarak gerçekleşmiştir. Son yıllarda ihraç edilen şarapların daha yüksek birim fiyat bulmasının nedeni, sektörde kaliteli şarap üretiminde sağlanan iyileşmelerdir. Ancak Türkiye'nin 2023 yılı ihraç birim fiyat değeri, Fransa'nın ortalama ihraç birim fiyatı olan 9.797 $/1000 litre'den oldukça düşüktür. Türkiye'nin en fazla şarap ihraç ettiği 5 ülke Çizelge 4'de verilmiştir. Türkiye'nin en fazla şarap ihracatı gerçekleştirdiği ülkeler Almanya (% 13,1), İngiltere (% 12,7), Belçika (% 10,7), Kıbrıs (% 10,5) ve Hollanda (% 7,9)'dır (ITC, 2024).

Çizelge 4. Türkiye Şarap İhracatında Önemli Ülkelerin Payı (%)

Ülke/Yıl	2023
Almanya	13,1
İngiltere	12,7
Belçika	10,7
Kıbrıs	10,5
Hollanda	7,9
Diğer	45,1

Kaynak: ITC, 2024

İthalat

Türkiye'de 2023 yılı verilerine göre ithalatın etkisi, şarap dışında diğer tüketim şekillerinde düşüktür. 2023 yılında sofralık üzüm ithalatı 4.422 ton, kuru üzüm ithalatı 25.456 ton ve şarap ithalatı 14.564.000 litre'dir. İthalat harcamaları incelendiğinde, sofralık üzüme 5.511.000 $, kuru üzüme 49.544.000 $ ve şaraba 72.925.000 $ ödenmiştir (ITC, 2024). Sofralık üzüm ithalatı coğrafi konum farkı nedeniyle Türkiye'de üzüm üretiminin olmadığı Ocak-Mart ayları arasında Şili, Peru ve Güney Afrika gibi ülkelerden düşük miktarlarda yapılmaktadır. Kuru üzüm ithalatı ise Türkiye'de yetiştiriciliği az olan ve spesifik olarak değerlendirilen çeşitlerden ağırlıklı olarak İran ve Özbekistan'dan gerçekleştirilmektedir. Şarap ithalatı ise ağırlıklı olarak İtalya, Fransa, Moldova ve Şili'den yapılmaktadır.

Dünya'da ve Türkiye'de Organik Üzüm Üretimi ve İhracatı

Üzüm Dünya'da organik ürünler içerisinde kahve, zeytin, sert kabuklu meyvelerden sonra 4. sırada yer almaktadır. Dünya'da 2022 yılında 561.503 ha alanda yapılan organik üzüm yetiştiriciliği, toplam bağ alanının % 8,3'ünü oluşturmaktadır. Organik üzüm alanlarının yaklaşık % 79,2'sini Fransa, İspanya, İtalya ve Türkiye karşılamaktadır (Willer vd., 2024). Türkiye'nin 2023 yılında toplam organik üzüm üretimi geçiş süreci dahil olmak üzere 7.590 ha alanda 123.144 ton olarak gerçekleşmiştir. 2023 yılında 6.581 ton organik üzüm ve üzüm ürünleri ihracatından 21.125.089 $ gelir elde edilmiştir. Organik üzüm üretiminin büyük bir kısmı çekirdeksiz kuru üzüm olarak ihraç edilmektedir. Organik üzüm ve üzüm ürünlerinin toplam organik ürünler içerisindeki payı ihracat miktarının % 11,1'ini, ihracat değerinin ise % 12,9'unu oluşturmaktadır (TOB, 2024b).

Türkiye'de Üzüm Tüketimi ve Kendine Yeterlilik

Üzüm; yaş üzüm olarak sofralık, kurutularak kuru üzüm ve şaraba işlenerek şarap olmak üzere üç temel tüketim şeklinde değerlendirilmektedir. Bu esas tüketim şekilleri dışında üzüm suyu, kuru üzümden sumalık alkol, geleneksel ve yöresel üzüm ürünleri olarak pekmez, sirke, pestil, köme, hardaliye, koruk suyu vb. olarak zengin tüketim şekilleri söz konusudur. Ayrıca hazır gıda sektöründeki gelişmeler nedeniyle asmanın ikincil ürünü olan sarmalık asma yaprağına olan talep son yıllarda artmaktadır. Asma yaprağının taze tüketim olarak pazara sunulmasının yanında ürünün salamura şeklinde muhafazası üreticilere geniş dönemde istikrarlı gelir imkanı sağlayan aile işletmeleri için uygun bir üretim modelidir. Çalışmada Dünya'da ihracata konu olan üç ana tüketim şekli baz alınarak veriler incelenmiştir. Türkiye'de üretilen üzümün tüketim sıralaması sofralık üzüm, kuru üzüm ve şarap şeklindedir. Bu sıralamada sofralık ve kurutmalık üzüm yetiştiriciliğinin daha yoğun yapılması etkili olsa da Türkiye'nin sosyo-kültürel yapısının da şarap tüketiminde sınırlı etkisi olduğu bir gerçektir. Türkiye'de 2022 yılında yaş üzüm tüketimi 2.226.588 ton ve kişi başına tüketim 26,1 kg'dır (TÜİK, 2024b). 2021/2022 sezonu kuru üzüm iç tüketim miktarı yaklaşık 75 bin ton olup, üretimin % 26'sı iç tüketime sunulmuştur. Kişi başına kuru üzüm tüketimi yaklaşık 1,2 kg hesaplanmıştır (INC, 2024). 2022 yılı verilerine göre kişi başına şarap tüketimi Fransa'da 47, Almanya'da 27, Avustralya'da 26 ve ABD'de 13 litre'dir. 2022 yılı Türkiye şarap tüketimi 83 milyon litre olup, kişi başına tüketim 1 litre civarındadır (OIV, 2024). Ülkemizde 2022 yılında üzümde yeterlilik derecesi % 146,3'dür (TÜİK, 2024b). Bu sonuç değerlendirildiğinde; Türkiye üzüm üretiminde kendine yeterli ülke konumunda olsa da sahip olduğu potansiyelin iç tüketim ve dış ticarette etkinliğini kullanma konusunda üzerinde önemle durulması gerekmektedir.

TARTIŞMA VE SONUÇ

Türkiye, sofralık üzümde üretim, kuru üzümde ise üretim ve dış ticaret açısından önemli bir ülkedir. Ancak sofralık ve şaraplık üzüm üretimini dış ticaret açısından etkili kullanamamaktadır. Sofralık üzüm yetiştiriciliğinde kaliteyi artırıcı uygulamaların geliştirilerek ihracat potansiyelinin artırılması gerekmektedir. İhracata yönelik örtü altı uygulamaların geliştirilmesi, sofralık üzüm ihracatında rekabet şansımızı artırabilir. Uluslararası sofralık üzüm piyasasının talepleri doğrultusunda ıslah çalışmaları ile geliştirilen iri taneli, erkenci-geççi, renkli ve çekirdeksiz çeşitlerin pazarda yer alması için çeşit tanıtım faaliyetlerine ağırlık verilmesi gerekmektedir (TAGEM, 2024). Sofralık ve kuru üzüm üretiminde yaşanan kalıntı sorunları dış pazarı da olumsuz etkilemektedir. Bu kapsamda sürdürülebilir bağcılık için kalıntı sorunu olmayan organik ve çevre dostu uygulamaların geliştirilmesi önem taşımaktadır. Türkiye'nin zengin asma gen kaynağı potansiyeli içerisinde, üzüm ürünlerinden katma değeri en yüksek olan şaraba işlenen yerli çeşit sayısı azdır. Ancak, son yıllarda kaliteli şaraplık özellikleri ortaya çıkarılan yerli üzüm çeşitleri, 2023 yılında Dünya şarap ticaretinin ulaştığı 38,9 milyar dolarlık pazar payından (ITC, 2024) Türkiye'nin pay alma şansının artırılmasına katkı sağlayacaktır. Şaraplık üzümde kendi ürettiğini işleyen verimden ziyade kaliteyi ön planda tutan butik işletmelerin desteklenmesi, sadece sektörün gelişimine katkı sağlamakla kalmayıp, aynı zamanda milli ekonomi açısından faydalı olacaktır.

Türkiye, üzüm çeşitleri, üretim kapasitesi ve geçmişten bugüne gelen farklı değerlendirme şekilleri dikkate alındığında beslenme ve sağlık açısından fonksiyonel, katma değeri yüksek ürünler üretme potansiyeline sahiptir. Ancak ülkemizde yetiştirme teknikleri ile işleme teknolojisi arasında Ar-Ge çalışmaları disiplinler arası nitelik kazanamamıştır. Bu nedenle katma değeri yüksek inovatif ürünlerin üretim potansiyeli değerlendirilememektedir. Ar-Ge çalışmaları ile üzüm, üzüm kabuğu, üzüm çekirdeği ve asma yaprağından inovatif ürünlerin geliştirilmesi, tıp ve eczacılık sektöründe kullanım olanaklarının belirlenmesi ve bu ürünlerin piyasada seri üretimi ile katma değer fırsatının yaratılması gerekmektedir. Küresel pazarda rekabet üstünlüğünün korunmasında piyasanın talep ettiği kaliteli ve güvenilir ürünlerin üretilmesi ve ihracat pazarında çeşitlendirme büyük avantaj sunabilir. Ayrıca, üzüm çeşitleri ve katma değerli ürünlerin uluslararası düzeyde coğrafi işaret ile korunması küresel pazarda marka değerini artırabilir.

KAYNAKLAR

FAO (2024). Food and Agriculture Organization of the United Nations. https://www.fao.org/statistics/en (Erişim 4.11.2024)

INC (2024). International Nut & Dried Fruit Council. https://inc.nutfruit.org/wp-content/uploads/2023/05/Statistical-Yearbook-2022-2023.pdf (Erişim 26.11.2024)

ITC (2024). International Trade Center. https://www.trademap.org/ (Erişim 13.11.2024)

Manisa Ticaret Borsası (2024). 2024 Yılı Çekirdeksiz Kuru Üzüm Sektör Raporu. https://www.manisatb.org.tr/UserFiles/Download/2023-24-Cekirdeksiz-kuru-uzum-sektor-raporu.pdf (Erişim 26.11.2024)

OIV (2024). International Organisation of Vine and Wine. https://www.oiv.int/ (Erişim 26.11.2024)

TAGEM (2024). Tarımsal Araştırmalar ve Politikalar Genel Müdürlüğü, Tarımsal Araştırma Mastır Planı (2021-2025). https://www.tarimorman.gov.tr/TAGEM/Menu/28/Yayinlar_veriler (Erişim 26.11.2024)

TOB (2024a). Tarım ve Orman Bakanlığı Tütün ve Alkol Daire Başkanlığı, Piyasa İstatistikleri. https://www.tarimorman.gov.tr/TADAB/Menu/23/Alkol-Ve-Alkollu-Ickiler-Daire-Baskanligi (Erişim 26.11.2024)

TOB (2024b). Tarım ve Orman Bakanlığı Bitkisel Üretim Genel Müdürlüğü. https://www.tarimorman.gov.tr/Konular/Bitkisel-Uretim/Organik-Tarim/Istatistikler (Erişim 28.11.2024)

TÜİK (2024a). Türkiye İstatistik Kurumu, Bitkisel Üretim İstatistikleri. https://biruni.tuik.gov.tr/medas/?kn=92&locale=tr (Erişim 4.11.2024)

TÜİK (2024b). Türkiye İstatistik Kurumu, Bitkisel Ürün Denge Tabloları. https://biruni.tuik.gov.tr/medas/?kn=104&locale=tr (Erişim 4.11.2024)

USDA (2024). United States Department of Agriculture National Agricultural Statistics Service, https://fas.usda.gov/sites/default/files/2024-06/fruit.pdf (Erişim 26.11.2024)

Willer, H., Trávníček, J., & Schlatter, S. (2024). The World of Organic Agriculture. Statistics and Emerging Trends 2024.

ÜZÜM POSASI: SÜRDÜRÜLEBİLİR BAĞCILIK İÇİN KATMA DEĞERİ YÜKSEK GERİ DÖNÜŞTÜRÜLEBİLİR ÜRÜN

GRAPE POMACE: VALUE-ADDED RECYCLING PRODUCT FOR SUSTAINABLE VITICULTURE

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ÖZET

Giriş ve Amaç: Üzüm posası, küresel üzüm üretiminin yan ürünü olarak ortaya çıkan ve döngüsel ekonomiye uyum potansiyeli yüksek olan geri dönüştürülen bir atıktır. Şarap üretimi sonrası ortaya çıkan bu atığın yönetilmesi önemli bir sorundur. Ancak, sürdürülebilirlik ve yüksek katma değer elde etme hedefleri doğrultusunda, üzüm posasının geri kazanımında teknolojik yaklaşımlar söz konusudur. Bu çalışma, üzüm posasının biyoaktif bileşenlerini ve bu bileşenlerin sürdürülebilir üretime katkısını ele almayı amaçlamaktadır.

Materyal ve Yöntem: Bu derlemede, üzüm posasının kullanımına dair mevcut bilimsel çalışmalar ve endüstri raporları incelenmiştir. Çalışmada, özellikle yeşil ekstraksiyon yöntemlerine odaklanılarak, polifenoller ve diyet lifleri gibi biyoaktif bileşenlerin geri kazanımı ele alınmıştır. Süperkritik akışkan ekstraksiyonu ve ultrason destekli ekstraksiyon gibi teknolojiler incelenmiştir.

Bulgular: Literatürde üzüm posasının gıda, ilaç ve kozmetik gibi farklı sektörlerde kullanılabilir yüksek değerli biyoaktif bileşenler içerdiği bildirilmiştir. Gelişmiş yeşil teknolojiler, bu bileşenlerin çevreye minimum zarar ile verimli bir şekilde geri kazanılmasını sağlamaktadır. Ancak, tüketicilerin geri dönüştürülmüş ürünlere yönelik algıları ve kabul düzeyleri önemli bir engel olarak öne çıkmaktadır. Ar-Ge, markalaşma ve bilinçlendirme kampanyaları, bu ürünlerin piyasada kabul edilebilirliğini artırmada etkili bulunmuştur.

Tartışma ve Sonuç: Üzüm posasının geri dönüşümü, şarap endüstrisinde atık sorununu azaltarak sürdürülebilirliğe katkı sunmaktadır. Yeşil teknolojilere öncelik verilmesi ve sosyal engellerin aşılması, üzüm posasının döngüsel ekonomi içinde daha etkin kullanılmasını

sağlayabilir. Üreticiler, araştırmacılar ve politikacılar arasındaki iş birliği, bu potansiyelin tam anlamıyla ortaya çıkarılmasında kritik öneme sahiptir.
Anahtar Kelimeler: Üzüm posası; Sürdürülebilir bağcılık; Katma değerli ürünler; Atık yönetimi; Geri dönüştürülebilir tarım ürünleri

ABSTRACT

Introduction and Purpose: Grape pomace is a by-product of grape processing technology and is a recycled waste with high potential for adapting recovery products. Therefore, grape pomas has a valuable resource in the circular economy. The management of this post-production waste is a major challenge. However, there are technological approaches for the recovery of grape pomace in line with sustainability and high value-added production strategies. This study aims to address the bioactive components of grape pomace and their contribution to sustainable production.
Materials and Methods: In this review, scientific studies and industry reports on the utilization of grape pomace were analyzed. The study addresses the recovery of bioactive components such as polyphenols and dietary fibers, with a particular focus on green extraction methods. Technologies such as supercritical fluid extraction and ultrasound-assisted extraction are examined.
Results: It has been reported in the literature that grape pomace contains high-value bioactive components that can be used in different sectors such as food, pharmaceuticals and cosmetics. Advanced green technologies enable efficient recovery of these components with minimal damage to the environment. However, consumer perception and acceptance of recycled products remains a significant barrier. R&D, branding and awareness campaigns have been found to be effective in increasing the acceptability of these products in the market.
Discussion and Conclusion: The recycling of grape pomace contributes to sustainability by reducing waste mainly in the wine industry and in other processes such as grape juice, pekmez. Prioritizing green technologies and overcoming social barriers can lead to more effective use of grape pomace in the circular economy. Collaboration between producers, researchers and policy makers is critical to fully unlocking this potential.
Key Words: Grape pomace; Sustainable viticulture; Value added products; Waste management; Recyclable agricultural products

GİRİŞ

Üzüm, insanlık tarihi boyunca hem tüketilebilir hem de işlenebilir öneme sahip bir tarım ürünü olmuştur. Dünyanın birçok bölgesinde yetiştirilen ve ılıman kuşak üzerindeki ülkeler için büyük bir ekonomik ürün olan üzüm, sofralık (taze tüketim) şaraplık, kuru üzüm, olarak tüketilmesinin yanında meyve suyu ve sirke gibi ürünlere işlenmekte; üzüm ayrıca etnografyanın öne çıkardığı geleneksel ürünlerin üretiminde önemli bir yer tutmaktadır. Şarap ise bu ürünler arasında katma değerli en teknolojik ürün olup küresel ekonomide önemli bir ticaret hacmine sahiptir.
Dünyada şarap üretimi yılda yaklaşık 250-300 milyon hektolitre arasında değişmektedir (OIV, 2022). Şarap üretiminin büyük hacimli atığı ise üzüm posasıdır. Şarap üretiminde kullanılan üzümün %75'inden fazlası, posası ile birlikte yan ürün olarak işlemden geçmekte ve bu da yılda milyonlarca ton üzüm posasının bertaraf edilmesini gerektirmektedir (Wang vd., 2024).
Dünyada 2022 yılında yaklaşık 6.7 milyon ha alanda 75 milyon ton yaş üzüm üretimi gerçekleşmiş ve bu ürünün %75'i şarap üretiminde kullanılmıştır (FAO, 2024). Küresel şarap üretimi 2022 yılında yaklaşık 260 milyon hektolitre olarak gerçekleşmiştir (OIV, 2022). Avrupa, bu üretimin %66.27'sini gerçekleştirerek en büyük paya sahip olurken, Asya %2.99 ile en düşük oranda kalmıştır (Wang vd., 2024).

Üzüm posası, üretim sürecinde atık niteliği ile çevresel sorunlara yol açmaktadır. Geleneksel bertaraf yöntemleri, sera gazı salınımını artıran küresel ısınma ve çevre sorunlarına sebep olan yöntemler içermektedir (Muhlack vd., 2018). Bu büyük hacimli atığa farklı bir bakış açısı ile yaklaşıldığında ise üzüm posası içerdiği biyolojik aktif maddeler nedeniyle atık olmaktan çıkarak, çeşitli sektörler için değerli bir hammaddeye dönüştürme fırsatı sunmaktadır (Wang vd., 2024).

Bu çalışma, üzüm posasının biyoaktif bileşenlerini ve bu bileşenlerin sürdürülebilir üretime katkısını ele almayı amaçlamaktadır.

MATERYAL VE YÖNTEM

Bu derleme çalışmasında, üzüm posası üzerine yapılan önceki araştırmalar, literatür taramaları ve sektör raporları incelenmiştir. Çalışma, literatür taraması ve sistematik derleme yöntemiyle yürütülmüştür. Üzüm posasının geri dönüşüm potansiyelini araştıran makaleler, kitaplar, raporlar ve akademik dergiler taranarak seçilen kaynaklar üzerinden analiz yapılmıştır. Bu araştırmalar, belirli anahtar kelimeler kullanılarak veri tabanları (Web of Science, Google Scholar, Scopus) üzerinden toplanmıştır.

BULGULAR

Üzüm Posasının Bileşenleri

Biyoaktif Maddeler

Üzüm posası polifenoller, flavonoidler, proantosiyanidinler ve fenolik asitlerin önemli bir kaynağıdır. Polifenoller, üzüm posasının en önemli bileşenlerinden biridir ve antioksidan kapasitesiyle dikkat çeker. Bu bileşikler, vücuttaki serbest radikallerin neden olduğu hücresel hasarları azaltarak oksidatif stresi önler (Sousa vd., 2014). Flavonoidler, polifenol ailesinin bir alt grubunu oluşturmakta ve özellikle anti-inflamatuar, antikanser ve kardiyovasküler koruyucu etkileriyle öne çıkmaktadır. Üzüm posasında yaygın olarak bulunan antosiyaninler ve proantosiyanidinler, flavonoidlerin biyolojik aktivitesini artırarak damar sağlığını desteklemekte ve bağışıklık sistemini güçlendirmektedir (Peixoto vd., 2018). Yapılan çalışmalar, bu bileşiklerin diyabet yönetiminde ve insülin direncini azaltmada etkili olduğunu göstermektedir (Huaman-Castilla vd., 2021). Antosiyaninler, kırmızı üzümlerde bulunan kırmızı pigmentlerdir ve gıda endüstrisinde doğal renklendiriciler olarak önemlidir (Beres vd., 2017).

Kırmızı üzüm posası, şaraptan ve beyaz üzüm posasından daha yüksek fenolik içeriğe sahiptir (Beres vd., 2017). Üzüm posasında 13 fenolik asit, 22 flavonol (çeşitli formlarda), 3 flavonol ve proantosiyanidin, 3 stilben ve 16 antosiyanin; beyaz üzüm posası içerisinde 11 fenolik asit, 19 flavonol (çeşitli formlarda), 14 flavonol ve proantosiyanidin olmak üzere 73 bileşik tespit edilmiştir (Wang vd., 2024).

Diyet Lifleri

Diyet lifi, insan ince bağırsağında sindirilemeyen ve kalın bağırsakta tamamen veya kısmen fermente olan bitkisel karbonhidratlardır (Howlett vd., 2010). Üzüm posası, özellikle üzüm kabukları, önemli miktarda diyet lifi içerir (Bender vd., 2020). Diyet lifinin içeriği, üzüm çeşidine bağlı olarak değişmekle birlikte, kırmızı üzüm kabukları ağırlıkça %51-56 oranında, beyaz üzüm kabukları ise %17-28 oranında diyet lifi içerir (Deng vd., 2011). Araştırmalar, diyet lifi tüketiminin kardiyovasküler hastalıklar ve diyabetin görülme sıklığını azaltmada olumlu etkiler sağladığını da ortaya koymaktadır (Macagnan vd., 2016).

Üzüm posası aynı zamanda zengin bir pektin kaynağıdır. Pektin, gıda ve ilaç endüstrilerinde yaygın olarak jelleştirici madde, emülgatör ve dengeleyici olarak kullanılmaktadır (Ezzati vd., 2020). Film oluşturma yeteneği nedeniyle pektin, gıda ürünlerinin raf ömrünü uzatan yenilebilir film ve kaplama üretmek için de kullanılmaktadır (Mobasserfar vd., 2024).

Diğer Bileşikler

Üzüm posası, içeriğindeki çözünebilir şekerler, tartarik asit, mineral elementler ve yağlar sayesinde geri dönüşüm açısından önemli bir potansiyel sunar. Posadaki şeker içeriği, üzüm çeşidine ve şarap yapımında uygulanan yöntemlere bağlı olarak önemli ölçüde değişiklik gösterir. Kırmızı üzüm posası, genellikle cibre fermantasyon ve mayalanma sürecinin etkisiyle kabuk kısmında daha düşük çözünebilir şeker konsantrasyonlarına (%1,3-1,7) sahip olmasına rağmen, beyaz üzüm çeşitleri fermantasyondan önce preslendiği için daha yüksek şeker içeriğine (%56-78) sahiptir (Deng vd., 2011). Üzüm posasında bulunan bu şekerler, kozmetik ve plastik işleme gibi endüstriyel uygulamalar için umut vadeden bir hammadde olarak değerlendirilmektedir (Jin vd., 2019).

Tartarik asit, pek çok bitkide doğal olarak bulunmasına rağmen, üzüm posası ve tortu, tartarik asidin çıkarılması için yüksek potansiyele sahip değerli yan ürünlerdir (Muhlack vd., 2018). Şarap üretiminden elde edilen bu atıklarda, tartarik asit genellikle potasyum hidrojen tartarat veya kalsiyum tartarat kristalleri şeklinde bulunur. Posa ve tortu gibi şarap yan ürünlerinden tartarik asidin geri kazanımı, uzun yıllardır bilinen ve uygulanan bir yöntemdir (Devesa-Rey vd, 2011). Bu süreç, sürdürülebilirlik açısından büyük bir öneme sahiptir ve atık yönetiminde geri dönüşüm stratejilerinin uygulanabilirliğini artırmaktadır.

Üzüm posası, potasyum gibi çeşitli mineral elementler açısından zengindir. Potasyum, osteoporoz ve kardiyovasküler hastalıkların önlenmesinde önemli bir role sahiptir (Çetin vd., 2011). Ayrıca, bağışıklık sistemini destekleyen çinko ve kan hücresi üretimi için gerekli olan demir de üzüm posasında bolca bulunur (Sousa vd., 2014). Bu eser elementler, insan sağlığı için gerekli olan günlük alım gereksinimlerini karşılayabilecek potansiyele sahiptir (Wang vd., 2024). Üzüm posasının bu zengin içeriği, bu ürünün, hem beslenme hem de sağlık açısından önemli bir geri dönüşüm kaynağı olarak değerlendirilmesine olanak tanımaktadır.

Üzüm posasında yer alan üzüm çekirdekleri, yüksek besin değeri ve etkinliğiyle öne çıkan, doymamış yağ asitleri açısından zengin bir yağ içeriğine sahiptir (Kim vd., 2020). Üzüm çekirdeği yağı, besleyici özelliğinin yanı sıra, antioksidan ve antikanser özellikler sunan E vitamini, fitosteroller ve diğer biyoaktif bileşenler açısından da zengindir (Wen vd., 2016). Bu özellikleri sayesinde üzüm çekirdeği yağı, hem sağlık hem de endüstriyel uygulamalar için değerli bir bileşen olarak görülmektedir.

Üzüm Posasının Katma Değerli Kullanımı

Hayvan besleme

Üzüm posası, hayvan yemi katkı maddesi olarak değerlendirilme potansiyeline sahip değerli bir yan üründür. Günümüzde üzüm posası üretiminin yalnızca %3'ü hayvan yeminde kullanılsa da (Brenes vd., 2016), içeriğindeki lif, protein ve biyoaktif bileşenler, hem hayvan sağlığını hem de et ve süt ürünlerinin kalitesini artırabilir. Üzüm posasındaki yüksek polifenol içeriği, antioksidan özellikleri sayesinde lipit oksidasyonunu geciktirerek etin oksidatif stabilitesini güçlendirebilir (Sharma vd., 2007). Ayrıca, üzüm çekirdeklerindeki yüksek linoleik asit içeriği, sağlıklı yağ asitlerinin üretimini destekleyerek, hayvansal ürünlerin besin değerini artırmaktadır (Guerra-Rivas vd., 2017). Ancak, üzüm posasının bileşimi, üzüm çeşitleri ve şarap üretim yöntemlerine bağlı olarak değişiklik gösterdiğinden, bu alanda daha fazla standardizasyon ve optimizasyon çalışmasına ihtiyaç duyulmaktadır.

Toprak iyileştirici

Üzüm posasının toprak iyileştirici uygulamalarda kullanılması, toprak besinlerinin sızma dinamiklerini değiştirerek, besin maddelerinin kontrollü salınımını sağlayan yüksek polifenol içeriği ile dikkat çekmektedir (Korz vd., 2023). Aynı zamanda, üzüm posasının toprakta pestisit ve böcek öldürücü maddelerin etkisini azaltmada etkili olduğu belirtilmiştir (Ohashi vd., 2023). Üzüm posasının kompost üretimindeki rolü de oldukça önemlidir. Üzüm posası, tarımsal değeri artırmanın yanı sıra, toprağa stabil organik madde ve besin maddeleri kazandırarak, verimliliği artırabilir ve toprak elementlerini bağlama yoluyla iklim değişikliğiyle mücadeleye katkı sağlayabilir (Wang vd., 2024).

Enerji sürdürülebilirliği

Üzüm posası, zengin organik bileşimiyle biyoyakıt üretimi için önemli bir hammadde olarak öne çıkmaktadır. Yüksek karbonhidrat ve yağ içeriği, üzüm posasının anaerobik sindirim yoluyla biyogaz üretiminde etkili bir enerji kaynağı olmasını sağlar. Araştırmalar, üzüm posasından 100 gram başına 8,7 kJ biyogaz elde edilebileceğini göstermiştir (Failla ve Restuccia, 2014). Bu, onu geleneksel biyokütle kaynaklarına kıyasla daha verimli bir seçenek haline getirmektedir.

Biyoetanol üretimi konusunda da üzüm posası dikkat çekici bir potansiyele sahiptir. Geleneksel lignoselülozik materyallerden, örneğin saman ve bagastan daha üstün performans göstererek, ton başına 400 litreye kadar biyoetanol verimi sağlayabilmektedir (Corbin vd., 2015). Üzüm posası ayrıca, yağ içeriklerinden biyodizel üretiminde kullanılabilme potansiyeline sahiptir. Bu biyodizel, yüksek oksidatif stabiliteye sahip olup, içten yanmalı motorlarla uyumlu bir şekilde çalışabilmektedir (Fernández vd., 2010). Bu bağlamda, üzüm posasından elde edilen biyoyakıtlar, ulaştırma yakıtları ve fosil yakıtlara sürdürülebilir bir alternatif olarak umut vadetmektedir.

Gıda biyoaktif bileşeni

Üzüm posası, gıda sektöründe doğal ve fonksiyonel bir bileşen olarak geniş bir kullanım alanına sahiptir. Özellikle, posadan elde edilen özlerin, doğal gıda katkı maddesi olarak kullanımı, ürünlerin hem besin değerini hem de işlevselliğini artırmaktadır (Antonić vd., 2020). Araştırmalar, üzüm posasının gıda ürünlerine eklenmesinin antioksidan kapasitesini artırdığını (Maestre vd., 2010), yağ asidi profilini iyileştirdiğini (Choi vd., 2010), diyet lifi içeriğini yükselttiğini ve bağırsak sağlığını desteklediğini göstermiştir (Bender vd., 2017).

Posadaki antosiyaninler, doğal bir renk verici olarak gıdalara parlaklık ve renk derinliği kazandırmanın yanı sıra, raf ömrünü uzatıcı etkileriyle dikkat çeker. Ayrıca, üzüm posasından elde edilen diyet lifleri, prebiyotik özellikleriyle fonksiyonel gıdalarda sıklıkla tercih edilmektedir (Mildner-Szkudlarz vd., 2013). Bu özellikler, üzüm posasını hem sürdürülebilir hem de yüksek katma değerli bir gıda bileşeni haline getirmektedir.

Kozmetik ve ilaç sektörlerinde biyoaktif bileşen

Üzüm posası, zengin biyoaktif bileşen içeriğiyle, kozmetik ve ilaç sektörlerinde önemli bir ham madde olarak kullanılmaktadır (Tapia-Quirós vd., 2022). Kozmetik ürünlerde sentetik maddelere bağlı sağlık riskleri, cilt tahrişi ve alerjik reaksiyonlara yönelik endişeler, doğal biyoaktif bileşenlerin tercih edilmesini teşvik etmektedir. Üzüm posası özleri, özellikle antioksidan ve yaşlanma karşıtı özellikleriyle bu alanda öne çıkmaktadır (Ferreira ve Santos, 2022). Üzüm posası özleri, güneş koruyucular, yaşlanma karşıtı nemlendiriciler, yüz serumları ve gece kremleri gibi ticari kozmetik ürünlerde yaygın olarak bulunmaktadır.

İlaç sektöründe ise üzüm posası özleri, özellikle diyet takviyeleri ve destekleyici ilaçlarda kullanılmaktadır. Üzüm polifenollerinin inflamasyonu düzenlemesi, mitokondriyal işlevleri desteklemesi ve insülin duyarlılığını artırması gibi faydaları, bu özlerin ilaç formülasyonlarında geniş bir kullanım alanı bulmasını sağlamaktadır. Üzüm kabuğu ve çekirdeği özleri kapsül formunda kullanılırken, resveratrol ürünleri sağlıklı inflamatuar yanıtı teşvik etmektedir (Annunziata vd., 2021).

Üzüm Posasının Katma Değerli Kullanımına İlişkin Sınırlamalar

Gelişen üzüm posası gibi atıkların katma değerli kullanımını desteklemek, yalnızca teknolojik yenilikleri değil, aynı zamanda tüketicilerin ve politikacılarının yüksek düzeyde katılımını gerektiren karmaşık bir süreçtir (Laufenberg vd., 2003). Ancak, son yıllarda geliştirilen birçok katma değerli teknoloji henüz geniş çapta uygulanmamıştır. Ekonomik açıdan bakıldığında, üzüm posasının işleme tesislerine tedarik edilmesi ve taşınması maliyetli bir süreçtir. Ayrıca, kalıntıların ayrıştırılması ve korunması gibi ek yöntemler, bu süreçlerin toplam maliyetini artırmaktadır. Bu bağlamda, her bölgede büyük miktarlarda üzüm posası üreten endüstrilerin kurulması, maliyetlerin düşürülmesi için etkili bir çözüm olabilir.

Bununla birlikte, işleme maliyetleri ve nihai ürünlerin fiyatları, tüketici talebini etkileyen önemli faktörlerdir. Üzüm posasından değerli bileşiklerin çıkarılması ve saflaştırılması konusunda önemli adımlar atılmasına rağmen, bu atıkların değerli ürünlere dönüştürülmesinde hâlâ teknik sınırlamalar bulunmaktadır. Verimli çıkarma tekniklerinin geliştirilmesi, kalıntıların geri dönüştürülmesi ve çevresel etkilerin en aza indirilmesi, bu alandaki temel zorluklardır. Kısa vadede, daha temiz üretim süreçleri ve atık geri kazanımını artırmak hedeflenirken, uzun vadede fonksiyonel gıdalar gibi yenilikçi ürünlerin geliştirilmesi amaçlanmaktadır.

Biyoaktif Bileşenlerin Yeşil Ekstraksiyonu

Gıda endüstrisinde, tarımsal ve endüstriyel atıklardan antioksidanlar, pigmentler, polimerler ve yağların geri kazanılması giderek daha önemli hale gelmektedir. Geleneksel çözücü çıkarma teknikleri, Soxhlet yöntemi gibi, çözücünün ısıtılarak buharlaşması ve katı maddelere geçişiyle çalışmaktadır (Luque de Castro ve Garcia Ayuso, 1998). Bu yöntem düşük maliyetli ve yüksek verimli olmasına rağmen, uzun süreli ekstraksiyon, büyük çözücü tüketimi ve çevresel etkiler gibi dezavantajlara sahiptir (Fontana vd., 2013; Patra vd., 2022).

Yeni "yeşil" ekstraksiyon teknolojileri ise iyi bir alternatif olup, daha az zaman, enerji ve çözücü kullandığı için daha saf bileşikler elde edilmesini sağlar ve çevreye daha az zarar verir (İlyas vd., 2021; Gil-Martín vd., 2022). Yeşil çözücülerle üretilen bileşikler, güvenlik ve saflık açısından tüketiciler tarafından daha çok tercih edilmektedir (Drevelegka ve Goula, 2020).

- **Sıvı-Sıvı Ekstraksiyon**: Su ve bitkisel çözücüler gibi yeşil çözücülerle yapılan bu ekstraksiyon yöntemi, biyoaktif bileşiklerin yüksek verimle çıkarılmasına olanak tanımaktadır (Drevelegka ve Goula, 2020).
- **Mikrodalga Destilasyonu**: Mikrodalga teknolojisi, ısının bitkisel materyale hızla iletilmesini sağlayarak çözücülerle daha verimli bileşik çıkarımı sağlamaktadır. Bu yöntem, daha kısa sürelerde yüksek saflıkta ürün elde edilmesini mümkün kılar (Gil-Martín vd., 2022).
- **Süperkritik Karbondioksit Ekstraksiyonu**: Çevre dostu bir çözüm olan süperkritik karbondioksit, yüksek çözünürlük ve düşük toksisiteye sahip olup, özellikle yağlar ve esansiyel yağlar gibi bileşiklerin çıkarılmasında etkilidir (İlyas vd., 2021).
- **Ultrasonik Ekstraksiyon**: Ultrasonik dalgalar, hücre duvarlarını parçalayarak biyoaktif bileşenlerin daha hızlı ve verimli bir şekilde salınmasını sağlar. Ayrıca enerji tüketimini azaltır ve daha saf bileşikler elde edilmesini mümkün kılar (Patra vd., 2022).
- **Enzimatik Ekstraksiyon**: Enzimlerin kullanılması, bitkisel hücre duvarlarını parçalayarak biyoaktif bileşiklerin serbest kalmasını sağlar. Bu yöntem, düşük sıcaklıklar ve çözücülerle çalışmayı gerektirir, böylece çevresel etkiler minimize edilir (Fontana vd., 2013).

Ekstraksiyon Sonrası Kalıntıların Biyorafinasyonu

Yeşil ekstraksiyon yöntemleriyle, üzüm posası gibi tarımsal atıklardan değerli biyoaktif bileşiklerin sürdürülebilir bir şekilde üretilmesi mümkündür. Ancak, ekstraksiyon sonrası kalan kalıntıların uygun şekilde yönetilmesi, çevresel etkilerin minimize edilmesi açısından kritik bir öneme sahiptir. Bu kalıntıların kontrolsüz bir şekilde bozulması, organik maddelerin ayrışarak sera gazı emisyonlarını artırması gibi çevresel riskler oluşturabilir. Dairesel ekonomi prensiplerine uygun olarak, bu kalıntılar "sıfır atık" yaklaşımıyla geri dönüştürülmeli ve hammaddelere dönüştürülmelidir. Biyorafinasyon, atıklardan değerli ürünlerin üretilmesini sağlayan bir süreçtir ve biyokütlenin sürdürülebilir şekilde geri kazanılmasına olanak tanır. Bu yöntem, atıkların geri dönüşümünde giderek daha fazla ilgi görmekte ve endüstriyel uygulamalarda yaygınlaşmaktadır (Leong vd., 2021).

Üzüm Posası Bertarafının Sürdürülebilirliği ve Döngüsel Ekonomisi

Döngüsel ekonomi, atıkların azaltılması ve kaynakların yeniden değerlendirilmesini hedefleyen bir ekonomik modeldir. Üzüm posası, bu modelin bir parçası olarak değerlendirildiğinde, sürdürülebilir kalkınma hedeflerine ulaşmada önemli katkı sağlamaktadır (Wang vd., 2024). Üzüm posasını katı biyoyakıt ve maya hammaddelerine dönüştüren bir 'sıfır atık süreci' kurulmuş ve bu da onu yüksek değerli kaynaklara dönüştürmüştür (Lisičar Vukušić vd., 2023).

TARTIŞMA VE SONUÇ

Üzüm posasının geri dönüşümü, şarap endüstrisinde çevresel sürdürülebilirliğe katkı sağlayarak atık yönetimi sorununu hafifletmektedir. Bu süreç, doğal kaynakların korunmasına yardımcı olurken, endüstriyel atıklardan değerli bileşenlerin çıkarılmasına da olanak sağlamaktadır. Üzüm posasının biyoyakıtlar, biyoaktif bileşikler ve organik gübreler gibi yüksek katma değerli ürünlere dönüştürülmesi, döngüsel ekonomi modelinin önemli bir parçasıdır (Patra vd., 2022). Ancak, bu potansiyelin tam anlamıyla kullanılması için yeşil teknolojilere öncelik verilmesi gerekmektedir. Yeşil ekstraksiyon ve biyorafinasyon gibi yöntemler, atıkların verimli bir şekilde geri kazanılmasını sağlamakta ve bu süreçlerin çevreye olan etkilerini minimuma indirmektedir (Drevelegka ve Goula, 2020). Üreticiler, araştırmacılar ve politikacılar arasındaki güçlü bir iş birliği, teknolojik gelişmelerin hızla hayata geçirilmesi ve sürdürülebilir kalkınmanın sağlanmasında kritik bir rol oynamaktadır (Gil-Martín vd., 2022). Bu iş birliği, şarap endüstrisindeki atıkların geri kazanılmasında daha verimli ve çevre dostu çözümler üretmek için gereklidir.

KAYNAKLAR

Annunziata, G., Ciampaglia, R., Maisto, M., D’Avino, M., Caruso, D., Tenore, G. C., & Novellino, E. (2021). Taurisolo®, a grape pomace polyphenol nutraceutical reducing the levels of serum biomarkers associated with atherosclerosis. Frontiers in Cardiovascular Medicine, 8, 697272.

Bender, A. B. B., Speroni, C. S., Moro, K. I. B., Morisso, F. D. P., dos Santos, D. R., da Silva, L. P., & Penna, N. G. (2020). Effects of micronization on dietary fiber composition, physicochemical properties, phenolic compounds, and antioxidant capacity of grape pomace and its dietary fiber concentrate. LWT, 117, 108652.

Bender, A. B. B., Speroni, C. S., Salvador, P. R., Loureiro, B. B., Lovatto, N. M., Goulart, F. R.,Penna, N. G. (2017). Grape pomace skins and the effects of its inclusion in the technological properties of muffins. Journal of Culinary Science & Technology, 15, 143-157.

Beres, C., Costa, G. N. S., Cabezudo, I., da Silva-James, N. K., Teles, A. S. C., Cruz, A. P. G., Mellinger-Silva, C., Tonon, R. V., Cabral, L. M. C., & Freitas, S. P. (2017). Towards integral utilization of grape pomace from winemaking process: A review. Waste Management, 68, 581–594.

Brenes, A., Viveros, A., Chamorro, S., & Arija, I. (2016). Use of polyphenol-rich grape by-products in monogastric nutrition. A review. Animal Feed Science and Technology, 211, 1-17.

Çetin, E. S., Altinoz, D., Tarçan, E., & Goktürk Baydar, N. (2011). Chemical composition of grape canes. Industrial Crops and Products, 34, 994-998.

Choi, Y.-S., Choi, J.-H., Han, D.-J., Kim, H.-Y., Lee, M.-A., Jeong, J.-Y., … Kim, C.-J. (2010). Effects of replacing pork back fat with vegetable oils and rice bran fiber on the quality of reduced-fat frankfurters. Meat Science, 84, 557-563.

Corbin, K. R., Hsieh, Y. S. Y., Betts, N. S., Byrt, C. S., Henderson, M., Stork, J., DeBolt, S., Fincher, G. B., & Burton, R. A. (2015). Grape marc as a source of carbohydrates for bioethanol: Chemical composition, pre-treatment and saccharification. Bioresource Technology, 193, 76–83.

Deng, Q., Penner, M. H., & Zhao, Y. (2011). Chemical composition of dietary fiber and polyphenols of five different varieties of wine grape pomace skins. Food Research International, 44, 2712-2720.

Devesa-Rey, R., Vecino, X., Varela-Alende, J. L., Barral, M. T., Cruz, J. M., & Moldes, A. B. (2011). Valorization of winery waste vs. the costs of not recycling. Waste Management, 31, 2327-2335.

Drevelegka, I., & Goula, A. M. (2020). Recovery of grape pomace phenolic compounds through optimized extraction and adsorption processes. Chemical Engineering and Processing Process Intensification, 149, 107845.

Ezzati, S., Ayaseh, A., Ghanbarzadeh, B., & Heshmati, M. K. (2020). Pectin from sunflower by-product: Optimization of ultrasound-assisted extraction, characterization, and functional analysis. International Journal of Biological Macromolecules, 165, 776-786.

Failla, S., & Restuccia, A. (2014). Methane potentials from grape marc by a laboratory scale plant. Applied Mathematical Sciences, 8, 6665-6678.

FAO (2024). Food and Agriculture Organization of the United Nations. https://www.fao.org/statistics/en (Erişim 4.11.2024)

Fernández, C. M., Ramos, M. J., Pérez, Á., & Rodríguez, J. F. (2010). Production of biodiesel from winery waste: extraction, refining and transesterification of grape seed oil. Bioresource technology, 101(18), 7019-7024.

Ferreira, S. M., & Santos, L. (2022). A potential valorization strategy of wine industry by-products and their application in cosmetics-Case study: Grape pomace and grapeseed. Molecules, 27, 969.

Fontana, A. R., Antoniolli, A., & Bottini, R. (2013). Grape pomace as a sustainable source of bioactive compounds: Extraction, characterization, and biotechnological applications of Phenolics. Journal of Agricultural and Food Chemistry, 61, 8987-9003.

Gil-Martín, E., Forbes-Hern´andez, T., Romero, A., Cianciosi, D., Giampieri, F., & Battino, M. (2022). Influence of the extraction method on the recovery of bioactive phenolic compounds from food industry by-products. Food Chemistry, 378, 131918.

Guerra-Rivas, C., Gallardo, B., Mantecón, Á. R., del Álamo-Sanza, M., & Manso, T. (2017). Evaluation of grape pomace from red wine by-product as feed for sheep. Journal of the Science of Food and Agriculture, 97(6), 1885-1893.

Howlett, J. F., Betteridge, V. A., Champ, M., Craig, S. A. S., Meheust, A., & Jones, J. M.n(2010). The definition of dietary fiber - discussions at the ninth Vahouny Fibernsymposium: Building scientific agreement. Food & Nutrition Research, 54(1), 5750.

Huamán-Castilla, N. L., Campos, D., García-Ríos, D., Parada, J., Martínez-Cifuentes, M., Mariotti-Celis, M. S., & Pérez-Correa, J. R. (2021). Chemical properties of vitis vinifera carménère pomace extracts obtained by hot pressurized liquid extraction, and their inhibitory effect on type 2 diabetes mellitus related enzymes.Antioxidants,10(3), 472.

Ilyas, T., Chowdhary, P., Chaurasia, D., Gnansounou, E., Pandey, A., & Chaturvedi, P. (2021). Sustainable green processing of grape pomace for the production of value-added products: An overview. Environmental Technology & Innovation, 23, 101592.

Jin, Q., O'Hair, J., Stewart, A. C., O'Keefe, S. F., Neilson, A. P., Kim, Y.-T., … Huang, H. (2019). Compositional characterization of different industrial white and red grape pomaces in Virginia and the potential valorization of the major components. Foods, 8, 667.

Kim, T.-K., Yong, H.-I., Jung, S., Kim, Y.-B., & Choi, Y.-S. (2020). Effects of replacing pork fat with grape seed oil and gelatine/alginate for meat emulsions. Meat Science, 163, 108079.

Korz, S., Sadzik, S., More, C., Buchmann, C., Richling, E., & Munoz, K. (2023). Effect of grape pomace varieties and soil characteristics on the leaching potential of Total carbon. Nitrogen and Polyphenols. Soil Systems, 7, 49.

Laufenberg, G., Kunz, B., & Nystroem, M. (2003). Transformation of vegetable waste into value added products::(A) the upgrading concept;(B) practical implementations. Bioresource technology, 87(2), 167-198.

Leong, H. Y., Chang, C.-K., Khoo, K. S., Chew, K. W., Chia, S. R., Lim, J. W., Show, P. L. (2021). Waste biorefinery towards a sustainable circular bioeconomy: A solution to global issues. Biotechnology for Biofuels, 14, 87.

Lisičar Vukušić, J., Millenautzki, T., Reichert, L., Mokhlis Saaid, A., Müller, L., Clavijo, L., & Barbe, S. (2023). Conversion of Problematic Winery Waste into Valuable Substrate for Baker's Yeast Production and Solid Biofuel: A Circular Economy Approach. Food Technology and Biotechnology, 61(4), 430-438.

Luque de Castro, M. D., & Garcia Ayuso, L. E. (1998). Soxhlet extraction of solid materials: An outdated technique with a promising innovative future. Analytica Chimica Acta, 369, 1-10.

Macagnan, F. T., da Silva, L. P., & Hecktheuer, L. H. (2016). Dietary fibre: The scientific search for an ideal definition and methodology of analysis, and its physiological importance as a carrier of bioactive compounds. Food Research International, 85, 144-154.

Maestre, R., Micol, V., Funes, L., & Medina, I. (2010). Incorporation and interaction of grape seed extract in membranes and relation with efficacy in muscle foods. Journal of Agricultural and Food Chemistry, 58, 8365-8374.

Mobasserfar, R., Shiri, A., Mofid, V., Noghabi, M. S., & Gharibzahedi, S. M. T. (2024). Optimizing, characterizing, and unveiling of functional properties and structure of grape pomace pectin obtained by a sequential ultrasound-microwave extraction. Biomass Conversion and Biorefinery. 1-14.

Muhlack, R. A., Potumarthi, R., & Jeffery, D. W. (2018). Sustainable wineries through waste valorisation: A review of grape marc utilisation for value-added products. Waste Management, 72, 99-118.

OIV (2022). International Organisation of Vine and Wine. https://www.oiv.int/(Erişim 12.12.2022)

Ohashi, T., Sugimoto, K., Sasaki, Y., & Hisamoto, M. (2023). Effect of wine pomace extract on dechlorination of chloroethenes in soil suspension. Bioresources and Bioprocessing, 10, 22.

Patra, A., Abdullah, S., & Pradhan, R. C. (2022). Review on the extraction of bioactive compounds and characterization of fruit industry by-products. Bioresources and Bioprocessing, 9, 14.

Sharma, S. D., Meeran, S. M., & Katiyar, S. K. (2007). Dietary grape seed proanthocyanidins inhibit UVB-induced oxidative stress and activation of mitogen-activated protein kinases and nuclear factor-κB signaling in in vivo SKH-1 hairless mice. Molecular Cancer Therapeutics, 6, 995-1005.

Sousa, E. C., Uchoa-Thomaz, A. M. A., Carioca, J. O. B., Morais, S. M.d., Lima, A.d., Martins, C. G., … Rodrigues, L. L. (2014). Chemical composition and bioactive compounds of grape pomace (Vitis vinifera L.), Benitaka variety, grown in the semiarid region of Northeast Brazil. Food Science and Technology, 34, 135-142.

Tapia-Quiros, P., Montenegro-Landívar, M. F., Reig, M., Vecino, X., Cortina, J. L., Saurina, J., & Granados, M. (2022). Recovery of polyphenols from Agri-food by-products: The olive oil and winery industries cases. Foods, 11, 362.

Wang, C., You, Y., Huang, W., & Zhan, J. (2024). The high-value and sustainable utilization of grape pomace: A review. Food Chemistry: X, 101845.

Wen, X., Zhu, M., Hu, R., Zhao, J., Chen, Z., Li, J., & Ni, Y. (2016). Characterisation of seed oils from different grape cultivars grown in China. Journal of Food Science and Technology, 53, 3129-3136.

A HIGH VALUE GRAPE CULTIVAR IN TURKISH VITICULTURE: "SULTANİ ÇEKİRDEKSİZ"

TÜRKİYE BAĞCILIĞINDA YÜKSEK KATMA DEĞERLİ BİR ÜZÜM ÇEŞİDİ: SULTANİ ÇEKİRDEKSİZ

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ÖZET

Giriş ve Amaç: Çekirdeksiz üzüm, Dünya Sağlık Örgütü'nün sağlıklı gıdalar listesinde yer alan zengin içerikli fonksiyonel üründür. Türkiye, çekirdeksiz kuru üzüm üretiminde ve ihracatında dünya lideridir. Manisa-İzmir-Denizli yörelerinde yoğun yetiştirilen Sultani çekirdeksiz üzüm çeşidi, taze tüketim ve kuru üzüm olarak küresel pazarda büyük bir ticari hacme sahiptir. Ülkemiz bağcılığında ise stratejik bir ürün olarak öne çıkmaktadır. Bu çalışmada, Sultani Çekirdeksiz'in üretim potansiyeli, ekonomik getirisi ve katma değer oluşturma kapasitesi ele alınmıştır.

Materyal ve Yöntem: Araştırma kapsamında, Sultani Çekirdeksiz'in dünya ve Türkiye için üretim ve ticari kapasitesi incelenmiştir. Çalışmada, literatür taramasına dayalı analizler yapılmış, sektör temsilcilerinden alınan bilgiler ile saha gözlemleri birleştirilmiş ve 2023-2024 sezonuna ait sektör değerlendirmesi yapılmıştır.

Bulgular: Sultani Çekirdeksiz, Türkiye'nin toplam kuru üzüm ihracatının %90'ını oluşturmaktadır. Modern bağcılık tekniklerinin uygulanması, ürün verimini artırırken, kaliteyi de dünya standartlarına taşımaktadır. Özellikle organik ve sürdürülebilir üretim uygulamaları, uluslararası pazarlarda daha yüksek fiyatlarla alıcı bulmayı sağlamaktadır. 2023-2024 sezonunda Türkiye'nin çekirdeksiz kuru üzüm ihracatı, miktar bazında %20 düşüşle 207 bin ton olurken, döviz geliri %11 artışla 490 milyon dolara ulaşmıştır. Avrupa Birliği, toplam ihracatın %78'ini oluşturarak en büyük pazar olmayı sürdürmüş ve özellikle İngiltere, Hollanda ve Almanya öne çıkmıştır. Ayrıca Uzakdoğu ve Güneydoğu Asya ülkelerine ihracatta %27 artış kaydedilmiştir. Rekoltedeki düşüş, iklim değişikliğine bağlı olumsuz etkilerden kaynaklanmış ve uzun yıllar ortalamasının 100 bin ton altında kalmıştır.

Tartışma ve Sonuç: Sultani Çekirdeksiz, Türkiye'nin bağcılık sektöründe yüksek katma değerli bir ürün olmaya devam etmektedir. Rekolte düşüşüne rağmen elde edilen döviz artışı, ihracattaki başarısının ve uluslararası pazar değerinin yüksek bir konumda olduğunu göstermektedir. Bu bağlamda, sürdürülebilir üretim uygulamalarına yönelerek kalite ve verimliliğin artırılması önemlidir.

Anahtar Kelimeler: Türk bağcılığı, Sultani Çekirdeksiz, Kuru üzüm ihracatı, Yüksek katma değerli ürün, Sürdürülebilir üzüm üretimi

ABSTRACT

Introduction and Purpose: Raisins are rich and functional products included in the World Health Organization's list of healthy foods. Türkiye is the global leader in seedless raisin production and export. The "Sultani Çekirdeksiz" grape variety, predominantly grown in the Manisa, İzmir and Denizli region, is a product of significant commercial value both as fresh fruit and as raisins in global markets. Within Turkish viticulture, it stands out as a strategic product. This study examines the production potential, economic benefits, and value-adding capacity of "Sultani Çekirdeksiz".

Materials and Methods: The study analyzed the production and trade capacities of "Sultani Çekirdeksiz" for both Türkiye and the world. Literature-based analyses were conducted, combined with insights from industry representatives and field observations, along with a sectoral assessment of the 2023-2024 season.

Results: "Sultani Çekirdeksiz" grapes account for 90% of Türkiye's total raisin exports. The application of modern viticulture techniques enhances both productivity and quality, bringing it to global standards. Organic and sustainable production practices, in particular, enable the product to achieve higher prices in international markets. In the 2023-2024 season, Türkiye's seedless raisin exports decreased by 20% in amount to 207.000 tons, while foreign exchange revenue increased by 11% to reach $490 million. The European Union maintained its position as the largest market, constituting 78% of total exports, with the United Kingdom, the Netherlands, and Germany leading. Additionally, exports to East and Southeast Asian countries rose by 27%. The decline in yield was attributed to adverse effects of climate change, with production falling 100.000 tons below the long-term average.

Discussion and Conclusion: "Sultani Çekirdeksiz" continues to be a high-value product in Türkiye's viticulture sector. Despite the decline in yield, the increase in foreign exchange earnings highlights the success of exports and the product's strong position in international markets. In this context, focusing on sustainable production practices to improve quality and efficiency is essential.

Key Words: Turkish viticulture, Sultani Çekirdeksiz, Raisin exports, High value product, Sustainable grape production

GİRİŞ

Üzüm, içerdiği şekerler, mineraller, organik asitler, enzimler, vitaminler ve fenolik bileşiklerle besin değeri yüksek bir ürün, farklı tat ve aroma özellikleriyle; sofralık, kurutmalık, şaraplık ve şıralık tüketimde tercih edilen bir meyvedir. Gıda başta olmak üzere, pek çok sektörde hammadde olarak kullanıma uygunluğu, istihdam oluşturması ve yüksek ihracat potansiyeline sahip olması gibi özellikleriyle, besin kaynağı olmasını yanı sıra, sanayi için de tüm dünyada stratejik bir ürün olarak önemli bir yere sahiptir.

Dünya Sağlık Örgütü (WHO) ile Gıda ve Tarım Örgütü (FAO) tarafından kuru üzümün amino asitler yönünden gerekli dengeyi sağladığı kabul edilmiştir (Batu, 1993) Beyaz, renkli çekirdekli veya çekirdeksiz üzümün 100 gramında 80.54 g su, 69 kcal (288 kj) enerji, 0.72 g protein, 0.16 g yağ, 0.48 g kül, 18.10 g karbonhidrat, 0.9 g lif, 15.48 g toplam şeker, 0.15 g sakkaroz, 7.20 g glukoz, 8.13 g früktoz, 10 mg kalsiyum, 0.36 mg demir, 7 mg magnezyum, 20 mg fosfor, 191 mg potasyum, 2 mg sodyum, 0.07 mg çinko, 0.127 mg bakır, 0.071 mg mangan, 0.1 µg selenyum, 10.8 mg C vitamini, 0.069 mg thiamin, 0.070 mg riboflavin, 0.188 mg niacin, 0.086 mg B6 vitamini, 39 µg β-karoten, 0.19 mg E vitamini ve birçok yağ asidi bulunmaktadır (Çelik, 2014). Yenilebilir 100 gram taze asma yaprağında ise 73.32 g su, 93 kcal (390 kj) enerji, 5.60 g protein, 2.12 g toplam yağ, 1.65 g kül, 17.31 g protein, 11 g toplam lif, 6.30 g toplam şeker, 363 mg kalsiyum, 2.63 mg demir, 95 mg magnezyum, 91 mg fosfor, 272 mg potasyum, 9 mg sodyum, 0.067 mg çinko, 0.415 mg bakır, 2.855 mg magnezyum, 0.9 µselenyum, 11.1 mg C vitamini, 0.040 mg thiamin, 0.354 mg riboflavin, 2.362 mg niasin, 0.4006 B6 vitamini, 27.251 IU A vitamini, b16.194 µg beta karoten, 2 mg E vitamini, 108.6 µg K vitamini, 0.336 g doymuş yağ asidi ve 0.081 g doymamış yağ asidi içermektedir (Lim, 2013). Üzümdeki demir +2 formunda olup vücut tarafından emilimi kolaydır (Gülcü ve vd., 2008).

FAO (2024) verilerine göre 2022 yılında Dünya'da yaklaşık 6.7 milyon ha alanda 75 milyon ton yaş üzüm üretimi gerçekleşmiştir. Türkiye ise, 384.536 ha alan ve 4.2 milyon ton üretim ile Dünya bağ alanı ve yaş üzüm üretiminin % 6'sını karşılamaktadır (TÜİK, 2024). Türkiye bağ alanı bakımından İspanya, Fransa, İtalya ve Çin'den sonra 5. sırada yer alırken, üzüm üretimi bakımından Çin, İtalya, Fransa, İspanya ve ABD'den sonra 6. sıradadır (FAO, 2024). Türkiye'de 2023 yılında üretilen 3.400.000 ton yaş üzümün %53'ü sofralık, %38'i kurutmalık ve %9'u şaraplık-şıralık olarak değerlendirilmiştir (TÜİK, 2024). Bunun dışında üzüm, pekmez, pestil, köfter, bulama ve sirke olarak sanayide yerel ürünlerin üretiminde de önemli bir hammaddedir.

Sultani Çekirdeksiz (*Vitis vinifera* L.) üzüm çeşidi, meyvesi; sofralık, kurutmalık ve şaraplık-şıralık olarak yaprağı ise sarmalık olarak değerlendirilen katma değeri yüksek bir üzüm çeşididir. Ege Bölgesi'ne ait olan bu çeşit, ilk kez 1838 yılında İzmir'den Girit'e, 1879 yılında Kaliforniya'ya (Aybers, 1954) ve 1895 yılında Yunanistan'a (Kenber, 1938) götürülmüştür (Yağcı ve İlter, 2018). Çekirdeksiz üzümün Avustralya'ya yayılması ise, İzmir'deki Rum bağcılarının bu ülkeye göç etmeleriyle gerçekleşmiştir (Reşat, 1931). Bu çeşit, ABD'de Thompson Seedless, Yakındoğu'da Sultanina veya Sultanieh, Orta Asya'da Oval Kişmiş, Güney Afrika ve Avustralya'da Sultana veya Sultanina, Rusya'da ise Akkişmiş olarak adlandırılmaktadır (Winkler vd., 1974).

Bu çalışmada, Sultani Çekirdeksizin üretim potansiyeli, ekonomik getirisi ve katma değer oluşturma kapasitesi ele alınmıştır.

MATERYAL VE YÖNTEM

Çalışmanın materyalini Sultani Çekirdeksiz (Şekil 1) üzüm çeşidi oluşturmaktadır. Çalışma kapsamında, Sultani Çekirdeksiz'in dünya genelinde ve Türkiye'deki üretim ile ticari potansiyeli ele alınmış, literatüre dayalı analizlerin yanı sıra, sektör temsilcilerinden edinilen bilgiler ve saha gözlemleri bir araya getirilerek 2023-2024 sezonuna yönelik kapsamlı bir sektör analizi gerçekleştirilmiştir.

Şekil 1. Sultani Çekirdeksiz (Foto: Doç. Dr. Fadime ATEŞ)

BULGULAR

Sultani Çekirdeksiz'in Sofralık Üzüm Bakımından Katma Değeri

Ege Bölgesi, yaş üzüm üretiminin yaklaşık yarısını tek başına karşılamaktadır ve sofralık üzüm üretiminde de önemli bir paya sahiptir. Sofralık üzüm üretimi ve ihracatında Sultani Çekirdeksiz üzüm, açık ara lider konumdadır. Manisa, Denizli ve İzmir illerinde yoğun olarak yetiştirilen bu değerli çeşit, genellikle kurutmalık olarak değerlendirilse de bitki gelişim düzenleyiciler (BGD) ve çeşitli kültürel uygulamalarla sofralık tüketim amacıyla da yaygın bir şekilde üretilmektedir (Söylemezoğlu vd. 2020)

Türkiye, 2020 yılında 110 milyon 734 bin dolarlık Sultani Çekirdeksiz sofralık üzüm ihracatı yaparken, ilk sırada 65 milyon dolarla Rusya Federasyonu yer almıştır. İkinci sıranın sahibi 13,4 milyon dolarla Ukrayna olurken, Almanya 6,6 milyon dolarlık alım yapmıştır. Polonya'ya 5 milyon dolarlık ve Beyaz Rusya'ya 3,4 milyon dolarlık sofralık Sultani Çekirdeksiz üzümü ihraç edilmiş ve ihraç edilen ülke sayısı ise 57 olmuştur (EİB, 2020). 2023 yılında Sultani Çekirdeksiz ihracatından elde edilen gelir 134,6 milyon dolardır. 2023 yılında 87 milyon dolar olan Sultani Çekirdeksiz ihracatımızın 2024 yılında 100 milyon doların üzerine taşınması hedeflenmektedir (EİB, 2023).

Sultani Çekirdeksiz'in Kuru Üzüm Bakımından Katma Değeri

Türkiye, dünyanın en büyük çekirdeksiz kuru üzüm üreticisi ve ihracatçısı konumundadır. Sultani Çekirdeksiz, Türkiye'nin toplam kuru üzüm ihracatının %90'ını oluşturmaktadır. Ülkemiz, dünya genelindeki ortalama üretimin %20'sine denk gelen 280-300 bin tonluk üretim kapasitesi ve 260 bin tonluk ihracatıyla hem üretimde hem de ihracatta liderdir. Türkiye'de çekirdeksiz üzüm üretimi ağırlıklı olarak Ege Bölgesi'nde yapılmakta olup, Manisa (%87), İzmir (%9) ve Denizli (%4) bu üretimde başı çeken iller arasındadır (TMO, 2020).

2023-2024 sezonunda Türkiye'nin çekirdeksiz kuru üzüm ihracatı, miktar bazında %20 düşüşle 207 bin ton olurken (Manisa Ticaret Borsası, 2024), döviz geliri %11 artışla 490 milyon dolara ulaşmıştır. Avrupa Birliği, toplam ihracatın %78'ini oluşturarak en büyük pazar olmayı sürdürmüş ve birlikte özellikle İngiltere, Hollanda ve Almanya öne çıkmıştır (Tablo 1). Ayrıca Uzakdoğu ve Güneydoğu Asya ülkelerine ihracatta %27 artış kaydedilmiştir. Rekoltedeki düşüş, iklim değişikliğine bağlı olumsuz etkilerden kaynaklanmış olup, ortalama, uzun yıllar 100 bin tonun altında kalmıştır.

Tablo 1. Çekirdeksiz kuru üzüm ihracatı yapılan ülkeler (Anonim, 2024)

Ülke Adı	**2021-2022 Miktar (Ton)**	**2021-2022 Tutar (1000$)**	**2022-2023 Miktar (Ton)**	**2022-2023 Tutar (1000$)**
İngiltere	64.364	111.049	65.314	108.402
Almanya	35.131	62.293	31.168	53.623
Hollanda	23.721	41.850	31.085	52.003
İtalya	20.093	34.486	17.994	29.584
Fransa	15.711	27.624	15.983	26.387
Avustralya	16.906	28.602	11.883	19.548
Japonya	6.272	13.245	8.286	17.381
İspanya	7.292	12.852	8.260	15.605
Kanada	8.061	13.406	9.179	14.985
Polonya	5.726	9.199	7.049	10.672
Belçika	5.109	8.630	5.031	8.168
İrlanda	4.449	7.150	4.146	6.673
İsveç	1.949	4.961	2.044	5.193
Çin	2.452	4.444	2.380	4.487
Avusturya	1.941	3.407	2.478	4.374
Yeni Zelanda	3.519	6.284	2.518	4.266
Rusya	2.477	4.723	2.223	4.117
Brezilya	945	1.527	2.375	3.691
İsviçre	2.603	5.836	1.590	3.387
Yunanistan	1.435	2.329	1.920	3.291
İlk 20 Ülke Toplamı	**230.156**	**403.897**	**232.907**	**395.836**
Diğer Toplam	**22.081**	**37.728**	**26.650**	**44.576**
Avrupa Ülkeleri	**197.462**	**345.413**	**205.020**	**345.656**
Genel Toplam	**252.237**	**441.625**	**259.558**	**440.412**

Kuru üzüm, "bandırılmış" ve "naturel" olarak iki ana gruba ayrılır. Naturel kuru üzüm, hasat edilen üzümlerin herhangi bir işlem görmeden doğrudan sergi alanında kurutulmasıyla elde edilir. Bandırılmış kuru üzüm ise üzümlerin, "potasa" olarak bilinen özel bir bandırma çözeltisine daldırıldıktan sonra sergi alanında kurutulmasıyla üretilir. Bandırma işleminde kullanılan çözeltinin, çevresel koşullara bağlı olarak doğru oranda hazırlanması büyük önem taşır. Ege Bölgesi'nde ideal bandırma çözeltisi, %5 potasyum karbonat ve %1 zeytinyağı karışımı olarak önerilmektedir (Güler, 2019).

Çekirdeksiz kuru üzümde, "Türk tipi üretim" kalite belirlemesinde ve fiyatlandırmada önemli bir rol oynamaktadır. Türk tipi üretimde, açık sarı renkli taneler yüksek kaliteyi temsil eder. TS 3411 standardına göre, 5 farklı tip numarası belirlenmiştir. En düşük kalite, siyah ve koyu kahverengi tanelerin çoğunlukta olduğu 7 numara olarak tanımlanırken, en yüksek kalite, açık sarı tanelerin hakim olduğu 11 numara olarak belirlenmiştir (Anonim, 2022).

Sultani Çekirdeksiz'in Sarmalık Yaprak Bakımından Katma Değeri

Ege Bölgesi, özellikle Manisa ili geniş üzüm bağları ile yaş üzüm, kurutulmuş üzüm ve asma yaprağının üretim merkezi konumundadır. Bölgede yaş meyve sebze üretimi ana geçim kaynaklarından biridir. Türkiye'de asma yaprağının en çok üretildiği il Manisa'dır. Dünyaca ünlü Sultani Çekirdeksiz üzümü, asma yaprağının inceliği, altının tüysüz olması, kendine has tadı ve aroması ile bilinmektedir. Çekirdeksiz kuru üzüm olarak dünyanın dört bir yanına ihraç edilmesinin yanında, asma yaprağı da dış pazarlarda çok rağbet gören, özellikle son yıllarda 800 bin dekarlık bir alanda üretim yapan 50 bin ailenin ikinci gelir kaynağı olmuştur (Anonim, 2021).

Ülkemiz için de önemli ihracat ürünü olan asma yaprağı gerek yaprak olarak gerekse de sarması olarak, Akdeniz ülkeleri başta olmak üzere dünyada çok büyük bir talep görmektedir. Hazır yemek endüstrisinde kendine yer bulan salamura yaprağına artan bir talep söz konusudur. Çiftçiler, toplanan asma yapraklarını, il genelinde oluşturulan asma yaprağı alım merkezlerine satarak ek gelir elde etmektedir. Üreticiler tarafından satın alınan asma yaprakları, salamura ve yaprak sarma olarak yurtiçine ve yurtdışına sevk edilmektedir. Salamura yaprak, vakumlu paketlerde, kavanozlarda ve pet şişelerde satışa sunulmaktadır. Hâlihazırda Avrupa Birliği ülkeleri başta olmak üzere, birçok ülkeye ihracat gerçekleştirilen sektörde, yükselen bir ihracat performansı mevcuttur. Manisa ilinde 2000'li yıllarda sadece beş ülkeye 2 bin ton salamura yaprak ihracı yapılırken; 2022 yılın da 50 farklı ülkeye ve 35 bin tona ulaşmıştır (Anonim, 2023). Ancak son yıllarda asma yaprağında kalıntı sorunu nedeniyle Avrupa Birliği'ne ihracatta sorunlar yaşanmaktadır.

Sultani Çekirdeksiz'in Şarap Olarak Katma Değeri

Sultani Çekirdeksiz çeşidi, son yıllarda meyve ve çiçek aromalarınca zengin yapısıyla şarap üretiminde giderek önem kazanmaya başlamıştır. Meyve aromalarınca zengin, damakta tatlı ifade bırakan, zarif ve kolay içimli sek şaraplar vermesi, şarap üreticilerince tercih edilmesinin ana nedeni olmuştur. Asitliğinin düşük oluşu, üzümün şarap üretimi bakımından olumsuz yönünü oluşturmaktadır. Bu nedenle yüksek asitli şaraplarla harmanlanarak asitliği dengelenebilmektedir (Kaya, 2017).

Sultani Çekirdeksiz'in Organik Kuru Üzüm Olarak Katma Değeri

Organik üzüm üretimi dünyada sınırlı sayıda ülkede gerçekleştirilmektedir. FİBL (Forschung Institute für Biologischen Landbau; Research Institute of Organic Agriculture; Organik Tarım

Araştırmaları Enstitüsü) 2018 verilerine göre dünyada 379.555 ha alanda organik üzüm üretilmekte olup, bu rakam dünya üzüm üretim alanının %5.3'ünü oluşturmaktadır. Üzüm, ülkemizde yetiştirilen 197 organik ürün içerisinde en önemlilerinden birisidir. 1985 yılından itibaren organik kuru üzüm üreten ve ihraç eden Türkiye, organik kuru üzüm üretiminde dünya lideri konumundadır. FİBL 2018 verilerine göre Türkiye'de 13.961 ha alanda organik üzüm üretimi gerçekleştirilmiş olup bu rakam Türkiye'nin toplam üretim alanının %3.2'sini oluşturmuştur (Lernoud ve Willer, 2019a, 2019b). Türkiye'nin 2023 yılında toplam organik üzüm üretimi, geçiş süreci alanları da dahil olmak üzere 7.590 hektarlık bir alanda 123.144 ton olarak kaydedilmiştir. Aynı yıl, 6.581 ton organik üzüm ve üzüm ürünü ihracatı gerçekleştirilmiş ve bu ihracattan 21.125.089 ABD doları gelir sağlanmıştır. Organik üzüm üretiminin önemli bir bölümü, çekirdeksiz kuru üzüm şeklinde ihraç edilmektedir (TOB, 2024).

Türkiye'nin organik çekirdeksiz kuru üzüm ihracatı yaptığı en önemli ülkeler, Almanya, Birleşik Krallık, İsviçre, Fransa ve Hollanda'dır. Ülkemiz pazarında ise konvansiyonel üzümde olduğu gibi organik çekirdeksiz kuru üzümde de tüketim oldukça düşüktür.

TARTIŞMA VE SONUÇ

Sultani çekirdeksiz üzüm, Türkiye bağcılığında yüksek katma değer yaratma potansiyeline sahip stratejik bir üründür. Türkiye'nin bu çeşitteki küresel liderliğini sürdürmesi için inovatif tarım uygulamaları, kaliteli üretim teknikleri ve etkili pazarlama stratejileri benimsenmelidir. Dünya genelinde kuru üzüm talebindeki artış, Türkiye için önemli fırsatlar oluşturmaktadır. Daha fazla pazar çeşitliliği ve sürdürülebilir üretim yöntemleri ile sektörde büyüme sağlanabilir. Özellikle Türkiye'nin Avrupa pazarındaki lider konumu güçlendirilmelidir. İklim değişikliği ve azalan su kaynakları, sektörün sürdürülebilirliğini tehdit ettiği için modern sulama sistemlerinin yaygınlaştırılması ve yenilikçi tarım yöntemlerinin desteklenmesi önerilmektedir. Sarmalık yaprak kalıntı sorununun çözülmesi için Maksimum Residü (Kalıntı) Limiti (MRL) değerlerinin yeniden gözden geçirilmesi ve çiftçilerin ilaç kullanımı konusunda bilinçlendirilmesi önemlidir.

Sonuç olarak, Sultani çekirdeksiz üzüm çeşidi, sadece ekonomik bir değer değil, aynı zamanda Türkiye'nin bağcılık geleneğini ve zengin tarımsal mirasını temsil eden bir sembol niteliğindedir. Bu potansiyelin doğru yönetimi, sürdürülebilir kalkınma hedeflerine önemli bir katkı sağlayabilir.

KAYNAKLAR

Anonim, 2021. Manisa İli Alaşehir İlçesi Yaprak Salamura Tesisi Ön Fizibilite Raporu. Zafer Kalkınma Ajansı, 55 s.

Anonim, 2022, Türk Standardı çekirdeksiz kuru üzüm (www.resmigazete.gov.tr/eskiler/ 2005/06/ 20050603-10.htm (Erişim: 23.12.2023).

Anonim, 2023.http://www.tuik.gov.tr/bitkiselapp/bitkisel.üzüm. (09.03.2023).

Anonim, 2024. Manisa Ticaret Borsası Çekirdeksiz Kuru Üzüm Sektör Raporu. Haziran, 2024.

Aybers, N., 1954, Üzümlerin Sun'i Kurutulması. İstanbul Teknik Üniversitesi, Makine Fakültesi, Isı Tekniği ve Ekonomisi Araştırma Kurumu Bülteni, No: 1, İstanbul.

Batu, A., 1993. Kuru Üzüm ve Pekmezin İnsan Sağlığı ve Beslenmesi Açısından Önemi. *Gıda, 18*(5): 303-307

Çelik, H. (2014). Üzümün besin değeri. *Türkiye Tohumcular Birliği Dergisi*, *3*(11), 18-21.

EİB, 2020. Ege İhracatçı Birkileri.https://www.eib.org.tr/ (Erişim tarihi: 20.11.2024).

FAO (2022). Food and Agriculture Organization of the United Nations. https://www.fao.org/statistics/en (Erişim 14.11.2024).

Gülcü, M., Demirci A.Ş., Güner K.G., 2008. Siyah Üzüm, Zengin Besin İçeriği ve Sağlık Açısından Önemi. Türkiye 10. Gıda Kongresi, 179-182.

Güler, A. 2019. "Çekirdeksiz kuru üzüm üretim teknolojisi", https://arastirma.tarimorman.gov.tr/manisabagcilik/Belgeler/genelbagcilik/UZUM%20KURUTMA%20ALI%20GULER.pdf (Erişim tarihi: 18 Aralık 2019).

Kaya, Z. (2017). Şarap üretimi ve kalite. *Aydın Gastronomy*, *1*(2), 17-30

Kenber, L.A., 1938. Ana Yurdu Türkiye Olan Ürünlerin Tarihi ve Ekonomik Bitkilerin Biyojeografisi. Tan Matbaası, Anakara.

Lim, T.K., 2013. Edible Medicinal and Non-Medicinal Plants. Volume 6, Fruits. Vitaceae: 450-482p. Springer Science and Business Media Dordrecht.

Lernoud, J., & Willer, H. (2019). Organic Agriculture Worldwide: Key results from the FiBL survey on organic agriculture worldwide 2019. *Research Institute of Organic Agriculture (FIBL), part*, *1*.

Lernoud, J., & Willer, H. (2019). Organic Agriculture Worldwide: Key results from the FiBL survey on organic agriculture worldwide 2019 Part 2: Crop data.
TMO, 2020. Toprak Mahsülleri Ofisi. https://www.tmo.gov.tr/

Manisa Ticaret Borsası (2024). 2024 Yılı Çekirdeksiz Kuru Üzüm Sektör Raporu. https://www.manisatb.org.tr/UserFiles/Download/2023-24-Cekirdeksiz-kuru-uzum-sektor-raporu.pdf (Erişim 26.11.2024).

TOB (2024). Tarım ve Orman Bakanlığı Bitkisel Üretim Genel Müdürlüğü. https://www.tarimorman.gov.tr/Konular/Bitkisel-Uretim/Organik-Tarim/Istatistikler (Erişim 28.11.2024)

Reşat, 1931. Kuru Üzümcülük. Birinci Ziraat Kongresi, İhtisas Raporları. Milli İktisat ve Tasarruf Cemiyeti Yayınları, Ankara.

Söylemezoğlu, G., Çelik, H., Kunter, B., Ünal, A., Özer, C., Kiracı, M. A., ... & Karaman, H. T. (2020). Bağcılıkta mevcut durum ve gelecek. Türkiye Ziraat Mühendisliği IX.Teknik Kongresi, 13-17. Ankara.

TÜİK (2022). Türkiye İstatistik Kurumu, Bitkisel Üretim İstatistikleri. https://biruni.tuik.gov.tr/medas/?kn=92&locale=tr (Erişim 14.11.2022).

TÜİK (2024). Türkiye İstatistik Kurumu, Bitkisel Üretim İstatistikleri. https://biruni.tuik.gov.tr/medas/?kn=92&locale=tr (Erişim 4.11.2024)

Winkler, A.J., Cook, J.A., Kliewer, W.M., & Lider, L.A. (1974). General viticulture. University of California Press. Berkeley. California. 710 p.

Yağcı, A., & İlter, E. (2018). Sultani Çekirdeksiz üzüm tiplerinin hasat sırasındaki verim ve bazı kalite özellikleri. *Türkiye Tarımsal Araştırmalar Dergisi*, *5*(3), 286-292.

A STUDY OF THE FACTORS INFLUENCING AGRITOURISM DEVELOPMENT AT BAO GIA FARM, HAU GIANG PROVINCE, VIETNAM

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Abstract
Agritourism provides a valuable platform for combining tourism and agriculture, resulting in a range of financial, educational, and social benefits for tourists, producers, and communities. Nestled in Hau Giang province, Bao Gia Farm stands out as a promising hub for agritourism growth, characterized by its distinctive agritourism products and services, unspoiled environment, and serene vistas. The study methods comprised the utilization of secondary data collection, on-site surveys, and interviews with 120 domestic tourists who explored agritourism at Bao Gia Farm. Exploratory factor analysis and linear regression analysis were employed for analysis. The research outcomes reveal five pivotal factors influencing agritourism development at Bao Gia Farm: Security and safety, Human resources, Quality of agritourism products and services, Infrastructure and Agritourism resources. Based on the aforementioned, the paper put forward several solutions to bolster the advancement of agritourism in this destination.
Key words: Factors, agritourism, Bao Gia Farm, Hau Giang province.

INTRODUCTION

Agritourism has emerged as a valuable strategy for promoting economic diversification, increasing income, and improving the quality of life in rural communities (Sharon & Kirsty, 2010; Yeboah et al., 2017). Agritourism is characterized by increasing income for farmers and their families, diversifying income sources to reduce economic risks, and encouraging investment in infrastructure and tourism services (Barbieri & Mahoney, 2010). Agritourism brings diverse economic benefits, contributing to the promotion of sustainable economic development in rural areas (Li, 2012). One important factor is the creation of additional income sources for farming households. Instead of relying solely on income from traditional agricultural activities, farms can leverage tourism to increase revenue. By organizing tours, seasonal harvest activities, and special events, farmers can attract visitors and charge admission fees. This not only helps stabilize income but also creates new business opportunities and diversifies revenue sources (Mirjam et al., 2021). In addition, agritourism facilitates direct marketing of agricultural products. Farms can sell fresh products and processed goods right on-site, eliminating intermediaries and increasing product value. The active involvement of local residents is instrumental in ensuring the long-term sustainability of agritourism, leading to local economic growth and improved living standards (Bagi, 2012; Togaymurodov, 2023). Furthermore, local engagement strengthens social connections and community support, further nurturing sustainable development (Khanal, 2019; Dinh et al., 2022).

Located in Dong Thanh Commune, Hau Giang Province, Bao Gia Spanning approximately 10 hectares and continuously expanding, Bao Gia Farm is strategically located in Dong Thanh Commune, Chau Thanh District, Hau Giang Province, at the crossroads of Can Tho City and Hau Giang Province. As a subsidiary of SEACORP Group, Bao Gia Farm is a brand developed by Hai Au Tourist, combining agritourism with educational activities in each experiential program. Farm has organized agritourism tours that contribute to diversifying tourism types in Hau Giang, bringing economic benefits to local people. With certifications such as GlobalGAP and JAS, Bao Gia Farm has attracted a significant number of tourists and partners, especially those interested in clean food. However, while Bao Gia Farm has introduced a fresh perspective to agritourism in Hau Giang Province, it still faces certain challenges in terms of development and visitor attraction. This study aims to analyze the potential for agritourism development at Bao Gia Farm, evaluate the factors influencing agritourism at the Farm, and propose solutions to promote its growth.

RESEARCH METHODS

Field survey method

Thorough field surveys were conducted at Bao Gia Farm, Hau Giang province from February to May 2024, employing a variety of research methods including observations, in-depth interviews, photography, and data collection. These surveys were instrumental in assessing the potential and advantages of agritourism development, as well as identifying the current limitations in the district's agritourism initiatives.

Interview method via questionnaire

To construct a questionnaire, follow these steps: (1) identify the information to be sought; (2) select data and collect primary data; (3) develop the structure and content of the questionnaire; (4) select the scale; (5) write a draft, (6) test it experimentally, (7) edit and finalize.

Sample size: Sample size: The study utilizes two analysis techniques, namely Exploratory Factor Analysis (EFA) and multiple linear regression analysis, to address the research problem. According to Hair et al. (2006; as cited in Tho, 2011), the number of observations should exceed 100, with a minimum ratio of 5:1 to the number of measurement variables. Since the study employs 24 measurement variables, the minimum required sample size would be 24 x 5 = 120 observations. For multiple linear regression analysis, Tabachnick and Fidell (1996) suggest a minimum sample size following the formula $n = 50 + 8 \times m$ (m: number of independent variables). In this study, there are 5 independent variables, indicating an expected sample size of $50 + 8 \times 5 = 90$ observations. By combining these two criteria, the study necessitates collecting and analyzing a minimum of 120 valid observation variables.

A five-point Likert scale was used in the questionnaire which the authors adopted and complied from previous studies of the literature (Strongly disagree = 1; Disagree = 2; Not sure = 3; Agree = 4; Strongly agree = 5).

Data analysis method: After collecting all 120 questionnaires surveyed from tourists, the authors filtered and entered data on SPSS (Statistical Package for the Social Sciences) version 20.0. The research used SPSS version 20 to analyse the data collected with Frequency, Percentage, Mean, Standard Deviation, Scale Reliability Analysis, Exploratory Factor Analysis and Linear Regression.

Through literature reviews, the proposed research model of this research is as follows:

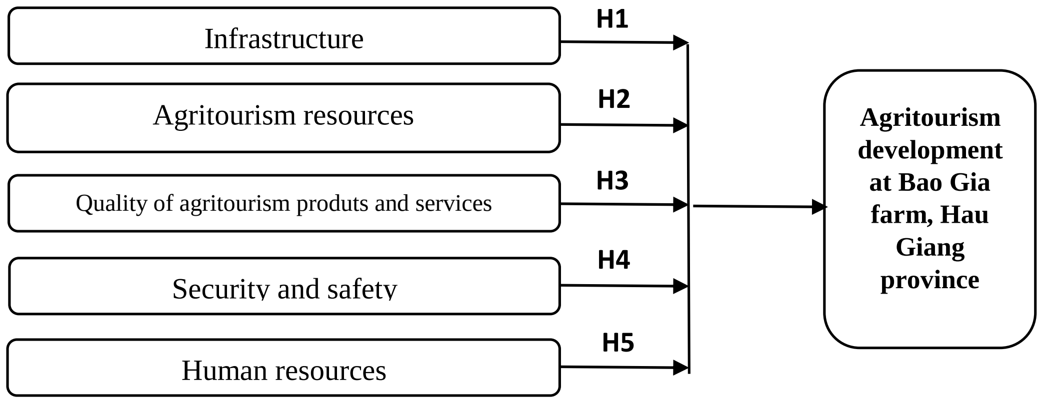

Figure 1: Proposed research model
(Source: The authorss' proposal, 2024)

- Hypothesis 1 (H1): There exists a positive relationship between H1 and agritourism development at Bao Gia Farm, Hau Giang province.
- Hypothesis 2 (H2): There exists a positive relationship between H2 and agritourism development at Bao Gia Farm, Hau Giang province.
- Hypothesis 3 (H3): There exists a positive relationship between H3 and agritourism development at Bao Gia Farm, Hau Giang province.
- Hypothesis 4 (H4): There exists a positive relationship between H4 and agritourism development at Bao Gia Farm, Hau Giang province.
- Hypothesis 5 (H5): There exists a positive relationship between H5 and agritourism development at Bao Gia Farm, Hau Giang province.

3. RESEARCH RESULTS

3.1. Agritourism products and services at Bao Gia Farm

The Farm specializes in cultivating unique fruit varieties like cantaloupe, golden laksa sapota, purple longan, fire banana, and so on which are rarely found in the Mekong Delta. The vegetable section offers a diverse range of seasonal crops, including basil, Tây Nguyên wild greens, sweet cabbage, and the unique black pepper variety,... Additionally, the Farm has recently cultivated flowers like purple chrysanthemum, small chrysanthemum, and sunflowers to meet market demand. Besides, Bao Gia Farm also trades in fresh and processed agricultural products. In recent years, the Farm has expanded its cultivation to include other types of plants based on research needs and seasonal demands.

In terms of livestock, the Farm raises various animals such as wild boar, indigenous pigs, sheep, goats, rabbits,... Poultry includes native chickens, Quy Phi chickens, Dong Tao chickens, pheasants, star chickens, waterhens,... Notably, breeds like Quy Phi chickens, H'mong chickens, and Dong Tao chickens are high-value breeds found only in specific regions of Vietnam. Aquaculture is also being expanded with species like tilapia, frogs, red tilapia, eels,... In addition to providing services to customers at Bao Gia Trang Vien Resort, these agricultural products are also used to process into other products sold at Danny Green stores.

Depending on the type of tourists, Bao Gia Farm offers a variety of tailored experiences. Some of the signature programs include:

- The program "Join Us for a Home Experience"

For groups such as families, friends, and individual guests, Bao Gia Farm offers the "Come Play at Home" program with a duration of 60-90 minutes. The nature of this program is suitable for groups who want to experience but have limited time for sightseeing, those who wish to purchase agricultural products, and those looking for a short experience.

The program includes participating in activities such as harvesting crops like pumpkins, bottle gourds, watermelons, and various other vegetables. Visitors will also have the opportunity to explore the livestock, poultry, and aquatic Farming areas and experience riding motorcycles, as well as personally packaging harvested bananas, vegetables, and fruits. Payment can be made on-site for the selected agricultural products.

- The program “Amazing Race”

For high school and college student groups, Bao Gia Farm offers the "Amazing Race" program, which lasts for 4-5 hours. This program is designed for schools looking to provide students with an entertaining and team-building experience through relay games and workshops.

The program entails participants gathering at the community house to select team leaders and be paired with Farm staff as guides. The guides will lead the teams on a tour of the Farm and guide them through challenges set up at various stations. The program concludes with a community house gathering for an "end game" activity. Upon completing the games, participants can engage in workshops such as paper crafting, planting, or cooking demonstrations. Payment is made via bank transfer after contract settlement.

- Other programs can be customized based on specific customer requests

Apart from the pre-designed programs, Bao Gia Farm also offers customized programs tailored to the specific requests of customer groups. Activities can be added or removed from existing programs, and even if some groups prefer purely sightseeing without participating in activities, the Farm can provide guides. If groups wish to combine their own activities with the tour, the Farm will accommodate those requests as well.

3.2. Summary of the demographics of respondents

Respondents’ gender: The survey results from 120 tourists indicate that 69 of them are male, accounting for 57.5%, while 51 are female, representing 42.5%. The proportion of male tourists exceeds that of female tourists by more than 25%.

Respondents’ age: Tourists aged between 18 and 29 years old constitute the highest proportion at 65%. Following this are tourists aged between 30 and 49 years old at 20.8%, with 40-49-year-olds making up 9.2%. The group aged 50-59 consists mainly of lecturers from colleges and universities leading student tours for exploration and study purposes.

Respondents’ educational levels: The results show that respondents with a "University" education level make up the highest percentage at 72.5%, totaling 87 guests. This is followed by "High School" at 11.7% with 14 guests, "Vocational School/College" at 7.5% with 9 guests, "Postgraduate" at 8.3% with 10 guests, and no guests below "High School" level. This indicates that the majority of tourists are individuals with a high level of knowledge, capable of objectively assessing and evaluating tourist destinations.

Respondents’ occupation: Among the participants surveyed, the group consisting of "Civil Servants/Teachers in private schools" accounts for the highest proportion at 52.5% with 63 guests. The "Students" group represents 27% with 33 guests, while the "Officers/Civil Servants" group makes up 10.8% with 13 guests, and the "Business/Trade" group accounts for 20% with 24 guests.

3.3. Evaluating the factors influencing agritourism development at Bao Gia Farm

To evaluate the factors that influencing on agritourism development at Bao Gia Farm, this study has analyzed exploratory factors including 5 criteria with 24 observed variables, specifically as follows:

(1) Infrastructure (5 observed variables)
(2) Agritourism resources (5 observed variables)
(3) Quality of agritourism products and services (5 observed variables)
(3) Security and safety (5 observed variables)
(4) Human resources (4 observed variables)

To ensure the reliability of the scale and observed variables, the authors uses the method of evaluating the scale's reliability. The reliability of the scales is assessed through Cronbach's Alpha coefficient. Cronbach's Alpha coefficient is used to eliminate "junk" variables. Variables with a total correlation coefficient less than 0.3 will be excluded (Nunnally, 1978; Peterson, 1994; Slater, 1995). The scale will achieve reliability when Cronbach's Alpha coefficient is greater than or equal to 0.6. The scale will reach reliability when Cronbach's Alpha coefficient is greater than 0.6. The analysis results show that non observed variables are excluded from the model because the correlation coefficient of variables is greater than 0.3.

(1) "Infrastructure" has Cronbach's Alpha coefficient of 0.796 and has 5 variables with variable correlation coefficients ranging from 0.541 to 0.604 meeting the requirements. Thus, unobserved variables are not considered in the research model.

(2) "Agritourism resources" has Cronbach's Alpha coefficient of 0.841 and there are 5 variables with variable correlation coefficients ranging from 0.525 to 0.742 meeting the requirements. Thus, unobserved variables are not considered in the research model.

(3) "Quality of agritourism products and services": The Cronbach's Alpha coefficient for the scale is calculated at 0.763 and there are 5 variables with variable correlation coefficients ranging from 0.469 to 0.629 meeting the requirements. Thus, unobserved variables are not considered in the research model.

(4) "Security and safety" with Cronbach's Alpha coefficient of 0.808 and 5 variables with variable correlation coefficients ranging from 0.533 to 0.641 meeting the requirements. Hence, Thus, unobserved variables are not considered in the research model.

(5) "Human resources" has Cronbach's Alpha coefficient of 0.842 and there are 4 variables with variable correlation coefficients ranging from 0.617 to 0.754 meeting the requirements. Thus, unobserved variables are not considered in the research model.

(6) "General assessment" has Cronbach's Alpha coefficient of 0.775 and there are 3 variables with variable correlation coefficients ranging from 0.581 to 0.634 meeting the requirements. Thus, unobserved variables are not considered in the research model.

Exploratory Factor Analysis (EFA) of Independent Variable Scales

After the authors evaluates the reliability of the scale, there are 5 scales of independent factors with 24 observed variables eligible to conduct exploratory factor analysis. Before conducting exploratory factor analysis, the study used the KMO test (Kaiser-Meyer-Olkin Measure of sampling adequacy) and Bartlett's Test of Sphericity to check the relevance of the research data. The results from the data test show that the KMO = 0.765>0.5, Sig = 0.000<0.05 (statistically significant), the total explanatory variance is 60.375% (greater than 50%), satisfying the conditions for exploratory factor analysis.

In exploratory factor analysis, the authors used the Principal Components Analysis with Varimax rotation. In Security to ensure the practical significance of the exploratory factor analysis, it is necessary to remove the measurement variables with unsatisfactory factor loading coefficients for each factor. According to Hair and collaborators (1998), factor loading is an indicator to ensure the practical significance of exploratory factor analysis. Factor loading above 0.3 is considered to reach the minimum level for sample size 350, if the sample size is about 100, it is recommended to choose a factor loading above 0.55 and sample size is about 50, the factor loading must be above 0.75. In the study, the authors interviewed 120 respondents, so as the factor loading coefficient is above 0.55, the measurement variable is kept.

Table 1. Rotated component matrix

Observation variable	**Factor**				
	1	2	3	4	5
TNDL4	0.860				
TNDL3	0.816				
TNDL5	0.751				
TNDL2	0.743				
TNDL1	0.583				
TTAT5		0.753			
TTAT2		0.736			
TTAT3		0.711			
TTAT4		0.672			
TTAT1		0.615			
NNL2			0.840		
NNL3			0.773		
NNL4			0.762		
NNL1			0.749		
CSHT2				0.757	
CSHT5				0.736	
CSHT4				0.736	
CSHT3				0.718	
CSHT1				0.644	
CLSPDVDL2					0.806
CLSPDVDL1					0.697
CLSPDVDL4					0.671
CLSPDVDL3					0.636
CLSPDVDL5					0.724

Source: Results from the authorss' empirical data analysis survey, 2024

Based on the rotated factor matrix table (Table 1), it shows that there are 5 factors attracting domestic tourists to Bao Gia farm, of which 24 observed variables all meet the requirements (due to factor loading coefficients > 0.5).

Factor 1 (F1) is affected by 5 observed variables: Diverse crop and livestock offerings (TNDL4); High-tech agricultural practices and certifications (TNDL3); Scenic attractions for tourists (TNDL5); Unique souvenirs and specialties (TNDL2); Clean and fresh natural environment (TNDL1). This factor is named "Agritourism resources".

Factor 2 (F2) is affected by 5 observed variables: Absence of superstitions (TTAT5); No solicitation or coercion of customers (TTAT2); Prevention of theft and pickpocketing (TTAT3); Fair pricing in the craft village (TTAT4); No begging activities (TTAT1). This factor is named "Security and safety".

Factor 3 (F3) is affected by 4 observed variables: Knowledgeable and skilled tourism staff (NNL2); Friendly and helpful engineers (NNL3, NNL1); Expertise in high-altitude Farming (NNL4). This factor is named "Human resources".

Factor 4 (F4) is affected by 5 observed variables: Adequate space for sightseeing, rest, and reception (CSHT2): Availability of essential amenities like medical facilities, ATMs, and restaurants (CSHT5); Reliable communication systems (CSHT4); Clean water and sanitation facilities (CSHT3); Well-maintained roads (CSHT1). This factor is named "Infrastructure".

Factor 5 (F5) is affected by 5 observed variables: High-quality agricultural products (CLSPDVDL 2); Diverse agricultural product offerings (CLSPDVDL 1); Opportunities for tourists to participate in Farming and raising activities (CLSPDVDL 4); Organic certification of agricultural products (CLSPDVDL 3); Engaging accompanying activities suitable for all ages. This factor is named “Quality of agritourism products and services”.

Exploratory Factor Analysis (EFA) of Dependent Variable Scales

Following the same procedures used for EFA analysis of independent variables, the observed variables “General assessment 1 – DGC1”, “General assessment 2 – DGC 2”, and “General assessment 3 – DGC 3” from the dependent variable group were subjected to EFA. The results of the analysis are as follows:

KMO and Bartlett's Test: KMO coefficient = 0.698 (> 0.5), Sig. = 0.000 (< 0.05).

Kaiser Criterion: Eigenvalue = 2.070.

Extracted Variance: 68.993%.

These results indicate that a single factor explains 68.993% of the data variation in the three observed variables. The extraction of just one factor for the dependent variable group is a positive outcome, suggesting that the dependent variable scale maintains unidimensionality and that the observed variables converge effectively.

Pearson Correlation Analysis

The Pearson Correlation Analysis results indicate significant correlations between the independent variables F1_TNDL, F2_TTAT, F3_NNL, F4_CSHT, and F5_CLDV, and the dependent variable F6_DGC. The correlation coefficients are 0.413**, 0.572**, 0.520**, 0.365**, and 0.306**, respectively. Since the significance levels (Sig.) of all independent variables in relation to the dependent variable are less than 0.01, it can be concluded that there is a linear correlation between the variables in the model with a confidence level of 99%. Additionally, there is no significant correlation among the independent variables themselves, indicating that multi-collinearity is not a concern in the regression analysis.

Among the variables, "Security and safety" has the strongest correlation with a coefficient of 0.572, while "Quality of services and products" has the weakest correlation with a coefficient of 0.306. Based on these findings, it can be concluded that these independent variables can be included in the model to explain the dependent variable "General assessment".

Multiple Linear Regression Analysis

Table 2: Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0,704[a]	0.495	0.473	0.47356	2.076

a. Predictors: (Constant), CLSVSP, TNDL, CSHT, NNL, TTAT

b. Dependent Variable: DGC

Source: Results from the authorss’ empirical data analysis survey, 2024

Table 3: ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	25.086	5	5.017	22.372	0,000[b]
	Residual	25.566	114	0.224		
	Total	50.652	119			

a. Dependent Variable: DGC

b. Predictors: (Constant), CLSVSP, TNDL, CSHT, NNL, TTAT

Source: Results from the authorss’ empirical data analysis survey, 2024

Through reliability assessment methods and exploratory factor analysis (EFA), the authors identified 5 scales representing factors that influence the development of agritourism at Bao Gia Farm, with 24 observed variables. Additionally, the model includes a dependent scale representing the overall assessment of tourists regarding the development of agritourism at Bao Gia Farm, measured by 3 observed variables.

To confirm the number of factors affecting the development of agritourism at Bao Gia Farm and the strength of each factor's impact, multiple linear regression analysis was employed. The results of the data analysis indicate that the adjusted R-squared value in the model summary table is 0.473 (Table 2), meaning that the independent variables account for 47.3% of the variation in the dependent variable. The significance level (Sig.) of the F-test in the ANOVA table is 0.000 (Table 3), indicating a significant relationship between the independent and dependent variables. The variance inflation factor (VIF) of the factors in the coefficients table is less than 2 (Table 4), suggesting no multicollinearity problem. The Durbin-Watson statistic is 2.076 (Table 2), falling within the range of 1.5 to 2.5, indicating no first-Security autocorrelation in the model. These findings confirm that the data is suitable for multiple linear regression analysis.

Table 4: Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-0.615	0.424		-1.450	0.150
	F1 - TNDL	0.165	0.082	0.149	1.999	0.048
	F2 - TTAT	0.385	0.096	0.326	4.014	0.000
	F3 - NNL	0.260	0.081	0.254	3.218	0.002
	F4 - CSHT	0.170	0.080	0.154	2.122	0.036
	F5 - CLSPDVDL	0.217	0.076	00.195	2.859	0.005

a. Dependent Variable: DGC

b. Predictors: (Constant), CLSVSP, TNDL, CSHT, NNL, TTAT

Source: Results from the authorss' empirical data analysis survey, 2024

We have the following multiple linear regression equation:

Y = -0.615 + 0.326F2 + 0.254F3 + 0.195F5 + 0.154F4 + 0.149F1 + ei

Factor 2 (F2) has a standardized coefficient of 0.326, indicating a positive and the strongest relationship with the development of agritourism at Bao Gia Farm. A one-unit increase in tourists' assessment of "Security and safety" leads to a 0.326-unit increase in the development of agricultural tourism, corresponding to an unstandardized coefficient of 0.385.

Factor 3 (F3) has a standardized coefficient of 0.254, also indicating a positive relationship with the development of agricultural tourism. A one-unit increase in tourists' assessment of "Human resources" leads to a 0.254-unit increase in the development of agricultural tourism, corresponding to an unstandardized coefficient of 0.260.

Factor 5 (F5) has a coefficient of 0.195 and is positively correlated with the development of agritourism at Bao Gia Farm. A one-unit increase in tourists' assessment of "Quality of agritourism products and services" leads to a 0.195-unit increase in the development of agricultural tourism, corresponding to an unstandardized correlation coefficient of 0.217.

Factor 4 (F4) has a coefficient of 0.154 and is positively correlated with the development of agritourism at Bao Gia Farm. A one-unit increase in tourists' assessment of "Infrastructure" leads to a 0.154-unit increase in the development of agricultural tourism, corresponding to an unstandardized correlation coefficient of 0.170.

Factor 1 (F1) has a coefficient of 0.149 and has the weakest positive relationship with the development of agritourism at Bao Gia Farm. A one-unit increase in tourists' assessment of "Agritourism resources" leads to a 0.149-unit increase in the development of agricultural tourism, corresponding to an unstandardized correlation coefficient of 0.165.

Table 5: The level of influence of factors on the development of agritourism at Bao Gia Farm

Factor	Standardized coefficient	Total standardized regression coefficient	Level of influence (%)
F2 - TTAT	0.326	1.108	30.24
F3 - NNL	0.254		23.56
F5 - CLSPDVDL	0.195		18.09
F4 - CSHT	0.154		14.29
F1 - TNDL	0.149		13.82

Source: Results from the authorss' empirical data analysis survey, 2024

Table 5 shows that the total standardized regression coefficient for factors 1, 2, 3, 4, and 5 is 1.178. Therefore, Factor 2 contributes 30.24%, Factor 3 contributes 23.56%, Factor 5 contributes 18.09%, Factor 4 contributes 14.29%, and Factor 1 contributes 13.82%. Research findings reveal that "Security and safety" have the most significant impact on the development of agritourism at Bao Gia Farm. Other factors, in descending Security of influence, are "Human resources", "Quality of tourism products and services", "Infrastructure", and "Agritourism resources".

Solutions to enhance the growth of agritourism at Bao Gia Farm

Ensuring security and safety in agritourism at Bao Gia Farm

Through research, it can be observed that "Security and Safety" is the most influential factor affecting the development of the Farm. Therefore, to ensure the stable development of Bao Gia Farm in the future, the management board needs to tighten control over strangers entering the Farm and provide additional lockers for visitors during their Farm tours. Additionally, the Farm should list and transparently disclose the prices of tourism products sold within the Farm.

Improving the quality of human resources at Bao Gia Farm

In general, the human resources serving tourists at Bao Gia Farm are highly educated and trained. However, there is a significant shortage of human resources serving as tour guides. Instead of seeking external collaborators, Bao Gia Farm can organize training sessions for engineers on guiding practices and customer care. This will not only enhance the tourist experience but also ensure that the Farm always has an adequate and competent workforce.

Enhancing quality and diversifying agritourism products and services at Bao Gia Farm

Seacorp is a conglomerate with diverse businesses. Bao Gia Farm can leverage this advantage to expand further by: collaborating with SeaFarm (a company within the Seacorp group) for infrastructure and technical development; coordinating with another company within Seacorp for the growth of biological resources. Additionally, partnerships can be established with service and product providers such as Danny Green and Bao Gia Trang Vien, both subsidiaries of Seacorp, to create a large interdependent tourism network in Hau Giang and Can Tho.

Upgrading infrastructure and technical facilities for agritourism at Bao Gia Farm

The Farm may consider adding resting areas, expanding greenhouse and fish pond zones to provide additional attractions for visitors. Planning flower planting areas to create picturesque spots for visitors to take photos can help spread more images of the Farm through tourists. Furthermore, the Farm could renovate, expand, and modernize restroom facilities as this is an aspect that most tourists are likely to pay attention to when visiting a tourist destination.

Strengthening promotion and marketing of agritourism at Bao Gia Farm

Tourism advertising plays a crucial role in developing tourist destinations, helping various customer segments become aware of the agritourism products of Bao Gia Farm. This serves as a means to provide customers with information about the Farm such as experiential tour programs, service packages, attractive seasonal offers, and more. Moreover, Bao Gia Farm needs to employ various methods to enhance effectiveness, including advertising on mass media platforms (radio broadcasts, travel magazines, documentaries, websites), designing and printing large-sized billboards on national highways to attract attention. Concurrently, creating high-quality promotional materials highlighting the prominent features of Bao Gia Farm like the natural landscapes, organic agriculture, and distributing them in locations with a high customer presence such as supermarkets, tourist spots, amusement parks, entertainment centers, etc.

Enhancing local government support

The Department of Agriculture and Rural Development of Hau Giang province should intensify the implementation of supportive policies for the development of agricultural land to create opportunities for the expansion of Bao Gia Farm. Clear regulations on agricultural land use should also be established to prevent environmental pollution in rural areas.

The Department of Culture, Sports, and Tourism of Hau Giang province should provide support and facilitate partnerships with local and external travel agencies to develop tours that include visits to Farms. This type of tourism, which has been successfully implemented in many provinces in our country, attracts numerous visitors and can be a new and promising approach for tourism development.

CONCLUSION

Bao Gia Farm is a novel agritourism destination with great potential in the market, offering a diverse range of agritourism products such as Farm tours, harvesting experiences, and hands-on Farming activities with engineers, as well as workshops, team building, and educational programs. However, the Farm is still in the early stages of tourism development and has yet to fully exploit its existing resources. The findings show that “Security and safety” have the most significant impact on the development of agritourism at Bao Gia Farm. Other factors, in descending Security of influence, are “Human resources”, “Quality of tourism products and services”, “Infrastructure”, and “Agritourism resources”. To foster the growth of agritourism at Bao Gia Farm, these factors should be carefully considered to maximize strengths and address weaknesses. The manager board should prioritize investments, develop a comprehensive strategy, and provide appropriate guidance to enhance the development of agritourism products.

REFERENCES

Bagi, F. S., & Reeder, R. J. (2012). Factors Affecting Farmer Participation in Agritourism. Agricultural and Resource Economics Review, 41(02), 189–199. doi:10.1017/s1068280500003348

Cerutti, A. K., Beccaro, G. L., Bruun, S., Donno, D., Bonvegna, L. and Bounous, G. (2016), Assessment methods for sustainable tourism declarations: The case of holiday Farms, Journal of Cleaner Production, vol. 111: pp. 511-519

POSSIBILITIES OF USING RENEWABLE ENERGY SOURCES IN LANDSCAPE STUDIES

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ABSTRACT

In recent years, increasing interest in environmental sustainability and energy efficiency has made the combined use of renewable energy sources in landscape design an important agenda item. Landscaping not only fulfills aesthetic and functional needs, but also serves the purpose of reducing energy consumption and conserving natural resources through environmentally friendly practices. Renewable energy sources such as solar, wind and biomass are used in various ways in landscaping projects, allowing solutions to be developed in harmony with the natural environment. The use of renewable energy sources in landscaping offers important opportunities to increase environmental sustainability and energy efficiency. In these studies, various renewable energy sources such as solar energy, wind energy, biomass and geothermal energy can be integrated without harming the aesthetic and functional characteristics of the natural landscape. Technologies such as solar panels and wind turbines support energy production in landscapes, while the use of biomass enables waste recycling and organic energy production. In addition, geothermal energy can be used for environmental heating and cooling, providing indirect benefits to landscape design. This study aims to provide innovative solutions in landscape design by examining how renewable energy sources can be integrated into landscape projects, their environmental benefits and their contribution to sustainable development goals.

Keywords: Energy, Landscape, Sustainability, Landscape Design.

INTRODUCTION

For years, human beings have been dependent on nature to survive and have benefited from nature's accumulations. The technological advances that started with the industrial revolution, lifestyle products, rapid population growth and the increasing need for energy have led to the depletion of existing natural resources. Energy used especially in sectors such as industry, housing, transportation and agriculture has caused environmental problems during production, cycle, transportation and consumption (Yegin, 2011). With the increase in the world population and industrialization, there is worldwide urban growth. However, according to the US Energy Information Administration International Energy Outlook, the energy consumption of the residential sector alone is expected to increase by about 48% in 2040 (Catalano and Baumann, 2017). According to the Ministry of Energy and Natural Resources of the Republic of Turkey, by 2040, fossil fuels will continue to be the dominant sources, even if their share has decreased. The share of nuclear energy in primary energy sources is projected to increase, the share of renewable energy sources in 2040 is expected to be 16.1%, and global electricity demand is expected to increase by 80%, with an average annual increase of 2.3% by 2040 (Anonymous, 2017a).

Energy efficient use in landscape architecture has an encouraging importance such as increasing the use of renewable energy and raising public awareness in social areas. However, while solar, wind, biomass and geothermal energy can be easily used in landscape architecture in cities, areas with dense settlements, coastal areas, national gardens, parks, public spaces, children's playgrounds, they should be included in landscape design processes and handled with holistic approaches. Thus, landscape designs should be supported by landscape planning processes that ensure the effective use of renewable energy resources and develop with the principle of sustainability within the balance of conservation and utilization (Acaray, 2023).

Landscape architecture is increasingly turning to energy efficiency and renewable energy solutions to address environmental challenges and implement sustainability principles. Challenges related to global warming, environmental pollution and energy consumption make it even more important to integrate renewable energy sources into landscape design. In this study, the environmental, economic and social benefits of using renewable energy in landscape projects will be discussed. In addition, studies on the integration of different energy sources such as solar, wind, biomass and geothermal energy into landscapes will be discussed from different aspects.

ENERGY EFFICIENT LANDSCAPE DESIGN

Landscape is a physical environment that is formed because of the interaction of living things with each other and with their environment and can be defined and limited within the framework of these relationships and interactions. It includes all topographical, natural and cultural data that interact between the past and the present, nature and culture, and come into view when viewed from a certain location (Gül and Küçük 2001).Energy-efficient landscape design should be a design with environmentalist features such as producing its own energy, having systems that use natural and renewable energy sources, using materials that contain fewer toxic substances or are obtained by recycling, protecting the green environment as much as possible, collecting rainwater and wastewater and reusing them by treating them. Energy-efficient landscape design should aim to be a part of the ecological environment in which the area is located and to adapt to it, from the material chosen to the construction technique (Yurtsev, 2015).

A properly designed landscape arrangement directs the sun's rays to the building in winter, directs strong winds and unwanted breezes in different directions and prevents steep sun rays in summer. With this feature, it reduces the amount of energy consumed by buildings throughout the year and can make great contributions to energy efficiency. It also improves indoor air quality. Planting interventions to the building envelope can provide extra thermal mass and insulation (Öztürk Sarı, 2013).

ENERGY EFFICIENT LANDSCAPE PLANNING REQUIREMENTS AND OBJECTIVES

To protect the environment and natural assets, prevent environmental pollution and combat climate change, spatial strategies that include areas of different sizes and qualities, from the smallest living spaces to the largest living spaces, should be defined and planned to include environmentally friendly and renewable energy use. In this context, to determine the targets and strategies for the efficient use of energy in urban and rural areas and the use and production of new and renewable energy resources in the landscape planning process, detailed analyses of the energy demand of the area and the resource potentials to meet the demand should be made different from landscape analysis (Yegin, 2011).

The act of planning in itself; natural, social and economic resources are regular, adequate, and sufficient to use the necessary proportion, but not to be completely consumed, thus providing sufficient and necessary production and distributing what is produced among individuals in an understanding of social justice, as well as some approaches to the subject; the comprehensive and holistic development of society and to provide people with happier and more comfortable living conditions, such as gradually eliminating the existing imbalance (Tuğaç 2003). The use of energy resources is closely related to landscape planning and spatial organization. Spatial structure creates energy requirements. It mobilizes the use of these energy resources and provides the needs of the spatial structure. However, changing any of the variables that make up the spatial structure (Table 1) such as land use, site selection principles, urban macroform, urban size, density, communication and transportation possibilities increases the energy resource requirement (Peker 1998).

Table 1. Energy demand of different urban functions (Kutluca, 2009)

Impact of Space Utilization on Energy Demand		
Planning Variables	**Energy Connectivity**	**Impact on Energy Demand**
Form of urban boundaries	Travel requirements	Up to 20% difference in energy use
The size and shape of land use decisions	Travel requirements (especially the length and frequency of the journey)	up to 150% difference
Composition of activities	Travel requirements (especially the length of the journey)	Up to 130% difference
Density / Clustering of travel lines	Transit facility	Up to 20% energy savings
Density and mixed land use	Space ventilation needs and heating/cooling cogeneration system possibility at neighborhood scale	Up to 15% energy savings Up to 30% efficiency in primary energy use with neighborhood-scale heating/cooling
Layout plan “orientation” design	Possibility to use solar energy	Up to 20% energy savings
Outdoor “landscaping”	Microclimatic improvements	Energy savings of at least 5% in exposed areas

RENEWABLE ENERGY SOURCES AND THEIR USE IN LANDSCAPE DESIGN

The use of energy in every field in today's world has made it important to use energy in landscape design. Renewable energy sources are continuous and inexhaustible energy sources offered by nature. Renewable energy types such as solar, wind, biomass and geothermal energy offer environmentally sensitive and sustainable energy solutions. The use of these energy sources in landscape design aims to create aesthetic and functional areas that increase energy efficiency as well as reducing environmental impacts.

Solar Energy and Landscape Design

The main source of renewable energy is the sun's energy, which is also the main source of fossil and hydraulic energy and heats the earth. The sun's energy is released during the conversion of hydrogen into helium and radiated into space. Solar energy is a clean, renewable and continuous source of energy. Solar-powered systems can be easily transported and installed. It is a very important system that has no polluting waste, is environmentally friendly, and can be easily replaced depending on the energy need when necessary (Kayhan, 2019). Since 1989, photovoltaic systems have been one of the most widely used areas of photovoltaic panels. There are many examples of billboards and signage lighting using photovoltaic solar power systems around the world. A battery charged by solar energy during the day automatically activates a special solar lamp to provide illumination at night. Bus stops, highway service areas, landscaping areas and parking lots are the most common uses for these simple but effective systems. Specialized electronic devices and semi-flexible glassless solar modules can be used in corrosive areas and harsh geographical applications (Özek, 2009).

Photovoltaic (PV) panels are a renewable energy source. They are used on the roofs of buildings to provide electricity to buildings and reduce dependence on fossil fuel energy consumption. They also have an indirect effect on the energy performance of the building by providing shade under the panels and absorbing solar radiation. This contributes to reducing heat gain on the roof (Dominguez et al., 2011). Utilizing solar energy, green roofs are the addition of a garden on top of a ground slab, which can include various layers such as planting, soil, waterproofing and drainage (Abuseif and Gou 2018).

Green roofs reduce heat losses and high temperature affects buildings. In hot Summer climates, when the air temperature reaches 35 ºC, the roof surface temperature exceeds 65 ºC. When the roof is protected by a layer of soil and shaded by plants, the surface temperature usually does not rise above the ambient air temperature. Apart from this, green roofs also have effects such as evaporation of water by plants and soil, creating a cooling effect, humidifying the building and cooling it naturally (Kabuloğlu, 2005). The recent interest in green roofs (Figure 1) is evidenced by special conferences, associations and competitions organized worldwide. Solar energy, which is frequently used in landscaping applications, is very advantageous in terms of cost and usability. Solar energy can be easily used for lighting, heating and irrigation in all kinds of parks and gardens. The biggest example of these uses are the installed areas in parks and gardens (Figure 2) and lighting lamps (Kayhan, 2019). The integration of a green roof with a building-scale PV system improves the energy performance of the PV system by providing a cooling effect for the PV panels (Hui and Chan, 2011). Recent research has focused on combining various existing technologies in a way that is both cost-effective and environmentally beneficial. Figure 3 shows an example of a PV-green roof.

Figure 1. Selected green roofs on different types of buildings according to the 2012 Green Roof Awards for Excellence: residential (1,2); commercial (3,4); institutional (5,6) (Berardi et al., 2014)

Figure 2. Lighting lamps in parking lots (Anonymous, 2024b)

Figure 3. Example of a PV-green roof (Shafique et al., 2020).

Wind Energy and Landscape Design

Wind energy, a clean and renewable source of electricity, is the easiest and fastest way to convert electricity in the world. The conversion of wind energy into electricity is the fastest developing area of renewable energy technology. Since wind energy is a completely natural resource, it does not pollute the environment and is not likely to run out. According to the International Energy Agency (IEA), the global wind energy potential is calculated as 53,000 tWh/year (Güler and Önder, 2006). Wind energy is generally a renewable system consisting of wind turbines. However, as a result of a study in France in 2014, a 'Wind Tree' model consisting of small propellers was developed for wind energy without the need for turbines. Thanks to this model, a quiet, aesthetic system has been developed without the need for large areas and has inspired its use in landscape architecture and landscape designs (Figure 4). With this design, modules that take up little space, are aesthetic, functional, do not harm the bird population and do not create noise pollution have emerged in the landscape areas (Acaray, 2023).

Figure 4. Wind energy in urban and coastal landscapes (Acaray, 2023).

In landscape designs, wind energy is used in many areas, although not as much as solar energy. Wind energy can be utilized in the lighting of areas such as highways, urban parks, national gardens and seating units. For example, it is aimed to generate electricity from the wind released by the vehicles passing through the streets of Istanbul, especially on the E-5 highway, and from the solar panels on these cylinders (Figure 5) (Anonymous, 2024c).

Figure 5. Wind energy on highways (Anonymous, 2024c).

Biomass Energy and Landscape Design

Biomass energy is the type of energy generated through living sources such as wood, charcoal, animal feces, organic fermentation of agricultural products and forest sector wastes, alcohol and methane fermentation, various aquatic plants. In short, biomass energy is a type of energy obtained from organic materials in a different way. The oldest known raw materials of this energy are firewood, charcoal and animal manure and are mostly used for heating. In addition to this type of biomass energy obtained by the known combustion process, it is possible to generate heat and electricity by converting biomass fuel obtained from energy agricultural products, urban incineration process or wastes into solid, gas and liquid fuels with different techniques (Kayhan, 2019).

Biomass is the most important renewable energy source in the world. Biomass fuel is a renewable energy source. As national energy policy and strategy focus more on renewable resources and conservation, its importance will increase greatly. Biomass power plants have advantages over fossil fuel power plants as they have less pollution emissions (Balat and Ayar, 2005).

This type of energy can be used effectively in Forest Landscapes (Figure 6). The conversion of forestry and agricultural residues, pulp and paper residues into heat and electricity in an environmentally benign way is the most common thermal process applied to biomass. Combustion is used to convert the chemical energy stored in biomass into heat, mechanical or electrical energy. Any type of biomass can be burned. However, direct combustion is not preferred for sources with a moisture content of more than 50% as it requires pre-drying (Kayhan, 2019).

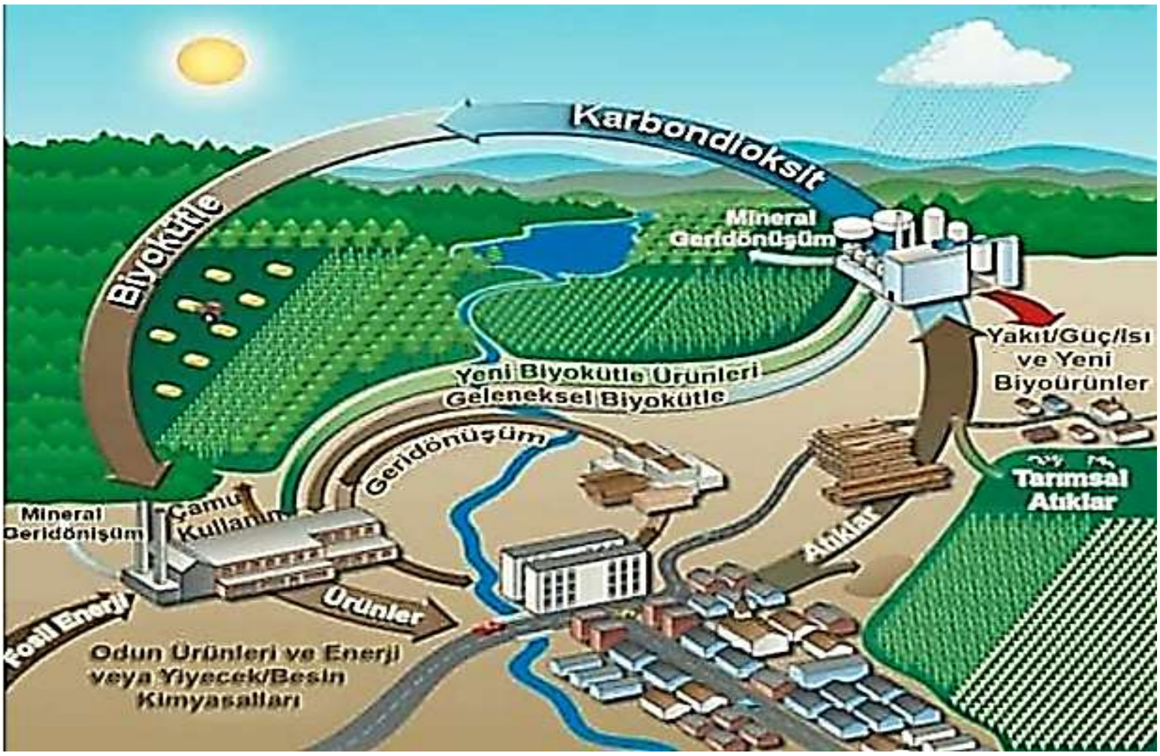

Figure 6. Biomass energy cycle (Anonymous, 2024d)

Consequently, the successful development and implementation of a landscape design process for bioenergy will have to combine the goal of producing bioenergy in a sustainable way with the needs of people involved at all stages of the supply chain. Projects may include proposals to use land traditionally used by local communities, nomadic pastoralists or seasonal residents. In such cases, the Food and Agriculture Organization (FAO) guidelines for any activity involving land transactions are compatible with landscape design (Beall and Rossi, 2011).

Tasarımı Geothermal Energy and Landscape Design

Geothermal energy, which is formed by the condensation of hot water, steam and gases in a part of the earth's crust, is a cheap, renewable, uninterrupted and environmentally friendly domestic renewable energy source due to its high efficiency and direct accessibility. The climate independence of geothermal energy is considered superior to other weather-dependent renewable energy sources such as wind and solar. In addition, geothermal energy emits a small amount of carbon into the environment, which is advantageous in terms of clean energy production. For these reasons, geothermal energy is a type of renewable energy that countries take seriously and encourage its use (Karagöl and Kavaz, 2017).

Figure 7. Diyadin thermal springs (Anonymous, 2024e)

Unlike other renewable energies, geothermal energy is important in landscape architecture due to its geological structure. This energy source should be structurally suitable for geothermal energy. In Turkey, there are many geothermal resources in the Aegean Region, Northwest, Central Anatolia, which have active faults in the orogenic belt (Acaray, 2023). According to Kayhan, (2019), landscaping with geothermal resources applied in parks and gardens;

a. Generating electrical energy,

b. Central heating, central cooling, greenhouse heating, heating-cooling applications

c. In thermal tourism, it can be used in tourism parks for spa purposes (Figure 7).

The water needs of the plants to be used in park areas can be met by utilizing geothermal energy from the earth's crust. This saves a lot of energy spent in plant and grass irrigation. At the same time, the sufficient temperature required by the park and plants and green areas can be obtained by using the heat extracted from the earth's crust with the geothermal energy system to be installed in the parks.

CONCLUSION

The use of renewable energy sources in landscaping has great potential for sustainability, energy efficiency and environmental adaptation. Resources such as solar energy, wind energy, geothermal energy and biomass can be integrated into landscape design to reduce environmental impacts and enrich living spaces both functionally and aesthetically. The use of these resources in the landscape is not only limited to energy production, but also encourages the efficient use of natural resources and supports an environmentally sensitive lifestyle.

Solar energy systems can be integrated to generate energy without disturbing the aesthetic fabric of the landscape, while wind turbines offer sustainable solutions that provide energy over large areas. Geothermal energy can be used to save energy, especially in areas such as heating and water supply. Biomass offers an environmentally friendly waste management solution by converting organic waste into energy.

The use of renewable energy sources in landscaping is not only an environmentally sensitive approach, but also an investment that provides social benefits. These systems provide significant economic and environmental advantages by reducing energy consumption. Furthermore, sustainable designs allow for the creation of environmentally friendly and aesthetically pleasing living spaces that enhance the quality of life of the public. In conclusion, the integration of renewable energy sources into landscaping has become an inevitable necessity in today's environmentally conscious world.

In addition to creating more sustainable, energy efficient and ecologically balanced designs, these approaches also serve the purpose of leaving a livable and natural environment to future generations. Therefore, the wider adoption of renewable energy solutions in disciplines such as landscape architecture and urban planning should be a cornerstone of modern landscape design.

As a result, it has been evaluated that the joint analysis and evaluation of landscape architects and other related professional groups are important in energy efficient landscape design. Thanks to this approach, the widest possible environmental impact assessment can be obtained, energy-efficient solutions can be developed at the design stage and new possibilities will be possible in achieving more livable environment goals.

RESOURCES

Abuseif, M., & Gou, Z. (2018). A review of roofing methods: Construction features, heat reduction, payback period and climatic responsiveness. Energies, 11(11), 3196.

Anonim, (2017a). Enerji ve Tabii Kaynaklar Bakanlığı, Dünya ve Türkiye Enerji ve Tabii Kaynaklar Görünümü Raporu. Ankara.

Anonim, (2024b). https://www.intelligentgreensolutions.com/solar-on-public-lands/ Erişim Tarihi:08.11.2024

Anonim, (2024c). https://www.platinonline.com/enerji/metrobus-ruzgari-enerjiye-dondu-1084482 Erişim Tarihi:08.11.2024

Anonim, (2024d). https://www.ekolekspertiz.com.tr/biyokutle-enerji-santralleri isletmelerinin-sigortalanmasinda-olasi-riskler-ve-risklerin-degerlendirmeleri/ Erişim Tarihi:08.11.2024

Anonim, (2024e). https://diyadinozyasamkaplicalari.com/ Erişim Tarihi:08.11.2024

Aydın, A. (2019). Enerji Etkin Peyzaj Tasarımında Bitkilerin Kullanımı.

Beall, E., & Rossi, A. (2011). Good socio-economic practices in modern bioenergy production.

Berardi, U., GhaffarianHoseini, A., & GhaffarianHoseini, A. (2014). State-of-the-art analysis of the environmental benefits of green roofs. Applied energy, 115, 411-428.

Boduroğlu, Ş. (2010). Akıllı binalarda enerji etkin cephe tasarımı. 5. Ulusal Çatı ve Cephe Sempozyumu, 15-16 Nisan, İzmir.

Balat, M., & Ayar, G. (2005). Biomass energy in the world, use of biomass and potential trends. Energy sources, 27(10), 931-940.

Catalano, C., & Baumann, N. (2017). Biosolar roofs: a symbiosis between biodiverse green roofs and renewable energy. CityGreen, 2017(15), 42-49.

Dominguez, A., Kleissl, J., & Luvall, J. C. (2011). Effects of solar photovoltaic panels on roof heat transfer. Solar Energy, 85(9), 2244-2255.

Erdoğan, E., & Uslu, A. (2011). Sürdürülebilir peyzaj düzenleme. Peyzaj Çevre ve Tarım. TC Anadolu üniversitesi, Açık öğretim Fakültesi, 1279.

Hui, S. C., & Chan, S. C. (2011, November). Integration of green roof and solar photovoltaic systems. In Joint symposium (pp. 1-12).

Genç, G. (2006). Peyzaj Tasarım Elemanlarının Enerji Korumaya Etkisi (Yüksek Lisans Tezi), İstanbul Teknik Üniversitesi, Fen Bilimleri Enstitüsü, İstanbul.

Gül, A., & Küçük, V. (2001). Kentsel Açik-Yeşil Alanlar Ve Isparta Kenti Örneğinde İrdelenmesi. Turkish Journal of Forestry, 2(1), 27-48.

Güler ve Önder, (2006). Türkiye'de Rüzgâr Enerjisi Durumu ve Geleceği, Türkiye 10. Enerji Kongresi, Dünya'da ve Türkiye'de Enerji-Uygulamalar ve Sorunlar,1, 27-30

Kabulologlu-Karaosman, S. (2005). Yeşil çatıların ekolojik yönünden değerlendirmesi. 2. Ulusal Çatı Cephe Kaplamalarında Çağdaş Malzeme ve Teknolojiler Sempozyumu, İstanbul.

Karagöl, E. T., & Kavaz, İ. (2017). Dünyada ve Türkiye'de yenilenebilir enerji. Analiz. Seta, 197, 18-28.

Kayhan, T. (2019). Peyzaj uygulamalarında yenilenebilir enerji kaynaklarından yararlanma olanakları. Süleyman Demirel Üniversitesi Fen Bilimleri Enstitüsü Peyzaj Mimarlığı Anabilim Dalı Yüksek Lisans Tezi, Isparta, Türkiye.

Kutluca, A. K. (2009). Developing a strategic decision-making process for local energy planning and urban land-use evaluations: The case for Balçova geothermal energy (Doctoral dissertation, Izmir Institute of Technology (Turkey)).

Özek, E. (2009). Peyzaj mimarisi uygulamalarında güneş enerjisinin kullanımının değerlendirilmesine yönelik bir araştırma ve Yalova-Termal Yolu örneği. (Yüksek Lisans Tezi).

Öztürk Sarı, S., 2013, Enerji Etkin Tasarımda Bir Arakesit: Toprak Örtülü Yapılar, İstanbul Teknik Üniversitesi Fen Bilimleri Enstitüsü, Yüksek Lisans Tezi, 141s.

Peker, Z. (1998). Energy Efficient Urban Design, İzmir Yüksek Teknoloji Enstitüsü (Doctoral dissertation, Yüksek Lisans Tezi, İzmir).

Shafique, M., Luo, X., & Zuo, J. (2020). Photovoltaic-green roofs: A review of benefits, limitations, and trends. Solar Energy, 202, 485-497.

Tuğaç, Ç. 2003. Enerji Etkin Planlama Yaklaşımının Kentlerin Ekolojik Planlaması ve Tasarımı Süreçlerine Etkisi: Güney Ankara Ahiboz Koridoru Örneği, Gazi Üniversitesi Fen Bilimleri Enstitüsü, Yüksek Lisans Tezi, Ankara.

Yegin, N. (2011). Çevre ve sürdürülebilir kalkınma bağlamında enerji etkin peyzaj planlama yaklaşımı İzmir/Urla örneği (Master's thesis, Ankara Universitesi (Turkey)).

Yurtsev, A. A. (2015). Sürdürülebilir mimarlık kapsamında enerji etkin peyzaj tasarım yaklaşımları. Ege Üniversitesi Fen Bilimleri Enstitüsü Peyzaj Mimarlığı Anabilim Dalı Yüksek Lisans Tezi, 21s.

POSSIBILITY OF USING LUPIN SEEDS AS AN ALTERNATIVE PROTEIN SOURCE IN POULTRY NUTRITION

KANATLI BESLEMEDE ALTERNATIF PROTEIN KAYNAĞI OLARAK ACI BAKLA TOHUMUNUN KULLANIM OLANAĞI

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Abstract: Soybean meal is the most commonly used plant-based protein source in poultry nutrition due to its high-quality protein structure and balanced amino acid profile for poultry. However, due to many factors, such as the decrease in soybean cultivation areas globally, supply-demand imbalance, food-feed competition due to the increased use of soybean as a protein source in human nutrition, and its use as biofuel, its price is increasing day by day. This situation poses a significant risk to the economic profitability and sustainability of poultry enterprises. The majority of soybean cultivation occurs in countries like the United States, Argentina, and Brazil, and its transportation to Europe results in environmental pollution. For various reasons, researchers have started exploring alternative protein sources to replace soybean meal in poultry nutrition. Researchers are currently investigating the use of oilseed meals, including sunflower seed meal, rapeseed meal, and certain legumes, along with insects. However, due to the high cellulose and antinutritional factor content of these oilseeds and legumes compared to soybean meal, their use in poultry is limited. This study aimed to share information about the nutritional content of lupin seed in poultry nutrition, antinutritional factors, its use in poultry nutrition, and the methods applied to increase its use in poultry nutrition while also evaluating the results of current studies to explore its potential as an alternative protein source.
Keywords: Alternative protein source, lupin seed, poultry feeding, soybean meal

Özet: Soya fasulyesi küspesi kaliteli protein yapısı ve kanatlılar için dengeli amino asit profili nedeniyle kanatlı beslemede en çok kullanılan bitkisel kökenli protein kaynağıdır. Ancak global çapta soya fasulyesinin ekim alanlarının azalması, arz talep dengesizliğini, soya fasulyesinin insan beslenmesinde protein kaynağı olarak kullanımının artması nedeniyle oluşan gıda-yem rekabeti ve biyoyakıt olarak kullanımı gibi birçok faktörden dolayı fiyatı her geçen gün artmaktadır. Bu durumda kanatlı işletmelerinin ekonomik karlılığı ve sürdürülebilirliğine önemli risk oluşturmaktadır. Ayrıca soya fasulyesinin ekiminin büyük çoğunluğunun Amerika Birleşik Devletleri, Arjantin ve Brezilya gibi ülkelerde yetiştirilmesi ve buradan Avrupa'ya taşınması nedeniyle de çevrenin kirlenmesine neden olduğunu belirtilmektedir. Bunun gibi birçok sebepten dolayı araştırmacılar kanatlı beslemede soya fasulyesi küspesinin yerine alternatif protein kaynağı arayışları başlamıştır. Bu amaçla, ayçiçeği tohumu küspesi, kolza tohumu küspesi, baklagiller ile bazı böcek türlerinin kullanımı araştırılmış ve araştırılmaktadır. Ancak söz konusu yağlı tohumların ve baklagillerin soya fasulyesi küspesine kıyasla yüksek selüloz ve antibesinsel faktörler içermesi nedeniyle kanatlılarda kullanımı sınırlıdır. Bu çalışmada kanatlı beslemede acı bakla tohumunun besin

içeriği, antibesinsel faktörlere, kanatlı beslemede kullanımı ve kanatlı beslemede kullanım olanağının artırılması için uygulanan yöntemleri ile ilgili güncel çalışmaların sonuçları değerlendirilerek alternatif protein kaynağı olarak kullanım imkanı hakkında bilgiler paylaşmak amaçlanmıştır.
Anahtar Kelimeler: Acı bakla tohumu, alternatif protein kaynağı, kanatlı besleme, soya fasulyesi küspesi

GİRİŞ

Soya fasulyesi küspesi (SFK) gerek protein kalitesi gerekse dengeli amino asit profili sayesinde kanatlı beslemede yoğun olarak kullanılan bitkisel kökenli protein kaynağıdır (Khan, 2018). Ancak SFK'nın dünya çapında soya fasulyesinin ekim alanlarının azalması, arz talep dengesizliğini, gıda-yem-yakıt rekabetinin oluşması gibi birçok faktörden dolayı fiyatı her geçen gün artmaktadır (Jozefiak ve Engberg, 2015; Çelik, 2019). Ayrıca bazı ülkelerde soya fasulyesi ekim alanı için ormanlık alanların tahrip edilmesi, aşırı pestisit kullanımı, soya ekiminin büyük çoğunluğunun Amerika Birleşik Devletleri, Arjantin ve Brezilya gibi ülkelerde yetiştirilmesi ve buradan Avrupa'ya taşınması nedeniyle yüksek maliyet ve ciddi çevre kirliliğine neden olduğu belirtilmiştir (van der Poel vd., 2013; Van Huis, 2015; Weinrich ve Busch, 2021). SFK'nın gerek maliyet artırıcı faktörler gerekse çevre kirliliği ile ilgili endişeler düşünüldüğünde kanatlı işletmelerinin ekonomik karlılığı ve sürdürülebilirliğine önemli risk oluşturduğu vurgulanmaktadır (Khan vd., 2016). Bu nedenle kanatlı beslemede SFK'nın yerine ucuz, erişilebilirliği kolay alternatif protein kaynakları araştırılmaktadır (van der Poel vd., 2013; Van Huis, 2015; Ma vd., 2018; Liu vd., 2024). Bu amaç doğrultusunda çeşitli yağlı tohum küspeleri, böcekler, alg ile bazı baklagillerin kanatlı beslemede kullanımı ve kullanım olanağının artırılmasına yönelik birçok çalışma yapılmıştır (van der Poel vd., 2013; Van Huis, 2015; Wang vd., 2017; Madeira vd., 2017; Ma vd., 2018; Liu vd., 2024).

Bu çalışmada, kanatlı beslemede bitkisel protein kaynağı olarak yoğun kullanılan SFK'nın yerine acı bakla tohumunun kullanımına yönelik yürütülen çalışmalar ve kanatlı beslemede kullanım olanağı ile ilgili güncel çalışmaların sonuçları değerlendirilerek alternatif protein kaynağı olarak kullanım imkanı hakkında bilgiler paylaşmak amaçlanmıştır.

Acı Bakla Tohumu

Akdeniz havzasında yetişen bir bitki olan acı bakla, Leguminosae familyasına ait ve Türkiye'de çoğunlukla beyaz (Lupinus albus), mavi (Lupinus angustifolius) ve sarı (Lupinus luteus) türleri bulunmaktadır (Tüzün, 2013; Hama ve Strobel, 2020; Uzun ve Okur, 2023). Acı bakla tohumu (ABT) %28-45 protein, %5-20 yağ, %30-40 lif ve %0-5 nişasta içerir (Çetiner ve Bilek, 2018; Yorgancılar vd., 2020; Uzun ve Okur, 2023). Ayrıca fenolik bileşikler, fitosteroller, E vitamini, β-karoten, tokoferol, kalsiyum, demir, fosfor, oleik asit, linoleik asit, karbonhidratlar ve oligosakkaritler açısından zengindir (Çetiner ve Bilek, 2018; Yorgancılar vd., 2020; Uzun ve Okur, 2023). ABT antioksidan, yüksek su bağlama ve emülsifikasyon özellikleri onu kanatlı hayvanlarının rasyonlarında kullanımı için çekici yem hammaddesi haline getirmiştir (Yorgancılar vd., 2020; Balcıoğlu ve Irak, 2020; Uzun ve Okur, 2023). Ancak ABT'nin içerdiği kinolizidin grubu alkaloitleri ve glikozitler kanatlı hayvanı beslenmesinde kullanımını sınırlayan faktörlerdendir (Yorgancılar vd., 2020; Uzun ve Okur, 2023; David vd., 2024). Bu alkaloitler (lupin, lupan, spartein, 13α-hidroksilupan, α-izolupan ve angustifolin) hayvanlar tarafından çiğ olarak tüketildiğinde antibesinsel faktör etkisi oluşturmaktadır (Yorgancılar vd., 2020; Uzun ve Okur, 2023; David vd., 2024). Acı baklalarda yürütülen ıslah çalışmalarında genetik olarak besin madde kompozisyonu çok daha üstün ve alkaloit içeriği çok düşük acı bakla çeşitleri geliştirilmiş ve beyaz acı bakla olarak adlandırılmıştır (David vd., 2024). Ancak, Hama ve Strobel (2020) çalışmalarında ise ıslah edilen beyaz acı baklanın çapraz tohumlanma ve yetiştirildiği toprak koşullarına göre alkaloit içeriklerinin farklılık gösterebileceğini belirtmiştir. Bu nedenle ABT'lerin kanatlı beslemede kullanımını sınırlayan faktörleri azaltmak ve rasyonda kullanım oranını artırmak için birçok işleme yöntemi uygulanmış ve in vivo denemeler yürütülmüştür (Ertaş ve Bilgiçli, 2014; Çetiner ve Bilek, 2018; Sengül vd., 2019; Uzun ve Okur, 2023; David vd., 2024).

Kanatlı Beslemede Alternatif Protein Kaynağı Olarak Acı Bakla Tohumunun Kullanımı

ABT'nin kanatlı beslemede SFK'ya alternatif protein kaynağı olarak kullanımına dair 2000'li yılların öncesinde ve başında yürütülen çalışmalarda kanatlılarda özelliklede genç kanatlılarda alternatif protein kaynağı olarak uygun olmadığını belirten çalışmalar yoğunlukta olduğu görülmektedir (Farrel vd., 1999; Olkowski vd., 2001; Steenfeldt vd., 2003; David vd., 2024). Ancak günümüze geldiğinde ABT'nin kanatlı beslemede kullanılabileceği düşüncesi yoğunlaşmıştır (David vd., 2024). Literatürdeki bu farklılığın ABT çeşitlerindeki alkaloit, nişasta tabiatında olmayan polisakkaritlerin farklılığından veya rasyonun yararlanılanılabilir enerji dengesinin ayarlanamamasından kaynaklanabileceği ileri sürülmüştür (David vd., 2024). Nalle vd. (2010) etlik civcivlerde rasyonun enerji ve aminoasit kompozisyonunun ayarlandığı sürece ABT'nin rasyonda %20 oranında herhangi bir olumsuz etkisi olmadan kullanılabileceğini belirtmişlerdir. Kaczmarek vd. (2016) ise etlik piliç rasyonlarında %15'in üzerinde ABT ilavesinin performansı düşürdüğü, %25-30 oranında ilavesinde ise rasyondan yararlanımının düştüğü rapor edilmiştir. Kaczmarek vd. (2016) çalışma sonuçlarının aksine Hejdysz vd. (2019) ise etlik piliç rasyonlarında SFK'ya alternatif protein kaynağı olarak uygun acı bakla çeşitinin ve rasyona katılma oranının tespiti için yürütülen çalışmada sarı ve beyaz ABT türlerinin etlik piliç rasyonlarında %25 oranında herhangi bir olumsuz etkisi olmadan kullanılabileceğini saptanmıştır (Hejdysz vd., 2019).

Etlik piliç rasyonlarına SFK'ya yerine %10, %20 oranında beyaz ABT ilavesi ve %10, %20 oranında beyaz ABT ilavesi ile birlikte fitaz enzim ilavesinin performansa etkisi incelenmiştir (Kubis vd., 2020). Araştırma sonuçlarına göre yem tüketiminde farklılık olmazken, fitaz ilavesinin etkisinin olmadığı ve %20 oranında ABT ilavesinin canlı ağırlık ve yemden yararlanmayı kötüleştirdiği saptanmıştır. Araştırmacılar beyaz ABT'nin etlik piliç rasyonlarında %10 oranında kullanılabileceğini belirtmişlerdir (Kubis vd., 2020). Sarı ve mavi ABT'nin etlik piliç rasyonlarına %20 oranında fitaz enzim ilavesiyle birlikte kullanımının performansa etkisi incelenen araştırmada canlı ağırlık kazancı ve yem tüketimi açısından gruplar arasında farklılığın olmadığı ancak sarı ABT ile içeren rasyonlarla beslenen grubun yemden yararlanma etkinliğinin kötüleştiği belirtilmiştir (Kaczmarek vd., 2015). Etlik piliç rasyonlarında SFK'nın yerine %50 ve %100 oranında ABT ile değiştirilmiş rasyonlarla beslenen etlik piliçlerin kas kalitesinin arttığı, kaslardaki doymuş yağ asitlerinin azalırken, doymamış yağ asitlerinin arttığı tespit edilmiştir (Kutlvasr vd., 2022). Etlik piliçlerde yürütülen başka bir çalışmada ise SFK yerine rasyona %5, 10 ve 20 oranında ilavesinin performans ve et kalitesine etkisi incelenmiştir (Lim ve Choi, 2023). Araştırma sonuçlarına göre %20 ABT ile beslenen grupların canlı ağırlığının diğer gruplara göre düşük olduğunu, yemden yararlanma oranının kontrol ve %5 ABT içeren rasyonla beslenen gruplara göre yüksek olduğunu tespit etmişlerdir. Göğüs etinin %20 ABT içeren rasyonla beslenen piliçlerin L* değerinin kontrole göre düştüğü, %10 ve %20 ABT içeren gruplarda çoklu doymamış yağ asitlerinin kontrole göre yüksek olduğunu saptamışlardır (Lim ve Choi, 2023).

Lee vd. (2016) beyaz ABT'nin %15 oranında enzim kullanılarak yumurtacı tavuk rasyonlarında kullanılabileceğini bildirmişlerdir. Benzer şekilde Park vd. (2016) yürüttükleri çalışmada da 29 haftalık Hy-Line Brown tavukların rasyonlarına %11 ve %22 oranında ABT ilave etmişlerdir. Araştırmacılar kontrol grubuna göre ABT ilaveli rasyonlarla beslenen tavukların yem tüketiminin arttığı, yumurta verimi, yumurta sarısı ile yumurta kabuk kalitesinin iyileştiğini bildirmişlerdir (Park vd., 2016). Sarı ABT'nin 32 haftalık Lohmann

Brown tavukların rasyonlarına %10, 20 ve 30 oranında SFK yerine ilave edilerek performans ve yumurta kalitesine etkisi incelenmiştir (Krawczyk vd., 2015). Sarı ABT ile oluşturulan rasyonla beslenen yumurtacı tavuklar ile kontrol (mısır-SFK temelli rasyon) grubu arasında yem tüketimi, yemden yararlanma oranı, yumurta verim ve ağırlığı ile arasında farklılığın olmadığını saptamışlardır. Diğer taraftan yumurta kabuk ve albumen kalitesinde de farklılık olmazken, sarı ABT içeren rasyonla beslenen tavukların yumurta sarı renk yoğunluğunun arttığını bildirmişlerdir. Araştırmacılar yumurtacı tavuk rasyonlarına SFK yerine %30 oranında sarı ABT kullanılabileceğini önermişlerdir (Krawczyk vd., 2015). Krawczyk vd. (2015) çalışmasının aksine yumurtacı tavukların (Hy-Line Brown) rasyonlarına %6, 12, 18, 24 ve 30 oranında SFK yerine beyaz ABT ilave edildiğinde %6 ikameli grup dışındakilerde ABT oranının artışına paralel şekilde yem tüketiminin arttığı belirlenmiştir (Kubis vd., 2018). Ayrıca %24 ve %30 ilaveli gruplarda da yumurta veriminin düştüğünü saptamışlardır. ABT ilavesinin yumurta ağırlığını ve kabuk kalitesini düşürdüğü belirtilmiştir. Araştırmacılar yumurtacı tavuk rasyonlarına ABT ilavesinin performans, rasyondan yararlanımın ve yumurta verim ve kabuk kalitesini negatif etkilediği sonucuna varmışlardır (Kubis vd., 2018).Yumurtacı tavuk rasyonlarına SFK'ya alternatif olarak farklı oranda ABT, bezelye ve kolza tohumu küspesi karışımı (%19.48 SFK yerine) ile ABT ve bezelye (%27.68) karışımını ilave edilmiş ve performansına etkisi incelenmiştir (Rutkowski vd., 2015). Araştırmacılar SFK yerine %27.68 oranında ABT ile bezelye karışımının yumurtlama oranı ile yem tüketimi düşerken, hem %19.48 hem de %27.68 oranındaki karışımlar ile beslenen tavukların yumurta ağırlığının ve yemden yararlanma oranın negatif etkilendiğini bildirmişlerdir (Rutkowski vd., 2015). Aynı araştırmacı grubunun diğer bir çalışmasında ise yumurtacı tavukların rasyonuna %10, 15, 20 ve 25 oranında sarı ABT ilavesinin etkisi incelenmiştir (Rutkowski vd., 2017). Yumurtacı tavukların rasyonuna %25 oranında sarı ABT ilavesinin yem tüketimini ve yemden yararlanma oranını kötüleştirdiğini saptamışlardır. Rasyona %20 oranında ABT ilavesinin yumurta verim ve yumurta ağırlığına olumsuz etkisinin olmadığını tespit etmişlerdir. Diğer taraftan rasyonda ABT oranı arttıkça yumurta kalitesinin düştüğünü belirtmişlerdir (Rutkowski vd., 2017). Yumurtacı tavuk rasyonlarına mavi ABT'nin %10, 15, 20 ve 25 oranında SFK'ya alternatif olarak ilave edildiğinde performansı olumsuz etkilemediği yumurta sarısı yoğunluğunu ve yağ asitlerini iyileştirdiği ve SFK'ya alternatif protein kaynağı olarak kullanılabileceği ileri sürülmüştür (Kowalska vd., 2020). Sarı ABT'nin yumurta rengine etkisinin araştırıldığı araştırmada ABT ilavesinin yumurta L* ve b* değerini düşürürken a* değerini artırdığı bildirilmiştir (Kuzniacka vd., 2020).

SONUÇ

Acı bakla tohumunun gerek etlik piliç gerekse yumurtacı tavuk rasyonlarında kullanımına dair çalışma sonuçlarında çelişkili sonuçlar bulunmaktadır. Söz konusu farklılıkların kullanılan farklı ABT çeşitlerinden, içeriğindeki alkoloitler ve nişasta tabiatında olmayan polisakkarit gibi antibesinsel faktörlerin miktarından kaynaklanabileceği düşünülmektedir. ABT'nin bir takım biyoteknolojik işlemlere tabi tutularak bünyesindeki antibesinsel faktörleri minimize ederek kanatlı beslemede soya fasulyesi küspesine alternatif protein kaynağı olabileceği düşünülmektedir.

KAYNAKLAR

Balcıoğlu, A. & Orak, A. (2020). The Effects of Plant Growth Regulators on Yield and Yield Components in White Lupin (Lupinus albus L.) Genotypes. J. Bahri Dagdas Crop Res. 9, 197–211.

Çelik, B. (2019). Tek hücre proteinlerinin hayvan besleme açısından önemi ve rasyonda kullanım olanakları. Lalahan Hay. Araşt. Enst. Derg. 59 (Ek Sayı): 113-116.

Çetiner, M. & Bilek, S.E. (2018). Plant protein sources. Çukurova J. Agric. Food Sci. 2018, 33, 111–126.

David, L.S., Nalle, C.L., Abdollahi, M.R. & Ravindran, V. (2024). Feeding Value of Lupins, Field Peas, Faba Beans and Chickpeas for Poultry: An Overview. Animals, 14(4), 619.
Ertaş, N. & Bilgiçli, N. (2014). Effect of different debittering processes on mineral and phytic acid content of lupin (Lupinus albus L.) seeds. J. Food Sci. Technol. 51, 3348–3354.
Farrell, D.J., Perez-Maldonado, R.A. & Mannion, P.F. (1999). Optimum inclusion of field peas, faba beans, chick peas and sweet lupins in poultry diets. II. Broiler experiments. Br. Poult. Sci. 40, 674–680.
Hama, J.R. & Strobel, B.W. (2020). Natural alkaloids from narrow-leaf and yellow lupins transfer to soil and soil solution in agricultural fields. Environ. Sci. Eur. 32, 126.
Hejdysz, M., Kaczmarek, S.A., Rogiewicz, A., Rutkowski, A. (2019). Influence of graded levels of meals from three lupin species on growth performance and nutrient digestibility in broiler chickens. Br. Poult. Sci. 60, 288–296.
Jozefiak, D. & Engberg, R.M. (2015). Insect as poultry feed. 20th European symposium on Poultry Nutrition, 24-27 August, Prague, Czech Republic.
Kaczmarek, S.A., Cowieson, A.J., Hejdysz, M., Rutkowski, A. (2015). Microbial phytase improves performance and bone traits in broilers fed diets based on soybean meal and containing lupin meal. Anim. Prod. Sci., 56: 1669–1676.
Kaczmarek, S.A., Hejdysz, M., Kubiś, M., Rutkowski, A. (2016). Influence of graded inclusion of white lupin (Lupinus albus) meal on performance, nutrient digestibility and intestinal morphology of broiler chickens. Br. Poult. Sci. 57, 364–374.
Khan, S. H. (2018). Recent advances in role of insects as alternative protein source in poultry nutrition. Journal of Applied Animal Research, 46(1), 1144-1157.
Khan, S., Naz, S., Sultan, A., Alhidary, I. A., Abdelrahman, M. M., Khan, R. U., Khan NA., Khan MA., Ahmad, S. (2016). Worm meal: a potential source of alternative protein in poultry feed. World's Poultry Science Journal, 72(1), 93-102.
Kowalska, E., Kucharska-Gaca, J., Kuźniacka, J., Lewko, L., Gornowicz, E., Biesek, J., & Adamski, M. (2020). Quality of eggs, concentration of lysozyme in albumen, and fatty acids in yolk in relation to blue lupin-rich diet and production cycle. Animals, 10(4), 735.
Krawczyk, M., Przywitowski, M., & Mikulski, D. (2015). Effect of yellow lupine (L. luteus) on the egg yolk fatty acid profile, the physicochemical and sensory properties of eggs, and laying hen performance. Poultry Science, 94(6), 1360-1367.
Kubis, M. Kaczmarek, S.A. Nowaczewski, S. Adamski, M. Hejdysz, M. Rutkowski, A. (2018). Influence of graded inclusion of white lupin (Lupinus albus) meal on performance, nutrient digestibility and ileal viscosity of laying hens. British Poultry Science, 59, 477-484.
Kubis, M., Kaczmarek, S., Hejdysz, M., Mikuła, R., Wiśniewska, Z., Pruszyńska-Oszmałek, E., Kołodziejski, P., Sassek, M., Rutkowski, A. (2020). Microbial phytase improves performance and bone traits in broilers fed diets based on soybean meal and white lupin (Lupinus albus) meal. Ann. Anim. Sci. 20, 1379–1394.
Kutlvasr, M., Straková, E., Suchý, P., & Všetičková, L. (2022). Effect of partial and complete substitution of lupin meal for soybean meal in diets on changes in fatty acid composition of muscle fat in broiler chickens. Czech Journal of Animal Science, 67(5).
Kuzniacka, J., Biesek, J., Banaszak, M., Grabowicz, M., & Adamski, M. (2020). The quality of eggs from Rosa 1 hens fed diets containing seeds of legume plants (Lupinus luteus L., Lupinus angustifolius, and Pisum sativum) in two laying phases. Animals, 10(11), 1942.
Lee, M.R., Parkinson, S., Fleming, H.R., Theobald, V.J., Leemans, D.K., & Burgess, T. (2016). The potential of blue lupins as a protein source, in the diets of laying hens. Veterinary and Animal Science, 1, 29-35.
Lim, C.I., & Choi, N.J. (2023). Effect of lupin (Lupinus angustifolius) as a soybean meal replacement on the performance, meat quality, and blood parameters of broilers. Canadian Journal of Animal Science, 103(2), 167-173.

Liu, B., Liu, H., Liu, D., Zhou, M., Jiang, Q., Ma, X., Wang, J., Tan, B., Zhang, C. (2024). Free gossypol removal and nutritional value enhancement of cottonseed meal via solid-state fermentation with Rhodotorula mucilaginosa TG529. Agriculture, 14, 1463.

Ma, D.L., Ma, X.K., Liu, L., Zhang, S. (2018). Chemical composition, energy, and amino acid digestibility in 7 cottonseed co-products fed to growing pigs. Animal Science Journal, 96, 1338–1349.

Madeira, M.S., Cardoso, C., Lopes, P.A., Coelho, D., Afonso, C., Bandarra, N.M., Prates, J.A.M., (2017). Micro-algae as feed ingredients for livestock production and meat quality: a review. Livestock Sci. 205, 111–121.

Nalle, C.L., Ravindran, V., Ravindran, G. (2010). Evaluation of faba beans, white lupins and peas as protein sources in broiler diets. Int. J. Poult. Sci. 9, 567–573

Olkowski, A.A., Olkowski, B.I., Amarowicz, R., Classen, H.L. (2001). Adverse effects of dietary lupine in broiler chickens. Poult. Sci. 80, 621–625.

Park, J. H., Lee, S.I., & Kim, I.H. (2016). Effects of lupin seed supplementation on egg production performance, and qualitative egg traits in laying hens. Veterinární medicína, 61(12), 701-709.

Rutkowski, A., Hejdysz, M., Kaczmarek, S., Adamski, M., Nowaczewski, S., & Jamroz, D. (2017). The effect of addition of yellow lupin seeds (Lupinus luteus L.) to laying hen diets on performance and egg quality parameters.

Rutkowski, A., Kaczmarek, S. A., Hejdysz, M., Nowaczewski, S., & Jamroz, D. (2015). Concentrates made from legume seeds (Lupinus angustifolius, Lupinus luteus and Pisum sativum) and rapeseed meal as protein sources in laying hen diets. Annals of animal science, 15(1), 129-142.

Sengül, A.Y., ˙Inci, H., ¸Sengül, Ö. (2019). Using Possibilities of Chickpeas (Cicer arietinum L.) in Poultry Diets. Atatürk Univ. J. Agric. Fac. 50, 305–311

Steenfeldt, S., Gonzalez, E., Bach-Knudsen, K.E. (2003). Effects of inclusion with blue lupins (Lupinus angustifolius) in broiler diets and enzyme supplementation on production performance, digestibility and dietary AME content. Anim. Feed Sci. Technol. 110, 185–200.

Tüzün, A.E. (2013). An alternative source of protein lupin (Lupinus L.) use of broiler nutrition. J. Anim. Prod. 54, 50–54.

Uzun, T., & Agma Okur, A. (2023). Impacts of Different Processes on the Nutritional and Antinutritional Contents of White and Blue Lupin Seeds and Usage Possibilities for Sustainable Poultry Production. Animals, 13(22), 3496.

Van der Poel, A.F.B., Van Krimpen, M.M., Veldkamp, T., & Kwakkel, R.P. (2013). Unconventional protein sources for poultry feeding–opportunities and threats. In Proceedings of the 19th European Symposium on Poultry Nutrition, Potsdam, Germany, 26-29 August 2013 (pp. 14-24).

van Huis A. (2015). Edible insects contributing to food security? Agr Food Secur. doi:10.1186/s40066-015-0041-5

Wang, Y., Deng, Q., Song, D., Wang, W., Zhou, H., Wang, L., Li, A., (2017). Effects of fermented cottonseed meal on growth performance, serum biochemical parameters, immune functions, antioxidative abilities and cecal microflora in broilers. Food Agric. Immunol., 28(4):725-738.

Weinrich, R., & Busch, G. (2021). Consumer knowledge about protein sources and consumers' openness to feeding micro-algae and insects to pigs and poultry. Future Foods, 4, 100100.

Yorgancılar, M., Başarı, D., Atalay, E., Tanur Erkoyuncu, M.A. (2020). Functional Food: Lupin. J. Bahri Dagdas Crop Res. 9, 89–101

DETERMINATION OF PHENOLOGICAL AND POMOLOGICAL CHARACTERISTICS OF PISTACHIOS GROWN IN BATMAN ECOLOGY

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ABSTRACT
Pistachio (Pistacia vera L.) is a concentrated fruit type known as “Green Gold” in its homeland countries and has high economic returns with its alternative consumption. Siirt variety has fresh and processed snack fruit characteristics that comply with world standards. It is also a variety used in the production of different products with high added value (such as paste, dessert, ice cream, cake, salami). This research with high original value was conducted to determine the phenological and pomological values of Siirt variety grown in Batman ecology, which is considered as a new production area for pistachio and where large gardens have been established in recent years. The material of the research was the 15-year-old trees of the “Siirt” variety, which were planted at 8x8 m intervals and distances grafted onto Siirt plains in dry conditions in Batman ecology in 2023 and 2024. Phenological observations (swelling of buds, first bloom, full bloom, end of bloom, blooming period, time from full bloom to harvest, harvest date) were made in the field conditions and pomological characteristics (fruit weight, split nuts rate, kernel ratio and empty fruit rate) were made on fruits sampled from the garden. It was determined that the flower buds swelled on average on April 1, the first blooming was on April 4, full blooming was on April 11, and the end of blooming was on April 17, while the blooming period was determined to be 13 days. The harvest date is determined as September 15 for 2024 and September 11 for 2023, and the period from full blooming to harvest is 148 days. Considering the pomological characteristics, in 2023, the fruit weight was 1.066 g, the kernel ratio was 43.82%, the splitting rate was 66.67%, the empty fruit rate was 6,67%, and in 2024, the fruit weight was 1.179 g, the kernel ratio was 48.98%, the splitting rate was 74.7%, the empty fruit rate was 6,67%. It is understood from the current literature findings that the phenological and pomological characteristics of pistachio, which has a special climate preference, change according to the changes in ecological conditions. In this first study conducted in Batman ecology, it was observed that pomological characteristics can change from year to year. It can be stated that the differences in the findings due to the changes in ecological factors are due to the cumulative effect of multiple gene effects and a requirement of quantitative inheritance in the emergence of the characteristics. Although it is a new production region, it can be stated that the findings are in general harmony with the data of the regions where mass production is made. In this study, appropriate strategies are suggested for garden establishment, fertilization biology and annual maintenance works in pistachio cultivation in the region.
Key Words: Pistachio, Pistacia vera, Phenology, Pomology, Batman

INTRODUCTION

Pistachio (Pistacia vera L.) is a concentrated fruit species known as "Green Gold" in its homeland countries and has high economic returns with its alternative consumption (Ayfer, 1990). Pistacia vera L. has larger varieties of fruit compared to other pistacia species. The species, which is also widely used as a rootstock, is economically important in commercial cultivation (Ferguson and Kallsen, 2016).

Pistachio belongs to the “Central Asia” and “Near East” gene centers. Throughout history, the Anatolian geography has interacted with the Central Asia geography and the Southeastern Anatolia Region of Turkey is within the Near East Gene Center. This is important in Turkey being one of the countries with the richest genetic material in the world in pistachio (Kaşka, 1990; Tekin et al., 1995; Tekin et al., 2001).

Pistachio is a type of fruit that is used to enhance color, flavor, visual and sensory quality in the production of fresh snacks, processed snacks and various high value-added products (paste, dessert, ice cream, cake, salami, etc.) due to its delicious taste and high nutritional value (Tous and Ferguson, 1996).

Although pistachios can be grown in nutrient-poor soils where other fruit species have difficulty growing, and in calcareous, rocky, and stony lands without irrigation, they require special climatic conditions: relatively cold winters and hot, dry, and long summers (Özbek, 1978).

Turkey has an important position in the world in pistachio production. As of 2022, 1,026,765 tons of pistachios were produced worldwide. The USA is the largest producer in world pistachio production with a production of 400,070 tons. Iran is second with a production of 241,668 tons. Turkey ranks third in the world in pistachio production with a production of 239,289 tons (FAO, 2022).

Pistachio cultivation in Turkey is concentrated especially in the provinces of Şanlıurfa, Gaziantep, Siirt, Adıyaman and Kahramanmaraş. According to 2023 data, Şanlıurfa ranks first with a production of 59,848 tons in an area of 1,627,111 da, while Gaziantep ranks second with 54,575 tons in an area of 1,427,441 da. Batman, which has new facility areas, ranks sixth with a production of 3,440 tons in an area of 129,405 da (TÜİK, 2023).

In pistachio production and productivity of countries and regions, fluctuations in yield (periodicity) can be seen from year to year due to physiological reasons specific to the species. In pistachio, periodicity occurs as a result of the shedding of the fruit buds that have formed, unlike other fruit species (Crane and Nelson 1971). The severity of periodicity is increased by ecological factors and inadequacy/ineligible annual maintenance conditions.

The Siirt variety has a large and oval fruit compared to other varieties, the shell cracking rate is high and the ripening period is mid-late. The outer shell color of the fruit is pinkish cream, the hard shell is bone-colored and the Siirt variety attracts attention with its high yield rate of approximately 43% (Gökçe and Akçay, 1993; Tekin et al., 2001).

In Batman province, which has an important position in fruit production among the provinces in the GAP region, according to the latest statistical data, fruit is grown on 138,169 decares of land, vineyards on 47,313 decares of land and vegetables on 31,490 decares of land. In Batman province, pistachio and strawberry cultivation has come to the fore in recent years, while fruit species such as walnut, almond, apricot and pomegranate are also grown in order of importance. Batman province's hot and dry summer conditions and calcareous soil structure restrict the cultivation of fruit species and varieties and require the implementation of regular and controlled maintenance conditions in cultivation (Anonymous, 2023).

This research, which has high original value, was carried out in 2023 and 2024 to determine the phenological and pomological characteristics of the 15-year-old Siirt variety grafted onto

Siirt varieties grown in the Batman ecology, which is considered as a new production area for pistachios in our country and where large gardens have been established in recent years.

MATERIALS AND METHODS

The research material consisted of 15-year-old "Siirt" variety trees planted at 8x8 m intervals and distances grafted on Siirt varieties grown under dry conditions in an area of 163 decares in Batman ecology in 2023 and 2024. Phenological observations (swelling of buds, first blooming, full blooming, end of blooming, harvest time, blooming period and the time from full flower to harvest) were made in the garden under field conditions in 2024 (Kuru, 1984, Ak et al., 1998; Gündeşli et al., 2019). Pomological characteristics (fruit weight, split nuts rate, kernel ratio and empty fruit rate) were determined in 75 fruits with 3 replications sampled from four directions of 15 trees in the same garden in 2023 and 2024 according to Ayfer (1964).

RESULT AND DISCUSSION

Phenological Observations

In the phenological observations made in 2024 of the Siirt variety grown in Batman ecology, it was determined that the flower buds swelled on average on April 1, the first bloom was on April 4, full bloom was on April 11, and the end of bloom was on April 17, while the blooming period was determined to be 13 days. The harvest date is determined as September 15 in 2024 and September 11 in 2023, and the period from full blooming to harvest date is 148 days (Table1.).

Table 1. Phenological observation dates of Siirt pistachio variety in Batman ecology in 2024

Flower bud swelling	Blooming date			Blooming period	The period from full blooming to harvest	Harvest date
	First	Full	End			
1 April	4 April	11 April	17 April	13 days	148 days	15 September

In similar studies previously conducted on the Siirt variety in the research region, in the ecology of Ceylanpınar (Şanlıurfa) in 1999, the bud swelling time was observed as 25 March, the first flowering as 9 April, the full bloom as 16 April, the end of bloom as 22 April, and the bloom period was determined as 14 days (Ak et al., 2002). In the study carried out in the ecologies of Kahramanmaraş, Pazarcık, Gaziantep, Ceylanpınar and Siirt in 2017 and 2018, significant differences were detected in phenological findings according to years and regions. Full bloom was observed on 16 April in Kahramanmaraş, 13 April in Pazarcık, 11 April in Gaziantep and Ceylanpınar (Şanlıurfa), and 15 April in Siirt in 2017; and on 9 April in Kahramanmaraş, 5 April in Pazarcık, 2 April in Gaziantep, 3 April in Ceylanpınar (Şanlıurfa), and 8 April in Siirt in 2018. The blooming period was determined as 8 days in Kahramanmaraş, 8 days in Pazarcık, 10 days in Gaziantep, 9 days in Ceylanpınar (Şanlıurfa), and 7 days in Siirt in 2017, and as 7 days in Kahramanmaraş, 7 days in Pazarcık, 10 days in Gaziantep, 10 days in Ceylanpınar (Şanlıurfa), and 8 days in Siirt in 2018 (Nikpeyma, 2024). It is thought that the differences in the blooming process and dates recorded in this study and the observation dates in similar studies are affected by the variability in the ecological factors of the regions, the variability of meteorological data according to years, and the differences in annual maintenance works in dry/wet conditions.

Pomological Properties of Fruits

Data on fruit weight, fruit length, fruit thickness, fruit width, kernel ratio, splitting rate, empty fruit rate obtained from samples sampled in 2023 and 2024 from the garden of the Siirt variety grown in Batman ecology are given in Table 2. When the average fruit characteristics of the Siirt variety in Batman ecology were examined, the fruit weight was determined as 1.07 g in 2023 and 1.18 g in 2024.

Gökçe and Akçay (1993) defined the weight of the standard Siirt variety as 1.14 g. Başarıcı (2014) determined the fruit weight of the Siirt variety as 1.18 g in Akçakale (Şanlıurfa). Nikpeyma (2024), in his study on the Siirt variety in 2017 and 2018, determined the average fruit weight as 1.43 g in Siirt ecology, 1.38 g in Gaziantep, 1.36 g in Pazarcık, and 1.29 in Kahramanmaraş. It can be stated that the findings in terms of fruit weight may vary according to years, yield status, and ecologies. It is seen that this change expands the acceptance limits according to the standard.

Table2. Pomological parameters of Siirt pistachio fruits in Batman ecology (years 2023-2024).

Years	Fruit weight (g)	Fruit lenght (mm)	Fruit thickness (mm)	Fruit width (mm)	Split nuts rate (%)	Kernel ratio (%)	Blank nuts rate (%)
2023	1.07	19.86	10.36	11.63	66,67	43,82	6,67
2024	1.18	20.21	11.29	12.08	74,70	48,98	6,67
Ortalama	1.12	20.03	10.82	11.85	70,68	46,40	6,67

In pistachio, the average fruit length, thickness and width of the fruit dimensions which have a positive relationship with fruit weight were determined as 20.03 mm, 10.82 mm, 11.85 mm, respectively (Table, 2). The fruit length of the standard Siirt variety was defined as 19.91 mm, fruit thickness as 11.02 mm, fruit width as 11.55 mm (Gökçe and Akçay, 1993). In Ceylanpınar ecology, in 1999, the fruit length of the Siirt variety was determined as 19.98 mm, fruit thickness as 11.45 mm, fruit width as 12.15 mm by Ak et al. (2002). Başarıcı (2014) determined the fruit length of the Siirt variety as 21.13 mm, fruit thickness as 12.32 mm, fruit width as 11.13 mm in Akçakale (Şanlıurfa). It can be stated that the fruit length, thickness and width values of the same variety of pistachio are affected by ecological factors, differences in annual maintenance work in dry/wet conditions and changes in fruit weight between years.

The kernel ratio of Siirt pistachio variety grown in Batman ecology was calculated as 43.82% in 2023 and 48.98% in 2024 (Table 2). Gökçe and Akçay (1993) reported the kernel ratio of the standard Siirt variety as 42.64%. Atlı et al. (2011) determined the average kernel ratio of the Siirt variety grafted onto pistachio seedling rootstock in the Harran Plain ecology as 45.8%. Başarıcı (2014) determined the kernel ratio of the Siirt variety in Akçakale as 30.15%. In another study, the highest kernel ratio of the Siirt variety was determined as 45.80% and the lowest as 38.80% (Atlı et al. 2003). In the study conducted in 2017 and 2018 in the ecologies of Kahramanmaraş, Pazarcık, Gaziantep, Ceylanpınar and Siirt, the kernel ratio of the Siirt variety was determined as 54.29% in Kahramanmaraş, 55.41% in Pazarcık, 53.81% in Gaziantep, 55.41% in Ceylanpınar and 53.59% in Siirt (Nikpeyma, 2024). It can be stated that the kernel ratio findings may vary depending on the years, yield status, ecological factors and annual maintenance conditions. These changes can be seen within the acceptance limits according to the standard.

The splitting rate, which is one of the important quality parameters, was determined as 66.67% in 2023 and 74.70% in 2024 (Table 2). When the literature information was searched, Ak (1998) determined the average splitting rate as 66.49% in the Siirt variety grown in Ceylanpınar (Şanlıurfa). Atlı et al. (2011) determined the average splitting rate as 98.30% in the Siirt variety grafted on pistachio seedling in the Harran plain (Şanlıurfa). Nikpeyma (2024), in the study conducted in 2017 and 2018 in Kahramanmaraş, Pazarcık, Gaziantep, Ceylanpınar and Siirt ecologies, determined the splitting rate as 63.91% in Kahramanmaraş, 78.34% in Pazarcık, 81.39% in Gaziantep, 83.38% in Ceylanpınar and 85.78% in Siirt. The splitting rate is defined as 92% in the variety catalog of the Ministry of Agriculture and Forestry (Gökçe and Akçay, 1993). It can be stated that the variability of the findings is very high. It can be stated that the parameter in question is polygenic. In general, it is thought that the differences in pomological trait parameters may be related to the effect of ecological factors on multiple genes, as well as inadequate maintenance conditions and cultivation in dry conditions are effective in the cracking rate. In addition, it is predicted that there is a relationship between pomological traits and that cultivation in dry conditions affects some parameters.

In commercial hard-shelled fruit species, parthocarpic fruit formation is seen due to insufficient fertilization, but it is not desired. The empty fruit rate was determined as 6.67% in both years (Table 2). It can be stated that this rate varies considerably according to ecologies and years in different studies. In fact, Ak (1998) found the empty fruit rate as 11.42% in Siirt variety in Ceylanpinar; Başarıci (2014) found the empty fruit rate as 6.67% in Akcakale (Sanliurfa); Nikpeyma (2024) found the average empty fruit rate as 12.40%, 7.69%, 7.03%, 4.51% and 7.39% in Kahramanmaras, Pazarcik, Gaziantep, Ceylanpinar and Siirt ecologies in 2017 and 2018, respectively. When the findings were compared with similar studies, it was shown that positive results were seen and the empty fruit rate was similar. In some studies, the differences may have been affected by factors such as high temperatures during the flowering period, rainfall during the pollination and fertilization periods, lack of irrigation and lack of additional fertilization programs.

CONCLUSION

It is understood from the current literature findings that the phenological and pomological characteristics of pistachio, which has a special climate preference, change according to the changes in ecological conditions. In this first study conducted in Batman ecology, it was observed that pomological characteristics can change from year to year. As an expression of the difference in findings depending on the changes in ecological factors, it can be stated that the emergence of the characteristics is due to a requirement of quantitative inheritance and the cumulative effect of multiple gene effects.

Although it is a new production area for pistachios, it can be stated that the findings are generally in line with the data of the regions where mass production is carried out. According to TÜİK data on the number of non-fruiting trees in 2023, Batman province shows that it has a great potential in pistachio production in the near future. The high number of non-fruiting trees in Batman province and the abundance of trees that have not reached optimum fruiting age reveal that Batman has a significant growth potential in pistachio production. In addition, pistachio festivals organized by the Batman Governorship, grant and support programs of the Ministry of Agriculture and Forestry, and facilitating the supply of materials for garden establishment and post-harvest processes lead to a rapid increase in the number of people engaged in pistachio cultivation. Expert and consultant support, R&D and feasibility studies, and appropriate strategies for garden establishment, fertilization biology and annual maintenance are important in pistachio cultivation in the region. It can be stated that planning needs to be made urgently on these issues.

REFERENCES

Ak, B. E. (1998). Fruit set and some fruit traits of pistachio cultivars grown under rainfed conditions at Ceylanpinar State Farm. Cahiers Options Méditerranéennes, (33), 217-223.

Ak, B. E., Acar, I., & Kaska, N. (1996, October). An investigation on the male determination for some female varieties throughout five years (1992-1996) grown at Ceylanpinar State Farm in Sanliurfa conditions. In Proceedings of the X. GREMPA seminar (pp. 14-17).

Ak, B. E., Kaşka, N., Açar, I., İkinci, A., & Tosun, I. (2002). Research on the adaptation of local and foreign pistachio varieties and types under irrigated conditions at Ceylanpinar Agricultural Enterprise. TÜBİTAK/TOGTAG/TARP-1894. 76 p.

Anonim. (2023). Brifing 2023. Batman İl Tarım ve Orman Müdürlüğü. https://batman.tarimorman.gov.tr/Belgeler/Brifing%20ve%20Faaliyet%20raporlar%C4%B1/Brifing-2023.pdf (Accessed on December 4, 2024).
Atlı, H. S., Arpacı, S., Akgün, A., Özgüven, A. I., & Özgüven, F. (1999). Determination of harvest time and feasibility of mechanical harvesting for some pistachio cultivars. Turkey III. National Horticultural Congress Proceedings, S, 248-251.
Atlı, H. S., Avdin, Y., Arpaci, S., Acar, I., Karadag, S. O. N. G. Ü. L., Bilgel, L., ... & Ak, B. E. (2011). Determination of growth, bearing, yield and some quality characteristics of pistachio cultivars grafted on different rootstocks under irrigated conditions. Acta Horticulturae, 912, 289-294.
Ayfer, M. (1964). Pistachio nut culture and its problems with special reference to Turkey.
Ayfer, M. (1990). The past, present, and future of pistachio. Turkey, 1, 11-12.
Başarici, M. F. (2014). Determination of phenological and pomological characteristics of some local and foreign pistachio cultivars under Akçakale conditions (Master's thesis, Institute of Science).
Crane, J. C., & Nelson, M. M. (1971). The unusual mechanism of alternate bearing in pistachio.
FAO. (2024). Faostat data: Food and agricultural statistics. https://www.fao.org/faostat/en/#data/QCL (Accessed on December 4, 2024).
Ferguson, L., & Kallsen, C. E. (2016). Origin and history in California. Pistachio Production Manual, 3545, 19.
Gokce, M. H., & Akçay, M. (1993). Pistachio cultivar catalog. Ministry of Agriculture and Rural Affairs, Ankara, Turkey, 361, 20-64.
Gündeşli, M. A., Kafkas, N. E., Kafkas, S., & Güney, M. (2019). Comparison of some phenological and pomological characteristics of the 'Uzun' pistachio cultivar between bearing 'on' and non-bearing 'off' trees.
Kuru, C., & Ayfer, M. (1984). Studies on artificial pollination of pistachio flowers.
Nikpeyma, Y. (2024). Phenological, pomological, biochemical, and physical characteristics of Siirt pistachio variety (Pistacia vera L.) in five different ecologies of Southeast Anatolia, Turkey. International Journal of Fruit Science, 24(1), 174-185.
Özbek, S. (1978). Special fruit growing. Çukurova University Faculty of Agriculture Publications, 128, 392-483.
Tekin, H., Arpacı, S., Atlı, H. S., Karaca, R., Mart, C., & Turan, K. (1995). Pistachio cultivation technique. Pistachio Research Institute Directorate, Publication, (4), 36.
Tekin, H., Arpacı, S., Atlı, H. S., Açar, İ., Karadağ, S., Yükçeken, Y., & Yaman, A. (2001). Pistachio cultivation, Pistachio Research Institute, Publication No: 13.
Tous, J., & Ferguson, L. (1996). Mediterranean fruits. Progress in New Crops, 416, 430.
TÜİK. (2024). Medas data. https://biruni.tuik.gov.tr/medas/?kn=92&locale=tr (Accessed on December 4, 2024).

PROMOTION OF ENTREPRENEURSHIP DEVELOPMENT AND MARKETING IN AGRICULTURAL PRODUCTION OF SENSITIVE GROUPS WHO ARE ENGAGED IN DEVELOPING AGRICULTURAL PRODUCTION AS AN EXAMPLE OF THE REPUBLIC OF SERBIA

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ABSTRACT:
The development and strengthening of entrepreneurship in agriculture, which can also include traditional crafts, which can have a high degree of hand-crafting, which are linked to functioning in agriculture.
In this way, it can contribute to the creation of new jobs, it can improve functioning in the field of production of healthy food and other inputs, the application of which will lead to stronger development and a better position of farmers and small processing plants in a country like the Republic of Serbia.
A substantial increase in the promotion of agricultural production can mean encouraging the development of already established entrepreneurial initiatives in agriculture, that is, increasing the promotion and education of farmers about the importance of processing and placing products with added value.
Vulnerable groups in the development of agriculture can have a strong support, such as groups that are responsible for the development and education of female farmers, but also women in rural areas, groups that are undergoing rehabilitation in the phase of recovery from drug use, mentally ill patients who, through engagement in agriculture, end up own treatment and other groups.

Keywords: management, accounting, analysis, risk factors, entrepreneurship in agriculture sensitive groups.

INTRODUCTION
The process of introducing and applying exploratory accounting should be a continuous process that is important in the functioning of agriculture, where marketing is becoming increasingly important both in agriculture and in the processing of agricultural products [1-5].
The goal of marketing in agriculture and its application is to improve managerial decision-making by top management in the management processes of agricultural enterprises and to use the numerous advantages of applying innovative accounting in various ways [6-9].
In this way, overall business results can be improved in the short term and should result in improving overall business in numerous heterogeneous enterprises, especially in production agricultural enterprises that apply marketing as a business strategy [10-15].
Marketing and innovative accounting and its application enable the improvement of overall management in a very short period of time, which is of great importance in agricultural

business, both in classical agriculture and in agriculture that operates in the work of vulnerable groups [16-20].

THE CONNECTION OF BUSINESS IN AGRICULTURAL ENTERPRISES AND THE MANAGEMENT DECISIONS OF THE TOP MANAGEMENT

An illustration of such management is given in Figure 1.

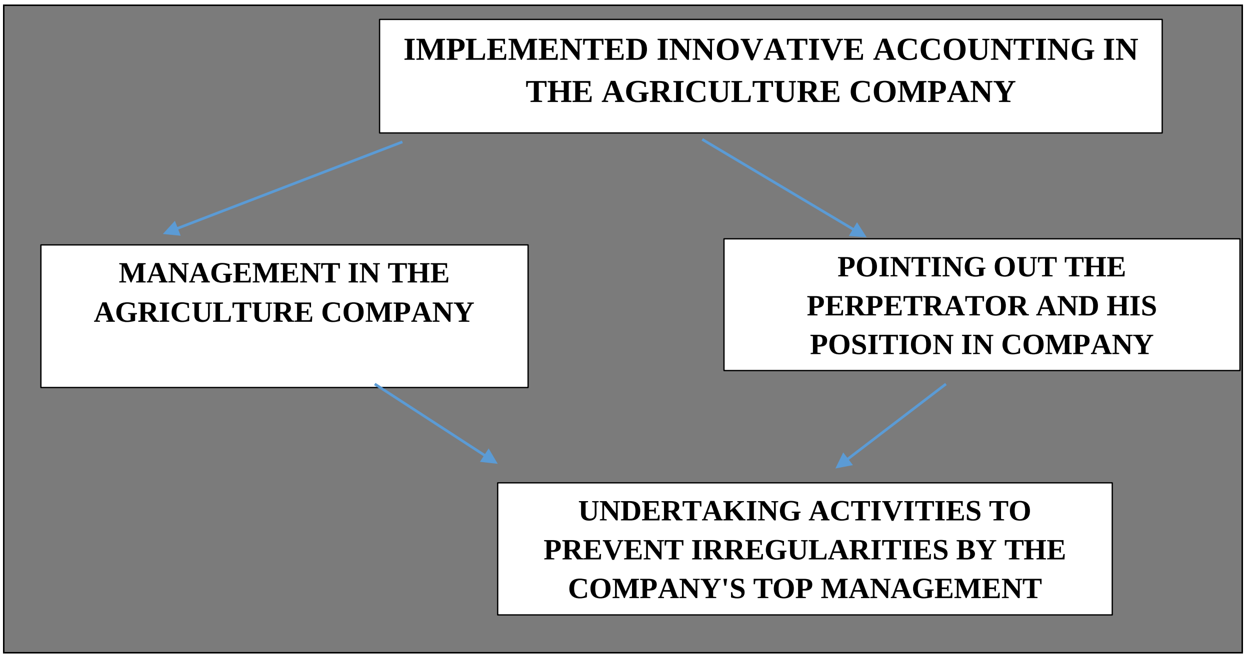

Figure: Presentation of the general setting of innovative accounting in the work of the agriculture company

INNOVATIVE ACCOUNTING IN THE WORK OF AGRICULTURAL COMPANIES THAT USE MARKETING IN THEIR WORK

Innovative accounting can provide significant positive results in the operations of numerous agricultural companies that use marketing in their work as a promotion of certain business segments.
An increasing number of private companies use innovative accounting in their regular operations. In addition to the above, forensic accounting prevents:
1. Economic crime in the company,
2. Reduces the number of frauds in the company.
3. Prevents the operation of companies with banking crime.
4. Prevents bankruptcy frauds,
5. Prevents significant frauds (for example, profit distribution),
6. Prevents multiple IT frauds and others.
7. It prevents unprofessional marketing of certain agricultural production.
8. It prevents excessive spending on the promotion of agricultural production.

CONCLUSION

The development and strengthening of entrepreneurship in agriculture with the application of traditional trades that continue to function in agriculture can also be observed through the influence of marketing. In this way, it can contribute to the creation of new jobs it can improve functioning in the field of production of healthy food and other inputs, the application of which will lead to stronger development and a better position of farmers and small processing plants in a transition country such as the Republic of Serbia. A substantial increase in the promotion of agricultural production can mean encouraging the development of already established entrepreneurial initiatives in agriculture.

References

[1] Bjelica, B., Bakmaz, O. & Vukasović, D. (2023). The importance of monitoring the realization of income and costs in the management and business of agricultural enterprises in relation to the introduced forms of internal-control mechanisms, Poljoprivredna tehnika, No. 2, 2023., 45 – 51, DOI: 10.5937/PoljTeh2302045B.
[2] Bakmaz, O., Milošević, M. & Marković, N. (2020). Poslovna Ekonomija, Business Economics, Regionalno planiranje-pojam, teorije i modeli, 2: 75-86, doi: 10.5937/poseko18-30482.
[3] Vitomir, J., Laban, B., Bakmaz, O., Nikolić, N., Čolović, M. (2019). Audit as a possible way to improve corporate governance with an overview of possible models of determining the risk interval and some of the basic impact factors identified by top management. Annals of the „Constantin Brâncuşi" University of Târgu Jiu, Economy Series, Issue 2/2019, ISSN 2344 – 3685/ISSN-L 1844 – 7007.
[4] Bakmaz, O., Bjelica, B., Ivić, Lj., Volf, D. & Majstorović, A. (2017). The significance of the audit profession in the financial analysis of agricultural enterprises of the Republic of Serbia. Annals of the „Constantin Brâncuşi" University of Târgu Jiu, Economy Series, pp. 117-123, ISSN 2344 – 3685/ISSN-L1844–7007.
[5] Radović, M., Vitomir, J., Laban, B., Jovin, S., Nastić, S., Popović, V. & Popović S. (2019). Management of joint stock companies and farms by using fair value of agricultural equipment in financial statements on the example of IMT 533 Tractor, Economics of Agriculture, 1: 35-50.
[6] Popović, S. (2014). Socio-ekonomski faktori ograničenja razvoja agrara, monografija, Fimek, Novi Sad.
[7] Popović, S., Novaković, S., Đuranović, D., Mijić, R., Grubliešić, Ž, Aničić, J. & Majstorović, A. (2017). Application of international accounting standard-16 in a public company with predominantly agricultural activities, Economic Research-Ekonomska Istraživanja, 30(1):1850–1864.
[8] Popović, S., Tošković, J., Majstorović, A., Brkanlić, S. & Katić, A. (2015). The importance of continuous audit of financial statements of the company of countries joining the EU, Annals of the „Constantin Brâncuşi" University of Târgu Jiu, Economy Series, Special Issue, 241-246.
[9] Radović, M., Vitomir, J. & Popović, S. (2021). Impact of internal control in enterprises founded by local self-government units: the case of Republic of Serbia, Inzinerine Ekonomika-Engineering Economics, 32(1): 82–90.
[10] Bjelica, B., Bakmaz, O., Mijić, R., Popović, S. & Popović, V. (2017). The implementation of heterogeneous risk to the company's operations and transition countries respecting the behavior of agricultural enterprises in the republic of Serbia. Annals of the „Constantin Brâncuşi" University of Târgu Jiu, Economy Series, 3/2017, 207-213, ISSN 2344 – 3685/ISSN-L 1844 –7007.

[11] Arnautović, I., Davidov, T., Nastić, S. & Popović, S. (2022). Značaj donošenja racionalne poslovne odluke top menadžmenta u poljoprivrednim preduzećima u Republici Srbiji, Poljoprivredna tehnika, 1-8.
[12] Majstorović, A. & Popović, S. (2015). Revizija poslovanja poljoprivrednog preduzeća, Računovodstvo, 1: 77-85.
[13] Tamas-Miškin, S., Vitomir, J., Dragosavac, M., Medan, N., Radaković, M., Vitomir, G., Davidov, T. & Popović, S. (2022). The significance of archiving documentation and assessment quality of archiving financial documentation given by top managers, Economics of Agriculture, Year 69, No. 4, 2022, (pp. 949-1252),
[14] Popović, S., Vitomir, J., Tomaš-Miskin, S., Davidov, T., Nastić., S., Popović, V., Popović, D., Vitomir, G. (2021). The importance of a realistically determined amount of tax on property rights relating to the ownership of agricultural land in the Republic of Serbia adopted by tax authorities of local selfgovernment units, Ekonomika poljoprivrede, Economics of agriculture, Vol.LXVIII, 4: 1029-1042.
[15] Popović, D., Vitomir, J., Tomaš-Miskin, S., Davidov, T., Popović, S., Jovanović, M., Aćimić-Remiković, M., Jovanović, S. (2021). Implementation of internal control with reference to the application of it in companies operating on the principles of the green economy. Agriculture & Forestry, Vol. 67 Issue 2: 261-269.
[16] Majstorović, A., Popović, S., Volf, D. (2015). Theory and politics of balance, second amended and supplemented edition, Novi Sad: Feljton.
[17] Popović, S. (2015). Implementacija heterogenih rizika u radu interne revizije, Revizor 69: 7-19.
[18] Bakmaz, O., Bjelica, B. & Vitomir, J. (2023). Application of internal audit in processes of reducing corruption in a transitional economy like the Republic of Serbia, Temel-IJ, 7:1, 36 - 42 https://doi.org/10.52576/TEMEL237.1036b
[19] Bakmaz, O., Bjelica, B. & Vitomir, J. (2023). Application of software solutions in companies that strive to achieve increased financial stability in their regular business, Temel-IJ, 7:1, 13 - 20 https://doi.org/10.52576/TEMEL237.1013b
[20] Bjelica, B., Bakmaz, O, & J. Vitomir, J. (2023). The importance of accounting policy in the context of strengthening financial stability in a company that previously implemented internal audit as a mechanism of regular business decision-making, Temel-IJ, 7:1, 57 - 63 https://doi.org/10.52576/TEMEL237.1013b

ÇÖREK OTU BİTKİSİNDE KULLANILA BİLECEK YENİ MARKIRLARIN DEĞERLENDİRİLMESİ

EVALUATION OF NEW MARKERS THAT CAN BE USED IN BLACK CUMIN PLANT

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ÖZET
Çörek otu bitkisi, Ranunculaceae familyasında bulunan önemli tıbbi aromatik bitkilerdendir. Orta Doğu'da ve yoğun olarak İran bölgesinde bazı hastalıklar için kullanılır. Önemli değere sahip tıbbi ve aromatik bitkilerin genetik kaynaklarının bilinmesi önem arz etmektedir. Popülasyonlarda genetik kaynakların karakterizasyonu hem gen kaynakların korunmasına hem de yapılacak olan ıslah çalışmaları için yardımcı olmaktadır. Günümüzde teknolojinin gelişmesi ile moleküler DNA markırları yoğun olarak kullanılmakta ve genetik kaynakların karakterize edilmesinde ön plana çıkmaktadır. Her ne kadar morfolojik veriler kullanılsa da çevre şartlarından etkilenmelerinden dolayı bir popülasyonu karakterize etmede yetersiz kalmakta ve yanıltıcı olabilirler. Fakat DNA moleküler markırları çevre şartları ve zamandan etkilenmediğinden daha doğru bilgiler vermekte ve daha kesin sonuçlara ulaşmaktadır. Çoğu tıbbi aromatik bitkiler içinde tam sekans verileri olmadığından sınırlı sayıda DNA markırları geliştirilebilmiştir. Yaptığımız bu çalışmada üniversal özellik gösteren minisatellit markırları ilk defa çörek otu bitkisinde çalışılmıştır. Elde edilen bulgular doğrultusunda çörek otu bitkisinin karekterize edilmesinde bu moleküler DNA markırlarının da kullanılabileceği sonucuna varılmıştır.
Anahtar Kelime: Minisatellit, Nigella sativa, Markır

ABSTRACT
The black cumin plant is one of the important medicinal and aromatic plants in the Ranunculaceae family. It is used for some diseases in the Middle East and intensively in Iran. It is important to know the genetic resources of valuable medicinal and aromatic plants. Characterization of genetic resources in populations helps both the protection of genetic resources and the breeding studies to be carried out. Today, with the development of technology, molecular DNA markers are used intensively and come to the forefront in characterizing genetic resources. Although morphological data are used, they are insufficient to characterize a population due to the effects of environmental conditions and can be misleading. However, since DNA molecular markers are not affected by environmental conditions and time, they provide more accurate information and reach more precise results. Since there is no complete sequence data for most medicinal and aromatic plants, a limited number of DNA markers could be developed. In this study, minisatellite markers showing universal properties were studied for the first time in the black cumin plant. In line with the findings obtained, it was concluded that these molecular DNA markers can also be used in characterizing the black cumin plant.
Keywords: Minisatellite, Nigella sativa, Marker

GİRİŞ

Ranunculaceae familyasına ait olan Çörek otu (Nigella sativa L.), içerdiği metabolitler nedeniyle önemli aromatik bitkilerden biridir. Bu bağlamda, bitkide bulunan etken maddeler sayesinde çeşitli hastalıklara (örn. dermatolojik komplikasyonlar, kanserler ve tip 2 diyabet) karşı kullanılmaktadır. Ayrıca, tohumları ve tohumda bulunan özleri geleneksel olarak bitkisel ilaç olarak kullanılmaktadır (Srinivasan 2018). Bu nedenle, çörek otu tamamlayıcı ve alternatif tıpta önemli bir aday olarak kabul edilmektedir (Yimer vd. 2019; Islam vd. 2019). Bunun dışında, çörek otu tohumları yenilebilir, fırıncılık ve peynir endüstrisinde lezzet için baharat olarak kullanılmaktadır (Bourgou vd. 2010). Çörek otu bitkisi yoğun olarak Güney Avrupa, Orta Doğu, Kuzey ve Doğu Afrika bölgelerinde yetiştirilmektedir (Srinivasan 2018). Çörek otu bitkisi içindeki önemli etken maddelerine rağmen çok bilinmediğinden bu bitki için moleküler çalışmalar oldukça sınırlıdır. Günümüzde moleküler markırlar, büyük veya küçük popülasyonlarda genetik çeşitlilik çalışmaları için yaygın olarak kullanılmaktadır. DNA parmak izi çalışmaları, belirli bir genotipe, taksona özgü DNA parçası, dizisi veya baz modifikasyonu olan DNA markırlarını kullanır.

DNA markırlarının bazı özellikleri, onları genetik ve genetik çeşitlilik çalışmalarında vazgeçilmez kılmaktadır; (i) tanımlama ve sınıflandırmada zorluklara neden olan ara morfolojilerin veya temel özelliklerin varlığına kıyasla belirsiz değildir, (ii) çevresel etkilere karşı etkilenmezler, (iii) organizmanın gelişiminden etkilenmezler, (iv) gen etkileşimine tabi değildir ve v) karakterizasyon için tür konusunda uzmanlık gerektirmezler. DNA markırlarının bu özellikleri, onları genetik çeşitlilik çalışmalarında en çok kullanılan araç haline getirmiştir (Morales, 2002; Thompson, 2002; Sostaric ve ark., 2012; Federici ve ark., 2013).

Çörek otu bitkisi ile ilgili moleküler karakterizasyonu RAPD (Random Amplified Polymorphic DNA), ISSR (Inter-Simple Sequence Repeat), SRAP (Sequence-Related Amplified Polymorphism) ve SCoT (Start Codon Targeted Polymorphism) belirteçleri gibi markır sistemleri ile gerçekleştirilmektedir (Al-Huqail ve Al-Saad 2010; Iqbal ve ark. 2011; Poyraz 2014; Birhanu ve ark. 2015; Neghab ve Panahi 2017; Mirzaei ve Mirzaghaderi 2017; KorehKhosravi ve ark. 2018; Golkar ve Nourbakhsh 2019). Bunun dışında Çelik ve Aydın (2023) yeni geliştirmiş oldukları SSR markırları bulunmaktadır. Minisatellitler, ökaryotik genomların tandem tekrarlı DNA bölgeleridir ve bunların çoğu tekrarlanan birim sayısındaki farklılıklar nedeniyle yüksek düzeyde allelik uzunluk varyasyonu göstermiştir (Jeffreys vd. 1985). Bu lokuslar, genetiğin birçok alanında yaygın olarak kullanılan oldukça bilgilendirici genetik markırlardır. Ayrıca minisatellit primerleri RAPD primerlerinden daha uzun olduğundan, bu markırlar ile yapılan PCR nispeten yüksek sıkılıktaki reaksiyonlar gerçekleştirdiğinden daha güvenilir olabilmektedir.

Moleküler düzeyde az çalışması bulunan çörek otu bitkisi için minisatellit markırlarının kullanımı bu bitki için alternatif ve uygulaması kolay bir markır tekniği olarak araştırıcılara yardımcı olması hedeflenmiştir.

MATERYAL VE METOT

Çalışmada Nigella sative türüne ait olan ve Türkiye'de tescil edilmiş olan Cameli çeşidi kullanılmıştır.

DNA İzolasyonu

Genomik DNA izolasyonu için cameli çeşidi viyolde tohumları yetiştirilerek gerçek yapraklarını çıkardıktan sonra steril şekilde toplanarak Aydın ve ark. (2018), DNA izolasyon protokolünde bazı değişiklikler yapılarak gerçekleştirilmiştir. Çıkarılan genomik DNA örnekleri, spektrofotometrik analiz ve agaroz jel elektroforezi kullanılarak analiz edilmiştir.

Polimeraz Zincir Reaksiyonu (PZR)

Çalışmada GeneAmp System 9700 termal döngü PZR cihazı (applied biosystems by Thermo Fisher Scientific) kullanılarak amplifikasyonların oluşumu gerçekleştirilmiştir. Reaksiyonlar, genomik DNA, primerler, 10x tamponu, $MgCl_2$, dNTP ve Taq DNA polimeraz enzimi içeren 25 µL'lik bir reaksiyon karışımından oluşan karışımdan oluşturulmuştur (Çizelge 1). Minisatellit PZR reaksiyonlarının özgüllüğünü artırmak için ise Çizelge 2'de gösterildiği gibi bir Touch-Down PZR kullanılarak hedef bölgeler çoğaltılmıştır.

Çizelge 1. TD-MS-RAPD için PZR reaksiyon karışımı

Kullanılan Kimyasallar		Stok	Miktar	Final
Genomik DNA			8.5 µl	100-120 ng
Steril-H2O			3.5 µl	
Primer		20 µM	3.0 µl	2.4 µM
Steril-H2O			4.6 µl	
10X Tampon Çözelti	TRIS-HCI (pH 9.1)	100 mM	3 µl	12 mM
	KCI	100 mM		60 mM
	Triton X-100	%0.1		%0.012
$MgCI_2$		50 mM	1.5 µl	3 mM
dNTP		10 mM	0.7 µl	0.28 mM
Taq DNA Polimeraz		5 ünite/ µl	0.2 µl	1 ünite
Toplam Hacim			25 µl	

Çizelge 2. TD-MS-RAPD-PCR profili

PZR Profili		**Zaman**	**Döngü Sayısı**	**Aşama**
Hot Start	94ºC	5 dk	1 döngü	Ön-denatürasyon
Ön PZR	94ºC	1 dk	10 döngü	Denatürasyon
	50ºC→45ºC	2 dk		Renatürasyon
	72ºC	2 dk		Sentez
PZR	94ºC	1 dk	30 döngü	Denatürasyon
	45ºC	2 dk		Renatürasyon
	72ºC	2 dk		Sentez
Final	72ºC	10 dk	1 döngü	Final Sentez
	4ºC	1 saat		

Çalışmada Kullanılan Minisatellit Primerleri

Çalışmada kullanılan minisatellit primer dizileri Karaca ve İnce (2008) çalışmalarında kullandıkları primer dizileri Macrogene firmasına sentezlettirilerek PZR çalışmalarında kullanılmıştır (Çizelge 3).

Çizelge 3. Minisatellit primer dizileri (Karaca ve İnce, 2008)

No	**Primer**	**5→3' dizi**
1	URP1F	ATCCAAGGTCCGAGACAACC
2	URP2F	GTGTGCGATCAGTTGCTGGG
3	URP2R	CCCAGCAACTGATCGCACAC
4	URP4R	AGGACTCGATAACAGGCTCC
5	URP6R	GGCAAGCTGGTGGGAGGTAC

6	URP9F	ATGTGTGCGATCAGTTGCTG
7	URP13R	TACATCGCAAGTGACACAGG
8	URP17R	AATGTGGGCAAGCTGGTGGT
9	URP25F	GATGTGTTCTTGGAGCCTGT
10	URP30F	GGACAAGAAGAGGATGTGGA
11	URP32F	TACACGTCTCGATCTACAGG
12	URP38F	AAGAGGCATTCTACCACCAC
13	FVIIEX8	ATGCACACACACAGG
14	FVIIEX8C	CCTGTGTGTGTGCAT
15	33.6	GGAGGTGGGCA
16	14C2	GGCAGGATTGAAGC
17	HBV3	GGTGAAGCACAGGTG
18	HBV5	GGTGTAGAGAGGGGT
19	M13	GAGGGTGGCGGCTCT
20	6.2H1	CCCTCCTCCTCCTTC
21	6.2H2	AGGAGGAGGGGAAGG
22	YNZ22	CTCTGGGTGTGGTGC

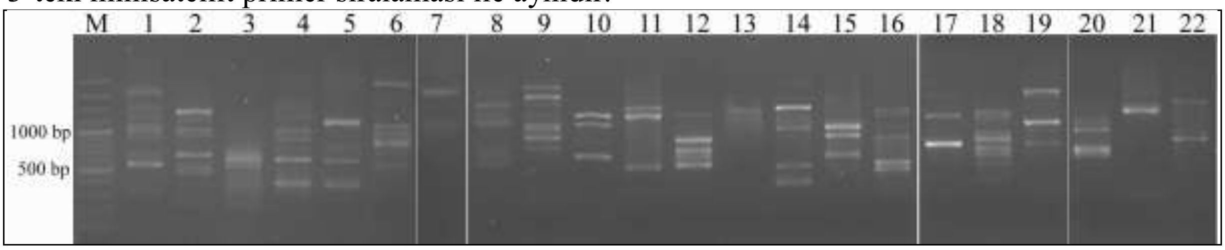
Agaroz Jel Elektroforezi

PZR deneyleri yapıldıktan sonra, her 25 µL PZR ürününe 5 µL 6x DNA yükleme tampon çözeltileri eklenmiş ve iyice karıştırılmıştır. Bu karışımlar, RedSafe içeren %2 yüksek çözünürlüklü agaroz jellere yüklendikten sonra 1x Tris Borate-EDTA tamponu varlığında 3 saat sabit voltajda 5 V/cm'de elektroforez yapılmış ve analiz için bir ultraviyole (UV) transillüminatör üzerinde fotoğraflanmıştır (Karaca ve ark., 2013).

BULGULAR VE TARTIŞMA

Çalışma kapsamında yetiştirilen çörek otu bitkisi gerçek yapraklarını çıkardıktan sonra yapraklar steril bir şekilte toparlanarak DNA izolasyonu Aydın ve ark. (2018)'e göre gerçekleştirilmiştir. Elde edilen genomik DNA NanoDrop ile A_{260}, A_{280} ve A_{280} okumaları gerçekleştirilmiş ve elde edilen genomik DNA'nın kalitesi/miktarı belirlenmiştir. Elde edilen NanoDrop okumalarında A_{260}/A_{280} değeri 1,871, A_{260}/A_{230} okuma değeri ise 1,124 olarak tespit edilmiştir. Araştırıcıların kaliteli DNA için nükleik asit okuması olan A_{260} ve protein okuması için olan A_{280} oranın 1,8 civarında olması gerektiği ve bu orandaki genomik DNA'nın kaliteli olduğunu rapor etmişlerdir (Karaca ve ark. 2005, Aydın ve ark. 2018). Fakat spektrofotometrik okumaların bir dezavantajı elde edilen nükleik asitin kırık olup olmadığı veya bir bütün halinde olduğu ile ilgili bilgi vermemektedir. Bundan dolayı da bunun tespit edilmesi için Jel elektoforez yöntemi kullanılmıştır. Elde edilen genomik DNA 500 nanogram (ng) olacak şekilde % 1'lik jelde 1 saat koşularak elde edilmiş olan genomik DNA'nın kırık olmadığı ve RNA'lardan arındırılmış olduğu saptanmıştır.

Kaliteli bir şekilde elde edilmiş olan genomik DNA Çizelge üçte belirtilen minisatellit primerleri ile Çizelge 1'deki konsantrasyonlar ve Çizelge 2'deki PZR profili ile amplikonla oluşturulmuştur. Elde edilen amplikonların görüntülenmesinde ise % 2'lik agaroz jelde yürütülmüş ve şekil 1'deki amplikonlar tespit edilmiştir. Jel üzerindeki numaralar Çizelge 3'teki minisatellit primer sıralaması ile aynıdır.



Şekil 1. Çörek otu bitkisinde taranan minisatellit primerlerinin jel görüntüsü

Agaroz jel görüntüsü incelendiğinde kullanılan 22 minisatellit primerininde çörek otu bitkisinde amplikon oluşturduğu gözlemlenmiştir. Sadece 13 numaradaki "FVIIEX8" minisatellit primerinin amplikonu net olarak ortaya koyulmamıştır. Fakat bu primer için PZR'de primer bağlanma sıcaklıklarında modifikasyonlar yapılarak çalıştırılabilir imkanı bulunmaktadır.

SONUÇ

Bu çalışmada Nigella sativa türünün Cameli çeşidi kullanılarak minisatellit primerleri taranmış ve çalışabilir oldukları tespit edilmiştir. Toplamda 22 primer kullanılmış ve kullanılan 22 primerin 21 tanesi belirtilen konsantrasyon ve PZR profilinde çalıştığı Şekil 1'deki jel görüntüsü ile teyit edilmiştir. Kullanılan primerler üniversal olmaları ve genom bilgisine ihtiyaç duymaması avantajları arasında bulunmaktadır. Ayrıca kullanılan bu markır tekniğinin ucuz olması gelişmekte olan ülkelerde kullanılabilirliği açısından avantaj sunmaktadır. Çörek otu bitkisi için ilk defa denenmiş olan bu primerler çörek otu bitkisinde moleküler karekterizasyon çalışmaları, haritalama çalışmaları, ıslah çalışmaları, morfolojik karakterler ile ilişkisi gibi çalışmalarda kullanılabilirliği ortaya konmuştur.

KAYNAKLAR

Al-Huqail A, Al-Saad F (2010) DNA fingerprinting and genotyping of four black seed (Nigella sativa L.) Taxa. J King Abdulaziz Univ Metrol Environ Arid Land Agric Sci 142(574):1–31

Aydin, A., Ince, A. G., Uygur Gocer, E., & Karaca, M. (2018). Single cotton seed DNA extraction without the use of enzymes and liquid nitrogen. Fresenius Environmental Bulletin, 27(10), 6722-6726.

Birhanu K, Tileye F, Yohannes P, Said M (2015) Molecular diversity study of black cumin (Nigella sativa L.) from Ethiopia as revealed by inter simple sequence repeat (ISSR) markers. Afr J Biotechnol 14(18):1543–1551.

Bourgou, S., Pichette, A., Marzouk, B., & Legault, J. (2010). Bioactivities of black cumin essential oil and its main terpenes from Tunisia. South African Journal of Botany, 76(2), 210-216.

Celik, I., Aydin, A. SSR mining of black cumin (Nigella sativa L.) transcriptome for molecular marker development. Genet Resour Crop Evol 70, 629–638 (2023).

Federici, S., Galimberti, A., Bartolucci, F., Bruni, I., Mattia, FD., Cortis, P., Labra, M. (2013). DNA Barcoding to Analyse Taxonomically Complex Groups in Plants: The Case of Thymus (Lamiaceae). Bot J Linn Soc 171: 687–699.

Golkar P, Nourbakhsh V (2019) Analysis of genetic diversity and population structure in Nigella sativa L. using agronomic traits and molecular markers (SRAP and SCoT). Ind Crop Prod 130:170–178.

Iqbal MS, Nadeem S, Mehboob S et al (2011) Exploration of genotype specific fingerprinting of Nigella sativa L. using RAPD markers. Turk J Agric for 35(6):569–578.

Islam, M. T., Khan, M. R., & Mishra, S. K. (2019). An updated literature-based review: Phytochemistry, pharmacology and therapeutic promises of Nigella sativa L. Oriental Pharmacy and Experimental Medicine, 19, 115-129.

Karaca, M., & Ince, A. G. (2008). Minisatellites as DNA markers to classify bermudagrasses (Cynodon spp.): confirmation of minisatellite in amplified products. Journal of Genetics, 87(1), 83.

Karaca, M., & Ince, A. G. (2008). Minisatellites as DNA markers to classify bermudagrasses (Cynodon spp.): confirmation of minisatellite in amplified products. Journal of Genetics, 87(1), 83.

combinations in multispectral imaging requires careful analysis to maximize information capture while minimizing data complexity (Lu et al., 2020).
Research efforts in this domain have focused on developing methodologies for identifying the most informative bands, leveraging machine learning, statistical techniques, and domain-specific knowledge. Effective band selection can enhance the performance of models used for crop classification, stress detection, and nutrient analysis (Aneece & Thenkabail, 2018). The integration of these advanced imaging techniques is essential for achieving sustainable and precise agricultural practices.
This paper explores the principles, methods, and applications of hyperspectral and multispectral band selection in agricultural research. It aims to provide a comprehensive overview of the current state of knowledge while highlighting the challenges and opportunities in this field. By addressing key questions related to band selection and optimization, this study seeks to contribute to the growing body of literature that supports the integration of advanced imaging technologies in agriculture.

Background and State of the Art

Hyperspectral and multispectral imaging technologies have revolutionized precision agriculture by enabling detailed analysis of vegetation health, crop type classification, and yield prediction. These technologies utilize spectral reflectance properties to identify specific characteristics of crops and their surrounding environment. Hyperspectral imaging, which captures data in hundreds of narrow and contiguous spectral bands, offers unparalleled precision in identifying subtle differences in vegetation reflectance. In contrast, multispectral imaging focuses on a smaller set of broader bands, making it computationally less intensive and more accessible for widespread agricultural use (Lu et al., 2020).
A critical aspect of these imaging systems is their ability to provide detailed insights into plant health and stress conditions. For instance, hyperspectral imaging has been used to distinguish crop types and growth stages, demonstrating superior accuracy compared to traditional multispectral approaches (Aneece & Thenkabail, 2018). This is primarily due to the high spectral resolution, which allows for the detection of unique spectral signatures associated with various crop conditions.
Despite their advantages, hyperspectral systems present challenges, including the high dimensionality of the data and computational costs associated with processing such large datasets. Effective band selection methods, such as principal component analysis (PCA) and feature correlation techniques, have been developed to address these issues, enabling researchers to extract the most relevant information while reducing data redundancy (Agilandeeswari et al., 2022).
Recent advancements in hyperspectral and multispectral imaging technology have also focused on improving sensor portability and affordability, making these systems more accessible for agricultural applications. Miniaturized hyperspectral sensors mounted on drones or satellites have significantly expanded the scope of precision farming, providing real-time monitoring capabilities over large agricultural fields (Bouyé & Tsamba, 2018).

Challenges in Band Selection and Optimization

Band selection in hyperspectral and multispectral imaging faces several challenges, primarily related to the high dimensionality of hyperspectral data and the redundancy among spectral bands. These issues, often referred to as the "curse of dimensionality," complicate data analysis and increase computational costs. Effective dimensionality reduction is essential to ensure the data remains manageable while preserving critical spectral information for accurate classification and prediction (Ye et al., 2021).

A key challenge is identifying bands that retain essential spectral characteristics while minimizing redundancy and noise. Traditional band selection methods often struggle with these competing objectives. Techniques such as multi-objective optimization and hybrid algorithms have been proposed to address these limitations, achieving a balance between reducing dimensionality and maintaining classification accuracy (Xu et al., 2017). Additionally, advanced algorithms like neighborhood rough set theory and evolutionary optimization have demonstrated potential in selecting the most informative spectral bands for agricultural applications (Liu et al., 2016; Du et al., 2013).

Another significant issue is the computational cost associated with analyzing hyperspectral data. Methods such as clustering and subspace decomposition have been employed to improve processing efficiency while maintaining the robustness of band selection. These approaches help reduce inter-band redundancy and enhance the discriminative power of selected bands for agricultural tasks, such as crop classification and stress detection (Wei et al., 2023; Xie et al., 2018).

Despite these advancements, challenges remain in creating universally applicable band selection methods. The highly variable spectral properties of different crops, environmental factors, and imaging conditions necessitate adaptive and context-specific solutions. Future research must focus on integrating machine learning and data-driven approaches to improve the flexibility and scalability of band selection techniques in agricultural contexts (Wang et al., 2020).

Methodologies for Band Selection

The methodologies for band selection in hyperspectral and multispectral imaging aim to address the challenges of dimensionality reduction, spectral redundancy, and computational efficiency while preserving the critical information necessary for agricultural applications. These methods can be broadly categorized into unsupervised, supervised, and hybrid approaches, each offering unique advantages depending on the application.

Unsupervised methods, such as clustering and low-rank modeling, focus on identifying distinct spectral bands by analyzing data distribution and inter-band correlations. For example, clustering-based approaches combined with single-layer neural networks have been shown to effectively reduce dimensionality while retaining critical agricultural information (Habermann et al., 2018). Similarly, low-rank representation methods have been proposed to minimize spectral redundancy and enhance classification accuracy (Yu et al., 2018).

Supervised methodologies utilize labeled datasets to guide band selection based on classification performance. Techniques like Random Forest and genetic algorithms have demonstrated strong performance in identifying the most informative bands. For instance, genetic algorithms have been employed to optimize classification accuracy while minimizing the number of selected bands, providing a balance between efficiency and effectiveness (Wen et al., 2016).

Hybrid methods combine unsupervised and supervised approaches to leverage the strengths of both techniques. A notable example is the integration of entropy-based unsupervised ranking followed by regression tree analysis, which has been used to enhance classification accuracy and manage computational requirements in hyperspectral imaging (Bajcsy & Groves, 2004).

Multi-objective optimization algorithms represent a significant advancement in band selection, addressing multiple criteria such as class separability, spectral uniqueness, and computational complexity simultaneously. Approaches like the firefly algorithm and multimodal evolutionary algorithms have proven effective in agricultural applications, demonstrating the ability to reduce data dimensionality while maintaining high classification accuracy (Su et al., 2014; Wei et al., 2023).

Applications in Agriculture

Band selection in hyperspectral and multispectral imaging plays a crucial role in advancing agricultural applications by enhancing the accuracy and efficiency of remote sensing tasks. These tasks include crop classification, disease detection, yield estimation, and soil property assessment. Effective band selection enables the identification of relevant spectral bands while reducing data redundancy and computational complexity.

One prominent application is crop classification, where specific spectral bands are utilized to differentiate between crop types and growth stages. Studies have shown that by eliminating redundant bands, hyperspectral imaging systems can achieve high classification accuracy, particularly in distinguishing between crops such as wheat and oats (Kaiser & Duchesne-Onoro, 2017). Advanced methodologies like binary-coded optimization algorithms further enhance classification capabilities by selecting optimal spectral subsets (Ye et al., 2021).

Disease detection in crops is another critical application. Hyperspectral imaging can detect subtle changes in vegetation reflectance caused by stress or disease. The use of metrics such as NDVI and entropy in band selection has been shown to improve the sensitivity of disease detection models (Agilandeeswari et al., 2022). These methods not only enhance the detection accuracy but also make it feasible to monitor large agricultural areas efficiently.

Yield estimation relies heavily on selecting bands that capture crop health and growth conditions accurately. Methods like Principal Component Analysis (PCA) and rank minimization have been instrumental in identifying critical bands that contribute to yield prediction models, reducing unnecessary data while retaining valuable spectral information (Zhu et al., 2017).

Soil property analysis also benefits from optimized band selection. Multispectral systems, in particular, can use selected bands to assess soil moisture, nutrient content, and organic matter. Parallel processing techniques further improve the efficiency of band selection, enabling real-time soil analysis (Yang & Du, 2009).

Overall, the strategic application of band selection methods in agriculture not only enhances data analysis but also supports sustainable farming practices by providing actionable insights into crop and soil health.

Technological Advancements

Recent advancements in hyperspectral and multispectral imaging have revolutionized their applications in agriculture, making these technologies more accessible, efficient, and versatile. Innovations in sensor design, data acquisition, and image processing have addressed many of the limitations previously faced in precision agriculture.

One of the most notable advancements is the development of portable and cost-effective hyperspectral sensors, which are now increasingly integrated into drones and robotics for field applications. These systems enable high-resolution, real-time data acquisition, significantly enhancing crop monitoring and management (Bouyé & Tsamba, 2018). The incorporation of liquid crystal tunable filters into hyperspectral systems has also allowed rapid and precise spectral imaging, suitable for both crop assessment and quality control of agricultural products (Mao & Heitschmidt, 1999).

Another breakthrough is the advent of snapshot hyperspectral imaging, which eliminates the need for scanning mechanisms and supports video-rate acquisition of three-dimensional spectral datacubes. This innovation is particularly beneficial for dynamic agricultural environments, where real-time monitoring of crop health and growth is critical (Bodkin et al., 2009).

Recent advances in image processing techniques have further bolstered the efficiency of hyperspectral data analysis. Algorithms that integrate active optical mapping and compressive sensing are now capable of reducing the computational burden of high-dimensional data while maintaining accuracy. These technologies enhance the usability of hyperspectral imaging in analyzing soil properties, detecting plant stress, and monitoring crop diseases (Park et al., 2021; Azari et al., 2016).

Moreover, non-scanning hyperspectral imaging systems, such as those using liquid crystal and light-field imaging, are increasingly used in precision farming. These systems allow detailed analysis of spatial and spectral variations, aiding in tasks ranging from crop classification to nutrient management (Jung et al., 2018).

These advancements collectively represent a significant step towards integrating hyperspectral and multispectral imaging into mainstream agricultural practices, paving the way for more sustainable and precise farming systems.

Future Directions and Opportunities

The future of hyperspectral and multispectral imaging in agriculture is marked by technological advancements, integration with new tools, and exploration of innovative applications. These directions aim to further enhance precision, efficiency, and sustainability in agricultural practices.

A key area of development lies in the miniaturization and affordability of imaging systems, which are increasingly integrated into drones and portable devices. These advancements facilitate real-time monitoring of large-scale agricultural fields, enabling farmers to assess crop health and soil properties with unprecedented accuracy (Jung et al., 2018). The deployment of spaceborne hyperspectral sensors is another promising direction, offering the potential for global agricultural monitoring and management (Lu et al., 2020).

Novel imaging techniques such as the fusion of hyperspectral and multispectral data are being explored to address the limitations of each approach. These hybrid systems promise to improve both spectral and spatial resolution, thereby enhancing applications in crop classification, disease detection, and yield estimation (Chakravortty & Subramaniam, 2014).

The integration of artificial intelligence and machine learning with hyperspectral and multispectral imaging is another promising frontier. These technologies are being leveraged to process vast amounts of data efficiently, identify complex patterns, and make predictive analyses in agriculture (Lei et al., 2021). For instance, deep learning methods are being applied to detect subtle variations in crop health and optimize resource use.

Additionally, advancements in 3D imaging technologies, such as light-field cameras and handheld systems, are opening up new possibilities for agricultural imaging. These systems can capture multi-dimensional data, providing detailed insights into plant structure and function, which are critical for precision farming (Robles-Kelly et al., 2018).

Finally, sustainable agriculture is expected to benefit significantly from these innovations. Hyperspectral imaging can support better water and nutrient management, reduce waste, and minimize environmental impact, aligning with the global push for sustainable food production (Maldonado et al., 2018).

Conclusion

Hyperspectral and multispectral imaging technologies have emerged as transformative tools in agriculture, offering unparalleled capabilities for monitoring crop health, detecting diseases, and optimizing resource utilization. By capturing rich spectral data, these technologies provide a deeper understanding of agricultural systems, enabling more precise and sustainable farming practices.

The challenges associated with high-dimensional data, such as spectral redundancy and computational inefficiencies, are being addressed through advanced methodologies like band

selection, machine learning integration, and hybrid imaging systems. These approaches ensure that the most relevant spectral information is retained while minimizing data complexity, enhancing the practical utility of these technologies in diverse agricultural applications.
Recent technological advancements, including portable sensors, drone-mounted systems, and real-time image processing, are paving the way for broader adoption of hyperspectral and multispectral imaging. Future developments in 3D imaging, data fusion, and artificial intelligence promise to unlock new applications, from yield prediction and soil analysis to precision irrigation and pest management.
As agriculture faces growing demands for efficiency and sustainability, hyperspectral and multispectral imaging are poised to play a central role in the transformation of this sector. Continued research and innovation will be essential to overcome existing limitations and fully harness the potential of these technologies, ensuring their integration into global efforts toward sustainable food production and environmental stewardship.

References

Agilandeeswari, L., Prabukumar, M., Radhesyam, V., Kumar, L. N. B. P., & Farhan, A. (2022). Crop Classification for Agricultural Applications in Hyperspectral Remote Sensing Images. Applied Sciences, 12(3), 1670. https://dx.doi.org/10.3390/app12031670

Aneece, I., & Thenkabail, P. (2018). Accuracies Achieved in Classifying Five Leading World Crop Types and Their Growth Stages Using Optimal Earth Observing-1 Hyperion Hyperspectral Narrowbands on Google Earth Engine. Remote Sensing, 10(12), 2027. https://dx.doi.org/10.3390/RS10122027

Bouyé, C., & Tsamba, C. (2018). Opportunities for Hyperspectral and Multispectral Imaging. Optics & Photonics News. https://dx.doi.org/10.1002/opph.201870408

Bouyé, C., & Tsamba, C. (2018). Opportunities for Hyperspectral and Multispectral Imaging. Optics & Photonics News. https://dx.doi.org/10.1002/opph.201870408

Lu, B., Dao, P. D., Liu, J., He, Y., & Shang, J. (2020). Recent Advances of Hyperspectral Imaging Technology and Applications in Agriculture. Remote Sensing, 12(16), 2659. https://dx.doi.org/10.3390/rs12162659

Du, Q., Zhou, A., Liu, C., & Zhang, G. (2013). Hyperspectral band selection based on evolutionary optimization. International Conference on Natural Computation. https://dx.doi.org/10.1109/ICNC.2013.6818073

Liu, Y., Xie, H., Tan, K., Chen, Y., Xu, Z., & Wang, L. (2016). Hyperspectral band selection based on consistency-measure of neighborhood rough set theory. Measurement Science and Technology, 27(5), 055501. https://dx.doi.org/10.1088/0957-0233/27/5/055501

Wang, Z., Zhao, Y., He, B., & Wang, H. (2020). A multi-criteria band selection method of hyperspectral images. Journal of Physics: Conference Series, 1651(1), 012147. https://dx.doi.org/10.1088/1742-6596/1651/1/012147

Wei, Y., Hu, H., Xu, H., & Mao, X. (2023). Unsupervised hyperspectral band selection via multimodal evolutionary algorithm and subspace decomposition. Sensors, 23(4), 2129. https://dx.doi.org/10.3390/s23042129

Xie, F., Li, F., Lei, C., & Ke, L. (2018). Representative band selection for hyperspectral image classification. International Journal of Geo-Information, 7(9), 338. https://dx.doi.org/10.3390/ijgi7090338

Xu, X., Shi, Z., & Pan, B. (2017). A new unsupervised hyperspectral band selection method based on multiobjective optimization. IEEE Geoscience and Remote Sensing Letters, 14(11), 2027–2031. https://dx.doi.org/10.1109/LGRS.2017.2753237

Ye, Z., Liu, S., Zong, X., Shu, Z., & Xia, X. (2021). A band selection method for hyperspectral image based on binary coded hybrid rice optimization algorithm. 11th IEEE

International Conference on Intelligent Data Acquisition and Advanced Computing Systems. https://dx.doi.org/10.1109/IDAACS53288.2021.9661017

Bajcsy, P., & Groves, P. (2004). Methodology For Hyperspectral Band Selection. Photogrammetric Engineering & Remote Sensing, 70(7), 793-802. https://dx.doi.org/10.14358/PERS.70.7.793

Habermann, M., Fremont, V., & Shiguemori, E. H. (2018). Unsupervised Hyperspectral Band Selection using Clustering and Single-Layer Neural Network. Research in Remote Sensing and Photogrammetry, 18(9), 327-334. https://dx.doi.org/10.52638/rfpt.2018.419

Su, H., Li, Q., & Du, P. (2014). Hyperspectral Band Selection Using Firefly Algorithm. Workshop on Hyperspectral Image and Signal Processing: Evolution in Remote Sensing (WHISPERS). https://dx.doi.org/10.1109/WHISPERS.2014.8077609

Wei, Y., Hu, H., Xu, H., & Mao, X. (2023). Unsupervised Hyperspectral Band Selection via Multimodal Evolutionary Algorithm and Subspace Decomposition. Sensors, 23(4), 2129. https://dx.doi.org/10.3390/s23042129

Wen, G., Zhang, C., Lin, Z., & Xu, Y. (2016). Band selection based on genetic algorithms for classification of hyperspectral data. International Conference on Image and Signal Processing. https://dx.doi.org/10.1109/CISP-BMEI.2016.7852892

Yu, C., Cen, K., Chang, C.-I., & Li, F. (2018). Unsupervised Hyperspectral Band Selection Method Based on Low-Rank Representation. Advanced Signal Processing Applications, 6(2), 249-255. https://dx.doi.org/10.1007/978-981-13-6264-4_124

Agilandeeswari, L., Prabukumar, M., Radhesyam, V., Boggavarapu, K. L. N. P., & Farhan, A. (2022). Crop Classification for Agricultural Applications in Hyperspectral Remote Sensing Images. Applied Sciences, 12(3), 1670. https://dx.doi.org/10.3390/app12031670

Kaiser, A., & Duchesne-Onoro, R. (2017). Discrimination of Wheat and Oat Crops Using Field Hyperspectral Remote Sensing. Proceedings of SPIE, 10427, 104270L. https://dx.doi.org/10.1117/12.2266219

Yang, H., & Du, Q. (2009). Unsupervised Hyperspectral Band Selection Using Parallel Processing. IEEE International Geoscience and Remote Sensing Symposium (IGARSS). https://dx.doi.org/10.1109/IGARSS.2009.5417727

Ye, Z., Liu, S., Zong, X., Shu, Z., & Xia, X. (2021). A Band Selection Method for Hyperspectral Image Based on Binary Coded Hybrid Rice Optimization Algorithm. 11th IEEE International Conference on Intelligent Data Acquisition and Advanced Computing Systems. https://dx.doi.org/10.1109/IDAACS53288.2021.9661017

Zhu, G., Huang, Y., Li, S., Tang, J., & Liang, D. (2017). Hyperspectral Band Selection via Rank Minimization. IEEE Geoscience and Remote Sensing Letters, 14(10), 1829-1833. https://dx.doi.org/10.1109/LGRS.2017.2763183

Azari, M., Habibi, N., Abolbashari, M., & Farahi, F. (2016). Hyperspectral scanning white light interferometry based on compressive imaging. Proceedings of SPIE, 9934, 99340H. https://dx.doi.org/10.1117/12.2213101

Bodkin, A., Sheinis, A., Norton, A., Daly, J., Beaven, S., & Weinheimer, J. (2009). Snapshot hyperspectral imaging: the hyperpixel array camera. Proceedings of SPIE, 7334, 733402. https://dx.doi.org/10.1117/12.818929

Bouyé, C., & Tsamba, C. (2018). Opportunities for Hyperspectral and Multispectral Imaging. Optics & Photonics News. https://dx.doi.org/10.1002/opph.201870408

Jung, A., Michels, R., & Graser, R. (2018). Portable snapshot spectral imaging for agriculture. Acta Agraria Debreceniensis, 150, 23-31. https://dx.doi.org/10.34101/ACTAAGRAR/150/1718

Mao, C., & Heitschmidt, J. (1999). Hyperspectral imaging with liquid-crystal tunable filter for biological and agricultural assessment. Proceedings of SPIE, 3606, 199-207. https://dx.doi.org/10.1117/12.336879

Park, J., Feng, X., Liang, R., & Gao, L. (2021). Active optical mapping for high-speed and hyperspectral imaging. Proceedings of IEEE Photonics Conference. https://dx.doi.org/10.1109/IPC48725.2021.9593012

Chakravortty, S., & Subramaniam, P. (2014). Fusion of Hyperspectral and Multispectral Image Data for Enhancement of Spectral and Spatial Resolution. ISPRS Archives, 40, 1099–1105. https://dx.doi.org/10.5194/ISPRSARCHIVES-XL-8-1099-2014

Jung, A., Michels, R., & Graser, R. (2018). Portable Snapshot Spectral Imaging for Agriculture. Acta Agraria Debreceniensis, 150, 23–31. https://dx.doi.org/10.34101/ACTAAGRAR/150/1718

Lei, Y., Guo, Y., Pu, M., He, Q., Gao, P., Li, X., Ma, X., & Luo, X. (2021). Multispectral Scattering Imaging Based on Metasurface Diffuser and Deep Learning. Physica Status Solidi (RRL) - Rapid Research Letters, 15(11), 2100469. https://dx.doi.org/10.1002/pssr.202100469

Lu, B., Dao, P. D., Liu, J., He, Y., & Shang, J. (2020). Recent Advances of Hyperspectral Imaging Technology and Applications in Agriculture. Remote Sensing, 12(16), 2659. https://dx.doi.org/10.3390/rs12162659

Maldonado, A. I. L., Fuentes, H., & Vidales Contreras, J. A. (2018). Hyperspectral Imaging in Agriculture, Food and Environment. IntechOpen. https://dx.doi.org/10.5772/INTECHOPEN.70213

Robles-Kelly, A., Wei, R., & You, S. (2018). A Multispectral Light Field Camera for 3D Imaging from a Single Lens. OSA Technical Digest (online). https://dx.doi.org/10.1364/3D.2018.JW5E.1

SÜRDÜRÜLEBİLİR MUTFAK İÇİN KATMA DEĞERLİ ÜRÜNLERİN KULLANIMI

USE OF VALUE-ADDED PRODUCTS FOR SUSTAINABLE CUISINE

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ÖZET

Günümüzün mutfak anlayışında sunumun ön plana çıkmasında ve mutfakta pratik çözümlerin geliştirilmesinde katma değeri yüksek ürünlerin kullanımını önemli rol oynamaktadır. Özellikle meyve- sebze atıklarının mutfağa kazandırılması, yeni sunum şekillerinin tasarlanması (köpük, tüil), yeni ürünlerin üretilmesi (sirke, baharat, uçucu yağlar) gıda israfının önlenmesi, atıkların ekonomik değere dönüştürülmesi oldukça kritiktir.
Çöpe atılan meyve- sebze kabukları (soğan, narenciye vb.) birçok karakteristik özelliklere sahiptir. Bunların başında; antosiyaninler (siyanidin, delfinidin, malvidin vb.), çeşitli fitokimyasallar (fenolikler, organik asitler, şekerler, pigmentler), kıvam arttırıcılar (pektin), antioksidan ve antimikrobiyal bileşikler (esansiyel yağlar) gelmektedir. Katma değerleri ürünler çeşitli mutfak türlerinin şekillenmesine de katkı sağlamaktadır. Özellikle moleküler mutfakta ürünlerin dokusunu, besin değerini, görsel gücünü arttırmaktadır. Meyve sularının su yerine jel veya kapsül olarak sunulabilmesi, kabukların farklı dekor süslemeleri eşliğinde kullanılması örnek olarak verilebilir. Bu çalışmada katma değerli ürünlerin mutfaklarda verimli etkin kullanımına yönelik uygulamaların önemi değerlendirilmiştir. Bu doğrultuda elde edilecek ürünler gastronomi dünyasına yeni deneyimler sunacaktır.
Anahtar Kelimeler: Meyve-sebze atıkları, moleküler mutfak, sürdürülebilir mutfak

ABSTRACT

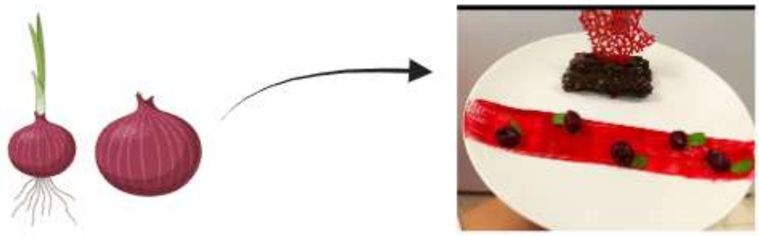
The use of high value-added products plays an important role in the development of practical applications in the kitchen as presentation comes to the fore in today's culinary concept. Especially contributing fruit and vegetable wastes into the cuisine, designing new forms of presentation (foam, tuile), producing new products (vinegar, spices, essential oils), preventing food waste and transforming wastes into economic value are very critical. Waste fruit and vegetable peels (onion, citrus, etc.) have many characteristic properties. These are anthocyanins (cyanidin, delphinidin, malvidin etc.), various phytochemicals (phenolics, organic acids, sugars, pigments), thickeners (pectin), antioxidant and antimicrobial compounds (essential oils). Value-added products also contribute to the shaping of various types of cuisine. Especially in molecular cuisine, it increases the texture, nutritional value and visual power of the products. For example, fruit juices can be presented as gel or capsule instead of water, and shells can be used with different decor decorations. In this study, the importance of applications for the efficient and effective use of value-added products in kitchens was evaluated. The products to be obtained in this direction will offer new experiences to the gastronomy world.
Keywords: Fruit and vegetable waste, molecular cuisine, sustainable cuisine

GİRİŞ

Meyve-sebze kabukları, hayvansal yan ürünler, meyve-sebze suları, bitki ekstraktları, bitki esansiyel yağları gıda proses sürecinde açığa çıkan önemli yan ürünlerdendir. Bunların çoğu genellikle atık olarak değerlendirilmekte ya da doğrudan doğaya atılarak çevre kirliliğine neden olmaktadır (Yağcı ve ark., 2006). Bu durum ekolojik döngü içerisinde zaman, iş gücü, enerji ve maddi kaynakların israfına yol açmaktadır (Çirişoğlu & Akoğlu, 2021). Gıda atıklarındaki fenolik bileşiklerin, uçucu yağların, renk pigmentlerinin, antioksidan ve antimikrobiyal özellikteki etken maddelerin etkili bir şekilde kullanılması ve katma değerli ürün haline dönüştürülmesi oldukça kritiktir (Bayaz, 2014). Mutfaklar, katma değerli ürünlerin değerlendirilmesi noktasında kullanılabilecek alanlardandır (Çirişoğlu & Akoğlu, 2021). Özellikle moleküler mutfak sürdürülebilirlik ve atık değerlendirmesi konusunda atık niteliğindeki malzemeleri etkin bir şekilde kullanarak yenilikçi sunum ve lezzetlerin açığa çıkarılmasına olanak sağlar (G. Çalışkan & Yıldırım, 2021). Bu çalışmadaki amaç atıkların katma değerli ürünlere dönüştürülerek mutfak alanında kullanılabilir ürünlere dönüştürülmesi mutfak ekonomisine etkili bir fayda sağlayacağı ön görülmektedir. Aynı zamanda atıkların ve gıda yan ürünlerinin katma değerli bir şekilde işlenmesi ve yalnızca lezzet odaklı değil, çevreye duyarlı bir hale getirilerek mutfakta sürdürülebilirliğini sağlamaktır.

MUTFAKTA GIDA ATIKLARI VE YAN ÜRÜNLERİN DEĞERLENDİRİLMESİ

Kiraz sapı, soğan kabukları, mısır püskülü, turunç kabukları vb. bitkisel orjinli atıklar katma değerli ürünler kapsamında değerlendirilmektedir (Yaman, 2012). Yemeklerin ve salataların malzemelerinden biri olan soğanların kabuk kısımları atık olarak çöpe atılmaktadır. Soğan kabuklarında bol miktarda biyoaktif bileşikler (ferulik asit, kuersetin, kumarik asit vb.) flavonoidler, kükürt bileşikleri bulunmaktadır (Hepsağ & Esmer, 2022). Katma değerli ürünler bakımından soğan ekstraksiyon işlemine tutularak doğal gıda boyası elde edilebilmektedir. Soğan kabuklarından tüil üretilmekte ve sunum tekniğinde dekor amaçlı tercih edilebilmektedir (Şekil 1).

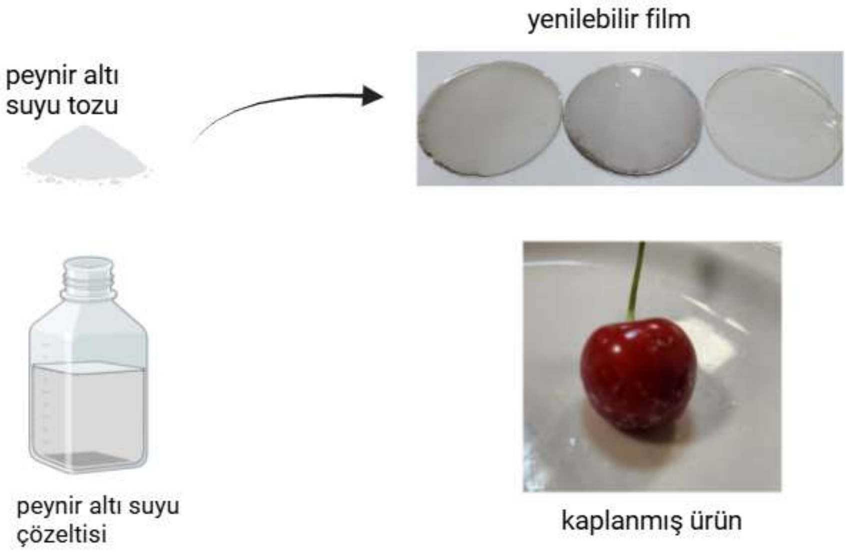


Şekil 1. Soğan kabuklarından tüil eldesi

Meyve-sebzeler, karotenoidler, yağ asitleri, flavonoidler, izoflavonlar, izosiyanatlar, fenolik asitler, polifenoller, lignanlar bakımından zengin biyoaktif bileşenlere sahiptirler (Karadağ ve ark., 2022). Moleküler mutfak kapsamında farklı meyve suları kullanılarak yapay havyar üretilmektedir (Şekil 2). Havyarın (balık yumurtası) besleyicilik (lipid, protein) özelliği oldukça yüksektir (Özden ve ark., 2018). Bu doğrultuda havyarın lezzet ve besin değerinin yanı sıra farklı bir bakış kazandırarak tabağa yansıtılması ele alınmıştır.

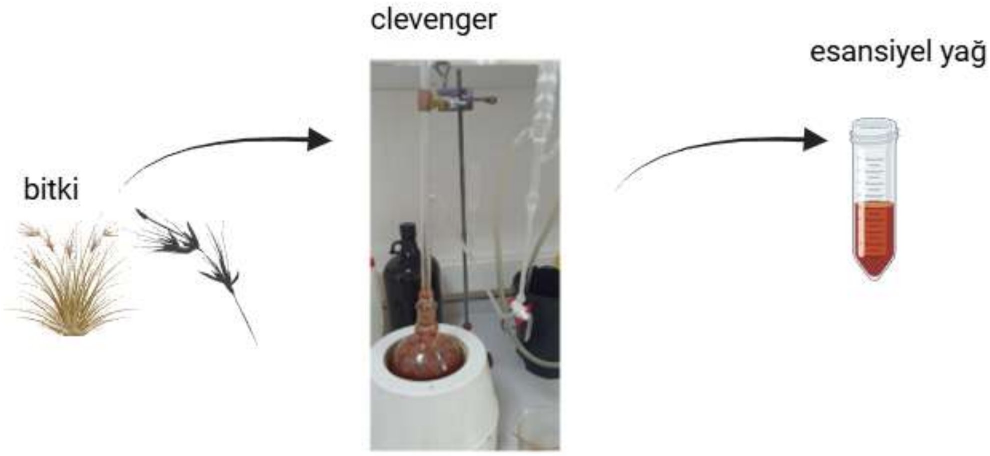
Şekil 2. Meyve sularından yapay havyar yapımı

Peynir altı suyu, süt sanayisinin değerli yan ürünlerindendir. Yapısındaki organik bileşiklerin kaybedilmeden farklı alternatif ürünlere dönüştürülmesi oldukça kritiktir. Atık olarak kullanılan peynir altı suyu hem doğa hem de canlılar için tehdit unsuruna dönüşebilmektedir. Bu bağlamda bu tarz yan ürünlerin geri dönüştürülebilmeleri gerekmektedir (Yüksel ve ark., 2020). Geri dönüştürülebilmeleri noktasında içerdiği yüksek protein oranından faydalanılarak ambalaj teknolojisinde yenilebilir film ve kaplama materyali olarak kullanılmaktadır (Di Pierro ve ark., 2018). Bunun yanı sıra ambalaj materyali içerisine ilave edilen esansiyel bitki yağları ile antimikrobiyal ve antioksidan özellik kazanılabildiği gibi, soğan kabukları, kırmızı lahana vb. gibi ürünlerden elde edilen doğal renk özellikleri ile de bozulma indikatörü (gösterge) olarak kullanılabilmektedir (Kandasamy ve ark., 2021; Kavrut, 2022, 2024). (Şekil 3).



Şekil 3. Peynir altı suyundan film ve kaplama (ürün uygulaması)

Bitkiler, mutfakta uçucu esansiyel yağları çıkartılabildiği aynı zamanda toz haline getirilerek baharat amaçlı yemeklerde kullanılabilmektedir (Kavrut & Sezer, 2024). Örneğin sumak, kekik, biberiye, karanfil, tarçın gibi bitkiler bu amaçla en çok tercih edilen bitkiler arasındadır (Akay ve ark., 2023)(Şekil 4).



Şekil 4. Clevenger ile esansiyel yağ eldesi

SONUÇ

Bu çalışma, katma değerli ürünler kapsamında meyve-sebze atıkları, gıda yan ürünlerinin katma değerli ürünler kapsamında değerlendirilerek mutfaklarda kullanımına ve mutfak sürdürülebilirliği üzerindeki etkisine odaklanılmıştır. Katma değerli ürünlerin mutfakta kullanımı, özellikle yapılan yemeklerin albenisinin arttırılması, tabak süslemelerinin geliştirilmesi açısından büyük fırsatlar sunmaktadır. Ayrıca, yapılan çalışmalara farklı dokunuşlar ile estetik değerler kazandırılabilmektedir. Gıdaların besinsel içeriklerinin yanı sıra kabuk kısımlarının ve tüketilmeyen parçalarının değerlendirilmesi, başta mutfak ekonomisine, ekolojik döngüye, israfın minimize edilmesine yardımcı olmaktadır. Bu tarz çalışmalar yapılacak yeni çalışmaların arttırılması için mutfaktaki sürdürülebilirlik çabalarına önemli katkılar sağlayabilir.

KAYNAKLAR

Akay, E., Yılmaz, İ., & Eyioğlu, U. (2023). Sumak (Rhus coriaria L.) Bitkisinin Fitoterapide Kullanımı ve Gastronomik Değeri. Journal of Academic Tourism Studies, 4(1), 56–65.

Bayaz, M. (2014). Esansiyel yağlar: antimikrobiyal, antioksidan ve antimutajenik aktiviteleri. Akademik Gıda, 12(3), 45–53.

Çalışkan, G., & Yıldırım, G. (2021). Geleceğin Restoranlarında Menü (G. , Y. G. Çalışkan, Ed.). Detay Yayıncılık.

Çirişoğlu, E., & Akoğlu, A. (2021). Restoranlarda oluşan gıda atıkları ve yönetimi: İstanbul ili örneği. Akademik Gıda, 19(1), 38–48.

Di Pierro, P., Mariniello, L., Giosafatto, V. L., Esposito, M., Sabbah, M., & Porta, R. (2018). Dairy whey protein-based edible films and coatings for food preservation. In Food packaging and preservation (pp. 439–456). Elsevier.

Hepsağ, F., & Esmer, B. (2022). Soğan (Allium Cepa L.) Kabukları: Biyoaktif Bileşikleri, Geri Dönüşümle Elde Edilen Ürünleri ve Değerlendirme Yöntemleri. ADYUTAYAM Dergisi, 10(2), 175–185.

Kandasamy, S., Yoo, J., Yun, J., Kang, H.-B., Seol, K.-H., Kim, H.-W., & Ham, J.-S. (2021). Application of whey protein-based edible films and coatings in food industries: An updated overview. Coatings, 11(9), 1056.

Karadağ, G., Karaman, A. D., & Öğüt, S. (2022). Meyve ve sebzelerde bulunan biyoaktif bileşenlerin sağlık üzerine etkileri. Toros University Journal of Food, Nutrition and Gastronomy, 1(1), 77–90.

Kavrut, E. (2022). Hazır köftelerde yenilebilir film ambalajlamanın Escherichia coli O157: H7 üzerine antimikrobiyal etkisi, Kafkas Universitesi, Doktora Tezi.
Kavrut, E. (2024). Production of pH-Sensitive Natural Decomposition Indicator With Whey Protein Isolate-Based Edible Film to Monitor Fish Freshness. Latin American Applied Research, 54(2), 247–252.
Kavrut, E., & Sezer, Ç. (2024). The antimicrobial effect of edible film packaging in instant meatballs on Escherichia coli O157: H7. Journal of the Hellenic Veterinary Medical Society, 75(1), 7059–7072. https://doi.org/10.12681/jhvms.34084
Özden, Ö., Erkan, N., & Varlık, C. (2018). Havyar. Aydın Gastronomy, 2(2), 21–34.
Yağcı, S., Altan, A., Göğüş, F., & Maskan, M. (2006). Gıda atıklarının alternatif kullanım alanları. Türkiye, 9, 24–26.
Yaman, K. (2012). Bitkisel atıkların değerlendirilmesi ve ekonomik önemi. Kastamonu University Journal of Forestry Faculty, 12(2), 339–348.
Yüksel, N., İstek, M. M., & Bulca, S. (2020). Peyniraltı Suyu Proteinlerinin Gıda Ambalajlamada Film ve Kaplama Materyali Olarak Kullanımı. Journal of the Institute of Science and Technology, 10(2), 1042–1052.

GGE BIPLOT ANALİZİ İLE ÇOKLU ORTAMLAR ALTINDA BİN TANE AĞIRLIĞINA GÖRE EKMEKLİK BUĞDAY GENOTİPLERİNİN SELEKSİYONU

SELECTION OF BREAD WHEAT GENOTYPES IN TERMS OF THOUSAND GRAIN WEIGHT UNDER MULTIPLE ENVIRONMENTS WITH GGE BIPLOT ANALYSIS

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ÖZET

Bin tane ağırlığı, buğday (Triticum aestivum L.) üretiminde önemli teknolojik kalite özelliklerinden biridir. Genetik yapı bin tane ağırlığında ana belirleyici faktör olmakla beraber, çevre koşullarının ve agronomik (gübreleme, sulama vb.) uygulamaların etkileri de önemlidir. Çalışmanın amacı, GGE biplot analizi sonuçlarına dayalı olarak çoklu ortamlarda stabil ve yüksek bin tane ağırlığına sahip genotipleri belirlemekti. Ayrıca, bin tane ağırlığına dayalı seleksiyon sürecinde GGE biplot grafiklerinin kullanılabilirliğini test etmekti. Araştırma 2011-2012 sezonunda, Diyarbakır ili Merkez ve Kızıltepe koşullarında yürütüldü. Denemeler, tesadüf blokları deneme desenine göre yağışa dayalı ve destek sulu koşullarda 4 tekrarlamalı olarak gerçekleştirildi. Denemede, 20 adet ileri kademe ekmeklik buğday hattı ve 5 adet kontrol (standart) çeşit materyal olarak kullanıldı. Biplot analizi sonuçlarına göre PC1 genotipler arasındaki varyasyonun %77,04'ünü, PC2 %10,75'ini ve PC1+PC2 %87,79'unu açıkladı. Bin tane ağırlığı bakımından Pehlivan, G9, G14 ve G23 genotiplerinin ön sırada olduğu, Pehlivan ve G14'ün stabil ve aynı zamanda yüksek bin tane ağırlığı değerleri verdiği belirlendi. Tüm ortamların aynı mega ortamda bulunduğu tespit edildi. Bin tane ağırlığına göre seleksiyon için en uygun ortamın 2. ortam (Diyarbakır destek sulama) olduğu belirlendi. Son olarak tüm ortamların aynı mega ortamda bulunması nedeniyle bin tane ağırlığına göre yapılacak seleksiyon için sadece 2. ortamda deneme kurulması yeterli ve maliyet açısından önemli bir karar olacaktır. Ayrıca GGE biplot tekniğinin çoklu ortamlarda en ideal genotipi belirlemede ayırt edici olduğu ve seleksiyonu kolaylaştırdığı görüldü.

Anahtar Kelimeler: Buğday, GGE Biplot, Bin Tane Ağırlığı, Seleksiyon

ABSTRACT

Thousand grain weight is one of the important technological quality characteristics in wheat (Triticum aestivum L.) production. Although genetic structure is the main determining factor in thousand grain weight, the effects of environmental conditions and agronomic (fertilization, irrigation, etc.) practices are also important. The aim of the study was to identify high thousand grain weight and stable genotypes with based on GGE biplot analysis results in multiple environments. Additionally, we aimed to test the usability of GGE biplot graphs in the process of thousand grain weight driven selection. The research was conducted in Diyarbakır Center and Kızıltepe conditions in the 2011-2012 growing season. The experiments were conducted in a randomized complete block design with 4 replications under rainfall and support irrigated conditions. In the experiment, 20 advanced bread wheat lines and 5 control (standard) varieties were used. According to the biplot analysis results, PC1 explained 77,04%, PC2 10,75% and PC1+PC2 87,79% of the variation between the genotypes. It was determined that Pehlivan, G9, G14 and G23 were the leading genotypes in terms of thousand grain weight, and Pehlivan and G14 gave stable and at the same time high thousand grain weight values. It was determined that all the environments were located in the

same mega environment. Also, the most suitable environment for selection for thousand grain weight was the 2nd environment (Diyarbakır supported irrigation). Finally, since all environments were located in the same mega environment, setting up a trial only in the 2nd environment for the selection to be made for thousand grain weight would be a sufficient and cost-effective decision. Also, it was observed that the GGE biplot technique was discriminative in determining the most ideal genotype in multiple environments and facilitated selection.
Key Words: Wheat, GGE Biplot, Thousand Grain Weight, Selection

GİRİŞ

Buğday, dünyada farklı şekillerde işlenerek insan tüketimine sunulan temel besin maddelerinden biri olmasının yanı sıra ülkelerin ekonomisine yön veren stratejik ürünlerdendir. Dünya genelinde buğday üretiminin yaklaşık %90-95'i, küresel gıda güvenliği için ana ürünlerden olan ekmeklik buğdaydan (Triticum aestivum L. 2n = 6x = 42, genom AABBDD) meydana gelmektedir. Buğday ıslah programlarında yüksek tane verimi öncelikli amaç olmakla beraber kalite vazgeçilmez unsurlardandır. Bu kapsamda teknolojik kalite özelliklerinden biri olan bin tane ağırlığı önem arz etmektedir. Ekmeklik buğdayda, bin tane ağırlığı genetik ve çevre şartlarının etkisi altında gelişmekte ve genetik performans üzerinde önemli derecede etkili olmaktadır. Özellikle, çiçeklenme aşamasından itibaren ekolojik koşulları lehine çeviren genotiplerin bin tane ağırlığı yüksek olmaktadır (Blue vd., 1990; Sakin vd., 2004; Aydoğan vd., 2007; Naneli vd., 2015; Olgun vd., 2022).

Otuzekmeklik buğday çeşidi ve farklı ülkelerden toplanan yirmi bir yerel popülasyon ile optimum ve kurak şartlarda yapılan çalışmada bin tane ağırlığının bitki boyu ve başaktaki başakçık sayısına göre kurak koşullara karşı daha hassas olduğu bildirilmiştir (Dencic vd., 2000). Tahılların vejetasyon sürecinde tane verimi ve verim komponentleri arasında gerçekleşen rekabetin bin tane ağırlığı üzerinde etkili olduğu vurgulanmıştır (Koca vd., 2011).

GGE biplot analizinin buğday çeşitlerinin seleksiyonu için kullanılabileceği (Bocci vd., 2020), sürdürülebilir tarımsal çevrelerde ekmeklik buğdayın performansının ve kararlılığının değerlendirilmesinde önemli bir seleksiyon aracı olarak daha kapsamlı bir şekilde kullanılması gerektiği bildirilmiştir (Bosi vd., 2022).

Bu çalışmanın amacı, GGE biplot analizi sonuçlarına dayalı olarak çoklu ortamlarda stabil ve yüksek bin tane ağırlığına sahip genotipleri belirlemekti. Ayrıca, bin tane ağırlığına dayalı seleksiyon sürecinde GGE biplot grafiklerinin kullanılabilirliğini test etmekti.

MATERYAL VE YÖNTEM

Araştırma, 2011-2012 yetiştirme sezonunda Diyarbakır ve Kızıltepe'de yağışa dayalı ve destek sulu koşullarda olmak üzere 4 farklı çevrede yürütüldü. Deneme, tesadüf blokları deneme desenine göre 4 tekerrürlü olarak aralık ayının son haftasında kuruldu. Materyal olarak 20 adet ileri kademe ekmeklik buğday hattı ve 5 adet kontrol (standart) çeşit kullanıldı. Toprak analizi sonuçlarına göre deneme alanı topraklarının; killi-tın, hafif alkali, fosfor içeriği düşük ve organik madde içeriği yetersiz olarak belirlendi. Bu bağlamda bitki besin maddesi takviyesi için ekimle birlikte saf madde hesabıyla 6 kg da^{-1} fosfor (P_2O_5) ve 6 kg da^{-1} azot (N) uygulandı. Ayrıca kardeşlenme döneminde üst gübre olarak 6 kg.da^{-1} N tatbik edildi. Destek sulama yapılan denemelerde, sulama işlemi başaklanma döneminde her parsel suya doyuncaya kadar su verildi. İhtiyaç halinde dar ve geniş yapraklı yabancı otlar ile mücadele etmek için yabancı otların 3-4 yapraklı olduğu dönemde uygun herbisitler kullanılarak mücadele yapıldı. Denemelere ilişkin hasat işlemleri 05-30 Haziran 2012 tarihleri arasında parsel biçerdöveri ile tamamlandı.

Tablo 1. Diyarbakır ve Kızıltepe lokasyonlarına ait iklim verileri

	Ortalama Sıcaklık (°C)				Yağış (mm)			
	Diyarbakır		Kızıltepe		Diyarbakır		Kızıltepe	
	2011 2012	Uzun Yıllar	2011 2012	Uzun Yıllar	2011 2012	Uzun Yıllar	2011 2012	Uzun Yıllar
Eylül	25.0	24.7	26.4	25.0	9.2	4.1	4.2	2.7
Ekim	16.4	17.1	18.1	18.7	11.8	34.7	26.2	23.3
Kasım	6.4	9.0	9.0	12.8	73.0	51.8	33.2	30.2
Aralık	2.3	3.7	6.0	6.0	40.2	71.4	24.5	40.7
Ocak	2.4	1.6	5.4	5.6	78.3	68.0	58.4	40.9
Şubat	1.9	3.6	5.9	6.5	74.4	67.8	39.4	44.4
Mart	5.1	8.6	8.9	13.6	44.0	67.3	36.8	25.5
Nisan	15.2	13.8	18.8	16.1	26.2	68.7	8.2	35.9
Mayıs	19.6	19.2	23.6	22.8	41.0	41.3	7.7	10.8
Haziran	27.7	26.3	31.0	28.1	7.0	7.9	0	0.9
Toplam					**405.1**	**483.0**	**238.6**	**231.3**

Lokasyonlara ilişkin toplam yağış miktarı bakımından Diyarbakır lokasyonunda uzun yılların yaklaşık 78 mm altında yağış gerçekleşirken, Kızıltepe lokasyonunda uzun yıllara ilişkin veriler ile benzer değerler görüldü. Aylar bazında yağış dağılımının ise her iki lokasyonda da düzensiz olduğu belirlendi.

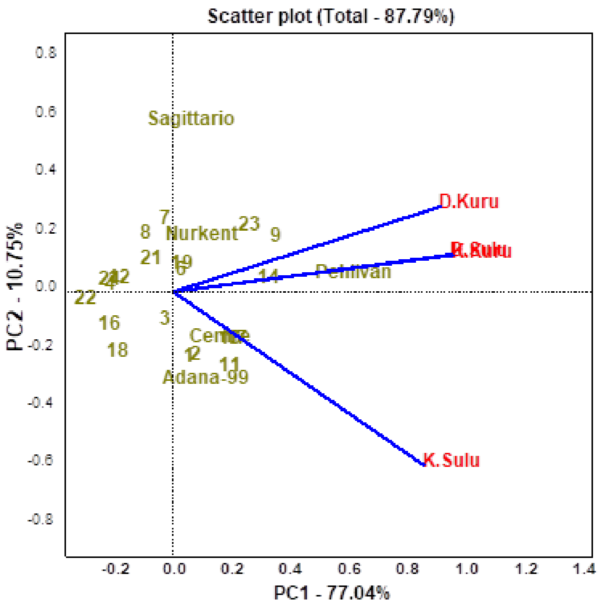
Diyarbakır'da kurulan denemelerde mart ve nisan, Kızıltepe'de kurulan denemelerde ise nisan ve mayıs aylarında uzun yılların altında yağış olması generatif döneme denk geldiğinden dolayı bin tane ağırlıklarını olumsuz etkilediği düşünülmektedir (Tablo 1). Sıcaklık değerleri incelendiğinde ise hem Diyarbakır hem de Kızıltepe'de nisan, mayıs ve haziran aylarında uzun yıllar ortalamasının üzerinde sıcaklık değerlerinin görülmesi ekmeklik buğday olum dönemlerine ilişkin süreleri kısalttığından dolayı bin tane ağırlıklarına negatif etkisi olduğu tahmin edilmektedir (Tablo 1).

ARAŞTIRMA VE BULGULAR

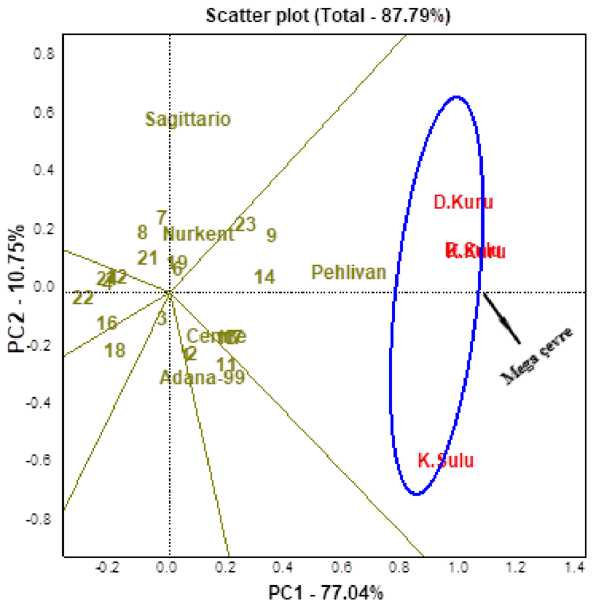
Çalışmada, GGE biplot analizinde farklı teknikler kullanılarak (vektörler, sektörler, mega çevre, poligon, ideal çevre, ideal genotip ve stabilite grafikleri) bin tane ağırlığı bakımından genotipler kıyaslanmıştır (Şekil 1, 2, 3, 4, 5 ve 6).

Çevreleri vektörler ile temsil eden Şekil 1'e göre özellikleri temsil eden vektörler arasındaki açı <90^{o} olduğundan dolayı çevreler arasında pozitif yönde korelasyon olduğu tespit edildi. Özellikle, Diyarbakır destek sulu ve Kızıltepe kuru (yağışa dayalı) çevreleri arasında güçlü pozitif ilişki olduğu belirlendi (Hagos & Abay, 2013). Bu çevrelerin çok benzer çevreler olduğu söylenebilir.

Çalışmada 6 farklı sektör oluşmasına rağmen tüm çevrelerin tek bir sektörde ve aynı mega çevrede kümelendiği gözlendi (Şekil 2). Bu durum, çevrelerin benzer olduğunu gösterdi. Geriye kalan diğer sektörlerde hiçbir çevrenin yer almadığı belirlendi. Bu durum, bu sektörlerde yer alan genotiplerin söz konusu çevrelere zayıf düzeyde adapte olduğunu göstermektedir (Yan & Tinker, 2006).

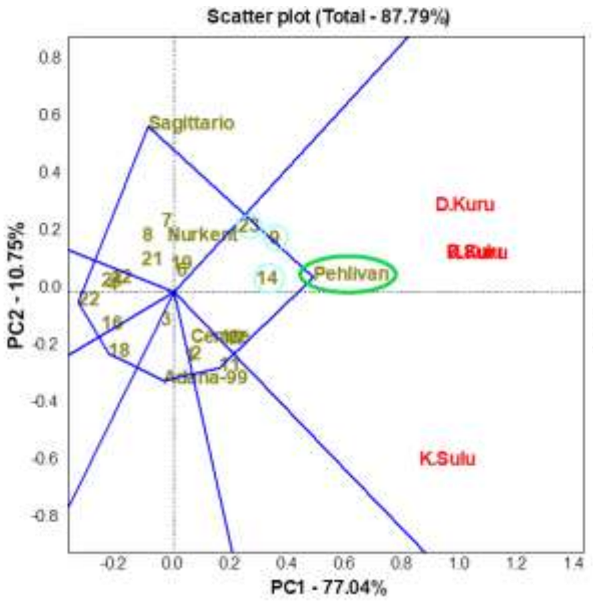


Şekil 1. Çevre-genotip ilişkisinin vektörler ile gösterimi

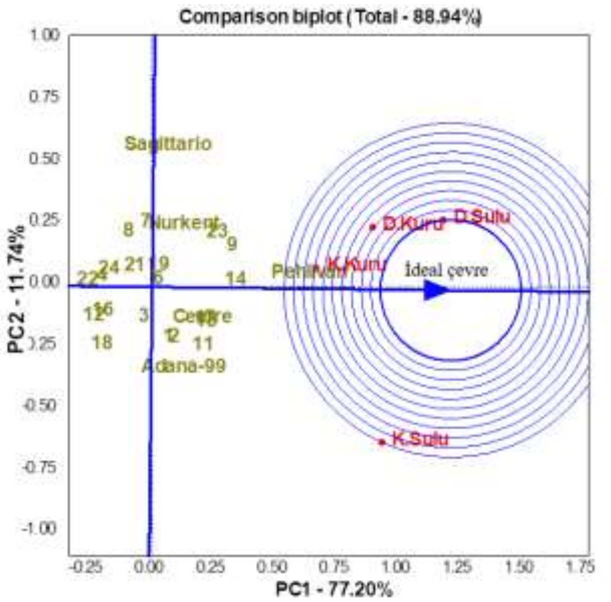


Şekil 2. Çevre-genotip ilişkisinin sektör ve mega çevre ile gösterimi

Pehlivan çeşidinin, poligonun köşegeninde yer alması (Şekil 3) ve aynı zamanda tüm çevreler ile aynı sektörde bulunması bin tane ağırlığı bakımandan tercih edilmesi gereken ideal çeşit olduğunu, yakın konumda olan G9, G14 ve G23'ün ise takip eden genotipler olduğunu doğruladı (Yan & Kang, 2003; Hagos & Abay, 2013).

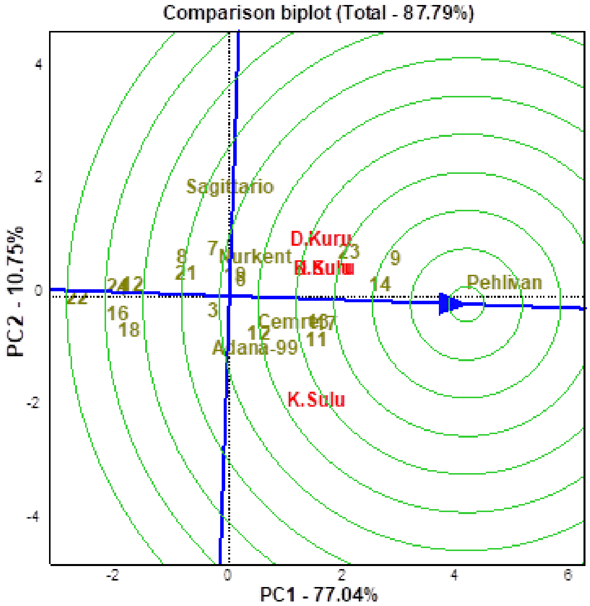


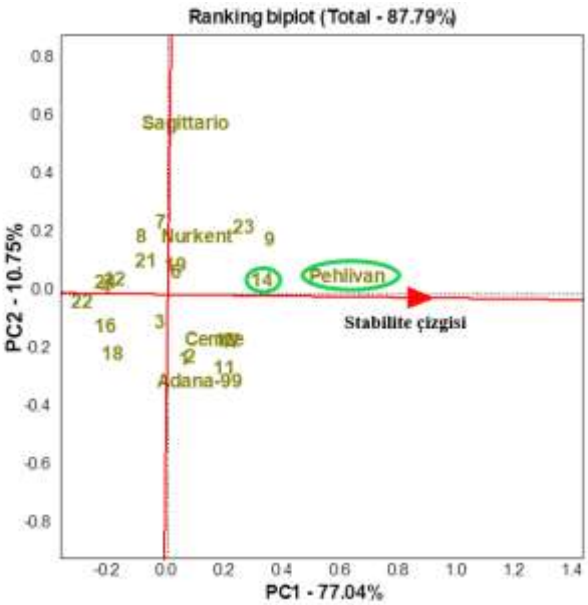
Şekil 3. Çevre-genotip ilişkisinin çokgen poligonu ile gösterimi



Şekil 4. İdeal çevreyi gösteren GGE biplot grafiği

Çevrelerin, ideal çevre olarak kodlanan en küçük çembere göre konumu değerlendirildiğinde Diyarbakır destek sulu olarak kodlanan çevrenin ideal çevreye en yakın konumda olduğu, bu bağlamda bin tane ağırlığı bakımından yapılacak seleksiyonlarda en ideal çevre olduğu anlaşıldı. Kızıltepe destek sulu koşulları temsil eden çevrenin ise seleksiyon tercihi açısından son sırada dikkate alınması gerektiği tespit edildi (Şekil 4). Hem yüksek ortalama bin tane ağırlığına hem de yüksek stabiliteye sahip olan ortam ideal ortam olarak değerlendirilir (Şekil 4). Bu bağlamda, biplot grafiğinde ideal ortama daha yakın olan ortamlar, diğerlerinden daha elverişli olarak kabul edilmektedir ((Farshadfar vd., 2013; Kendal & Şener, 2015).





Şekil 5. İdeal genotipi gösteren GGE biplot grafiği **Şekil 6.** Genotiplerin stabilitesini gösteren GGE biplot grafiği

İdeal genotipi temsil eden en küçük çembere göre genotiplerin konumu değerlendirildiğinde Pehlivan çeşidinin en yakın konumda yer aldığı, G9, G14 ve G23'ün bin tane ağırlığı bakımından takip eden genotipler olduğu saptandı (Şekil 5). İdeal genotip, bütün çeşitlerin en yüksek ortalama performansına sahip ve çok farklı çevrelerde kesinlikle kararlı sonuçlar veren bir genotip olarak değerlendirilmektedir (Sharma vd., 2010; Akçura vd., 2011). Bin tane ağırlığına göre genotiplerin stabilitesini gösteren ranking biplot (Şekil 6) grafiğine göre G14 ve Pehlivan'ın iri taneli ve en stabil genotipler olduğu, sonrasında G9'un geldiği tespit edildi (Saeidnia vd., 2023).

SONUÇLAR

Diyarbakır ve Kızıltepe koşullarında bin tane ağırlığına ilişkin dört farklı çevrede yürütülen çalışma sonucunda, araştırma konusu çevrelerin aynı mega çevrede yer aldığı belirlendi. Çevreler içerisinde Diyarbakır destek sulu çevrede genotiplerin performansını en yüksek seviyede gösterdiği, bin tane ağırlığı dikkate alınarak yapılacak seleksiyonlarda en ideal çevre olduğu saptandı. Araştırmada G9, 14, G23 ve Pehlivan genotiplerinin en iri taneli olduğu, özellikle G14 ve Pehlivan'ın iri taneye sahip olmasının yanı sıra en stabil genotipler olduğu tespit edildi. Islah programlarının maliyetli olduğu dikkate alındığında söz konusu çevrelerin aynı sektör ve mega çevrede yer alması nedeniyle gelecekte bin tane ağırlığına yönelik kurulacak denemelerin sadece Diyarbakır destek sulu koşullarda kurulması ve seleksiyonun bu çevrede yapılmasının yeterli olduğu tespit edildi.

KAYNAKLAR

Akçura, M., Taner, S. & Kaya, Y. (2011). Evaluation of bread wheat genotypes under irrigated multi-environment conditions using GGE biplot analyses. Agriculture, 98:35-40.
Aydın, N., Bayramoğlu, H.O.,Mut, Z. & Özcan, H. (2005). Ekmeklik Buğday (Triticum aestivum L.) çeşit ve hatlarinin karadeniz koşullarinda verim ve kalite özelliklerinin belirlenmesi. AÜZF Tarım Bilimleri Dergisi, 11(3):257-262.
Aydoğan, S. & Soylu, S. (2017). Ekmeklik buğday çeşitlerinin verim ve verim öğeleri ile bazı kalite özelliklerinin belirlenmesi. Tarla Bitkileri Merkez Araştırma Enstitüsü Dergisi, 26(1):24-30.
Blue, E.N., Mason, S.C. & Sander, D.H. (1990), Influence of planting date, seeding rate and phosphorus rate on wheat yield. Agron. J., 82:762-768.

Bocci, R., Bussi, B., Petitti, M., Franciolini, R., Altavilla, V., Galluzzi, G., Di Luzio, P., Migliorini, P., Spagnolo, S. & Floriddia, R. (2020). Yield, yield stability and farmers' preferences of evolutionary populations of bread wheat: A dynamic solution to climate change. Eur. J. Agron., 121:126156.
Bosi, S., Negri, L., Fakaros, A., Oliveti, G., Whittaker, A. & Dinelli, G. (2022). GGE biplot analysis to explore the adaption potential of ıtalian common wheat genotypes. Sustainability, 14:897.
Dencic, S., Kastori, R., Kobiljski, B. & Duggan, B. (2000). Evaluation of grain yield and its components in wheat cultivars and landracesunder near optimal and drought conditions, Euphytica, 113:43-52.
Farshadfar, E., Rashidi, M., Jowkar, M.M. & Zali, H. (2013). GGE biplot analysis of genotype × environment interaction in chickpea genotypes. European J. Exp. Biol., 3(1):417-423.
Giraldo, P., Benavente, E., Manzano-Agugliaro, F. & Gimenez, E. (2019). Worldwide Research Trends on Wheat and Barley: A Bibliometric Comparative Analysis. Agronomy, 9:352.
Hagos, H.G. & Abay, F. (2013). AMMI and GGE bıplot analysıs of bread wheat genotypes ın the northern part of Ethiopia. J. Plant Breed. Genet., 01(2013):12-18.
Kendal, E. & Şener,O. (2015). Examination of genotype × environment interactions by GGE biplot analysis in spring durum wheat. Indian J. Genet., 75(3):341-348.
Koca, Y.O., Dere, Ş., Erekul, O. (2011). İleri ekmeklik buğday hatlarında tane verimi ve bazı kalite özelliklerinin belirlenmesi. ADÜ Ziraat Fakültesi Dergisi, 8(2):15-22.
Naneli, İ., Sakin, M.A., Kıral, A.S. (2015). Tokat-Kazova şartlarinda bazi ekmeklik buğday (Triticum aestivum L.) çeşitlerinin verim ve kalite özelliklerinin belirlenmesi. GOÜ. Ziraat Fak. Derg., 32(1):91-103.
Olgun, M., Budak Başçiftçi, Z., Ayter Arpacıoğlu, N.G., Belen, S., Katar, D., Katar, N. & Aydın, D. (2022). Bazı buğday çeşitlerinde verim, verim unsurları ve kalite parametrelerinin incelenmesi üzerine bir araştırma. Research Journal of Biology Sciences, 15(2):124-142.
Sakin, M.A., Yıldırım, A. & Gökmen, S. (2004). Tokat Kazova koşullarinda bazi makarnalik buğday genotiplerinin verim, verim unsurlari ile kalite özelliklerinin belirlenmesi. A.Ü. Ziraat Fakültesi Tarım Bilimleri Derg., 10(4):48-489.
Sharma, R.C., Morgounov, A., Braun, H.J., Akin, B., Keser, M., Bedoshvili, D., Bagci, A., Martius, C. & Van, G.M. (2010). Identifying high yielding stable winter wheat genotypes for irrigated environments in Central and West Asia. Euphytica, 171:53-64.
Yan, W. & Kang, M.S. (2003). GGE Biplot Analysis: A graphical tool for breeders, geneticists, and agronomists. CRC Press,Boca Raton, FL.
Yan, W. & Tinker, N. (2006). Biplot analysis of multilocation trail data: principles and applications. Can. J. Plant Sci. 86:623-645.

MEKSİKA ORİJİNLİ EKMEKLİK BUĞDAY İLERİ KADEME HATLARININ DİYARAKIR İLİ KOŞULLARINDA TARIMSAL ÖZELLİKLER BAKIMINDAN DEĞERLENDİRİLMESİ

EVALUATION OF MEXICAN ORIGIN BREAD WHEAT ADVANCED STAGE LINES IN TERMS OF AGRICULTURAL CHARACTERISTICS IN DIYARBAKIR PROVINCE CONDITIONS

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ÖZET
Buğday, insan beslenmesinde en önemli bitki besin kaynaklarından biridir. Çevresel faktörlerin yanı sıra fizyolojik özellikler, verim ve bileşenleri doğrudan veya dolaylı olarak tane verimini etkilemektedir. Bu çalışmanın amacı, Meksika'dan temin edilen ileri kademe ekmeklik buğday genotiplerinin adaptasyonunu, verimini, verim bileşenlerini ve normalize edilmiş bitki örtüsü farklılık indeksini (NDVI) Diyarbakır ili koşullarında gözlemlemekti. Çalışma, 2018-2019 üretim sezonunda, Diyarbakır ilinin yağışa dayalı koşullarında yürütüldü. Deneme, tesadüf blokları deneme desenine göre 3 tekrarlamalı olarak kuruldu. Denemede materyal olarak 21 adet ileri kademe ekmeklik buğday hattı ve 4 adet kontrol çeşit kullanıldı. İncelenen tüm özelliklerde genotipler arasında p≤0,01 düzeyinde önemli farklılıklar olduğu gözlemlendi. Başak uzunluğunun 5,36-9,44 cm, başakta başakçık sayısının 21,80-34,6 başakçık/başak, başakta tane sayısının 27,80-54,40 tane/başak, başak ağırlığının 0,96-2,74 g, tane veriminin 73,31-335,31 kg/da, NDVI'nın ise 0,380-0,680 arasında değişim gösterdiği saptandı. Analiz sonuçları, sapa kalkma dönemindeki NDVI ile tane verimi arasında pozitif ve önemli bir ilişki olduğunu gösterdi. İleri kademe ekmeklik buğday hatları arasında H1, H2, H4, H6, H13, H17 ve H19'un birçok özellik bakımından ön planda olduğu belirlendi. Bu ümit verici ileri kademe ekmeklik buğday hatlarından H2, H17 ve H19'un melezleme programları için gen havuzuna aktarılmasının önemli olduğu ve aynı materyalle farklı ortamlarda araştırmanın tekrarlanmasının uygun olacağı sonucuna varıldı.
Anahtar Kelimeler: Buğday, Verim Bileşenleri, Korelasyon, NDVI

ABSTRACT
Wheat is one of the most important plant nutrients in human nutrition. In addition to environmental factors, physiological characteristics, yield and its components directly or indirectly affect grain yield. The aim of this study was to observe the adaptation, yield, yield components and normalized vegetation difference index (NDVI) of advanced bread wheat genotypes supplied from Mexico in Diyarbakır province conditions. The study was conducted in the rainfall conditions of Diyarbakır province in the 2018-2019 production season. The experiment was set up according to randomized block design with 3 replications. In the experiment, 21 advanced bread wheat lines and 4 control varieties were used as materyal. In all investigated traits, significant differences were observed between genotypes at p≤0,01 level. It was found that spike length 5,36-9,44 cm, spikelet number per spike 21,80-34,6 spikelet/spike, grain number per spike 27,80-54,40 grain/spike, spike weight 0,96-2,74 g, grain yield 73,31-335,31 kg/da, and NDVI varied between 0,380 and 0,680. The analysis results showed that there was a positive and significant relationship between NDVI at the stem elongation period and grain yield. It was determined that H1, H2, H4, H6, H13, H17 and H19, among the advanced bread wheat lines, were at the forefront in terms of many features.

It was concluded that it is important to transfer these promising advanced bread wheat lines H2, H17 and H19 to the gene pool for crossing programs and that it would be appropriate to repeat the research with the same material in different environments.
Key Words: Wheat, Yield Components, Correlation, NDVI

GİRİŞ

Buğday, değişen ve gelişen dünyamızda bazen ham, bazen de işlenerek insan tüketimine sunulan, özellikle geri kalmış ve gelişmekte olan ülkelerin beslenmesinde ana besin maddesi olarak stratejik önemini muhafaza eden önemli bir tahıl türüdür. Türkiye, yaklaşık 6.6 milyon hektar ekim alanı ile dünya buğday ekim alanına %3 katkı sağlamaktadır (FAO, 2022). Ülkemizde buğday üretiminde düşüş meydana geldiğinde ekmek ve/veya unlu mamüllerin fiyatlarında artış olduğu ve bu durumdan herkesin olumsuz etkilendiği gözlenmektedir. Bu sebeple, ülke nüfusuna yeter miktarda buğday üretilmesi ve ekstrem koşullar için stok yapılması stratejik önemdedir (Süzer, 2019; Özsoy & Erbaş Köse, 2022).

Verim bileşenleri, buğdayın birim alan tane verimi üzerinde belirleyici rol oynamakla birlikte aynı türü temsil eden farklı çeşitler uyum, verim ve verim komponentleri bakımından farklı çevre şartlarında değişkenlik gösterebilmektedir (Atak, 1997). Ülkemizde, yakın gelecekte meydana gelebilecek gıda açığını önlemenin ve günlük beslenme ihtiyacını karşılamanın yegane yolu birim alandan elde edilen tane verimini artırmaktır. Bu bağlamda biyotik ve abiyotik stres faktörlerine tolerant ve adaptasyon yeteneği yüksek çeşitlerin ıslah edilmesi sürecinde verim komponentlerinin dikkate değer, yetiştirme tekniklerinin optimum seviyede tutulmasının önemli olduğu vurgulanmıştır (Öztürk, 1996; Geleta vd., 2002; Sönmez & Olgun, 2020).

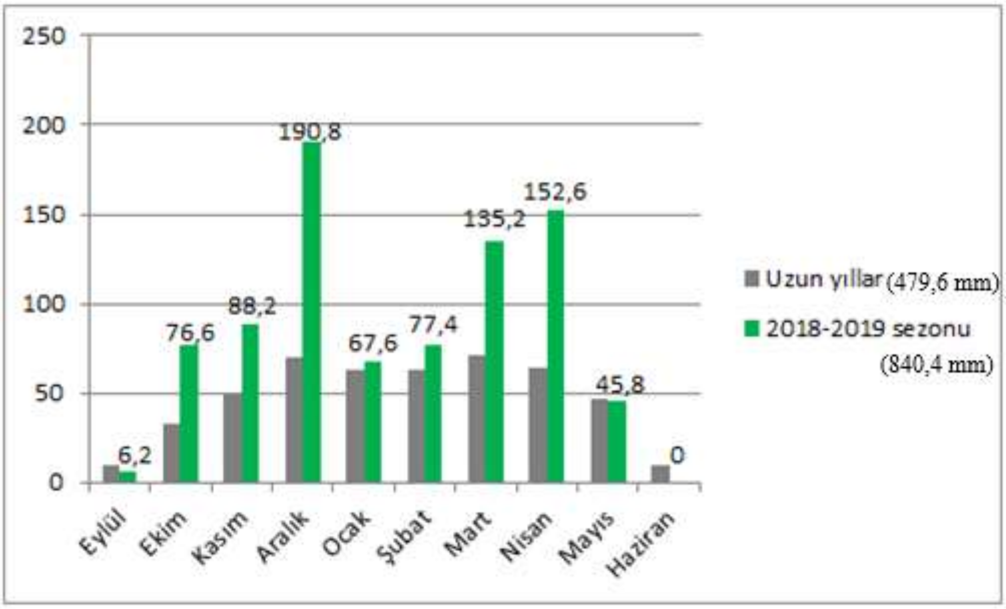
Başak uzunluğu, en önemli verim bileşenlerinden biri olmakla beraber başakçık sayısını etkilediği, başakta gerçekleşen fotosentez sonucunda üretilen besin maddelerinin tamamının taneye taşınması nedeniyle başak uzunluğunun tane verimini doğrudan etkilediği bildirilmiştir (Özkan, 2022; Özsoy & Erbaş Köse, 2022).

Ülkemiz, iklim ve toprak yapısı bakımından farklı çevreleri bünyesinde barındırmakla birlikte bölgeler bazında verimi sınırlayan biyotik ve abiyotik stres faktörleri üretim miktarını olumsuz etkilemektedir. Bu bağlamda, ıslahçılar lokasyon odaklı çeşitler geliştirerek olumsuz koşulları minimize etme gayreti içerisinde olup, geliştirilen genotiplerin verim, verim komponentleri ve fizyolojik özelliklerinin belirlenmesi amacıyla birçok çalışma gerçekleştirmiştir (Kızılgeçi vd., 2017; Güngör & Dumlupınar, 2019; Karaman, 2022).

Bu çalışmanın amacı, yurt dışından temin edilen ileri kademe ekmeklik buğday hatlarının uyum kabiliyetini, verimini, verim bileşenlerini ve normalize edilmiş bitki örtüsü farklılık indeksini (NDVI) Diyarbakır ili koşullarında incelemek ve özellikler arasındaki ilişkiyi belirlemekti.

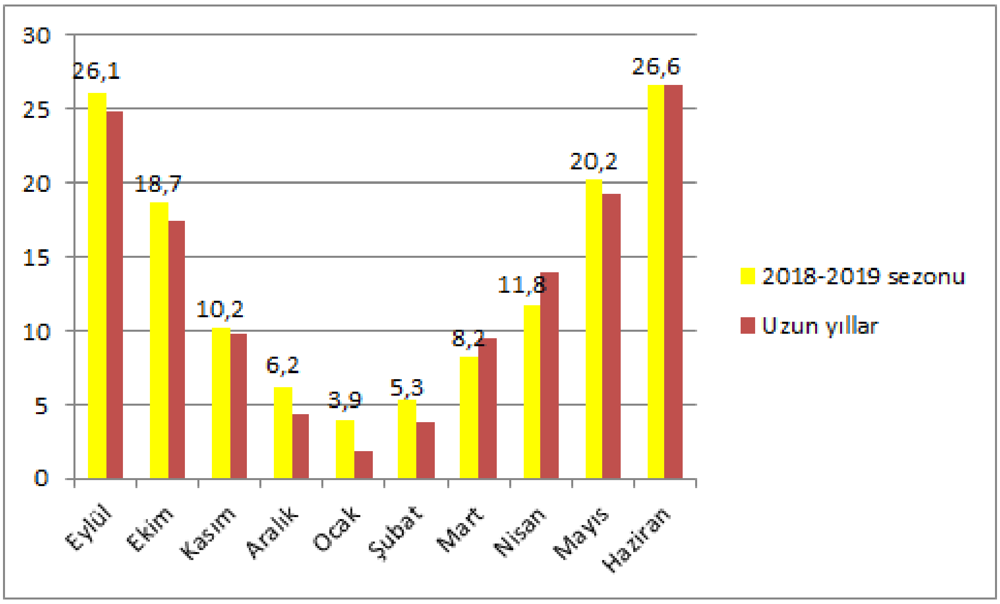
MATERYAL VE YÖNTEM

Çalışma, 2018-2019 üretim sezonunda Diyarbakır ilinin yağışa dayalı koşullarında yürütüldü. Araştırma materyalini Obregon/Meksika'dan temin edilen 21 ileri kademe ekmeklik buğday hattı ve kontrol (standart) olarak 4 adet tescilli ekmeklik buğday (Cemre, Dinç, Kale ve Tekin) çeşidi oluşturdu. Deneme, tesadüf blokları deneme deseninde 3 tekrarlamalı olarak tasarlandı. 2018 yılının aralık ayının son haftasında parsel uzunluğu 2.5 m, 6 sıra ve sıra arası 20 cm olarak oluşturulan 3 m^2'lik deneme parsellerinde 450 tohum/m^2 normunda ekim yapıldı. Deneme alanı topraklarının; killi, organik madde (% 0.96) ve fosfor (1.49 kg da^{-1}) içeriği bakımından fakir, tuzsuz (% 0.023) ve alkali (pH: 8.15) olduğu belirlendi. Bu bağlamda, bitki besin elementi eksikliğini telafi etmek amacıyla saf madde hesabıyla 6 kg/da fosfor (P_2O_5) ve 14 kg/da azot (N) toprağa uygulandı. Fosforun tamamı ve azotun 6 kg/da'ı ekim işleminden 1 hafta önce toprağa uygulanarak rotovatör ile karıştırıldı. Kalan azot (8 kg/da) miktarı kardeşlenme döneminin ortalarında uygulandı.



Şekil 1. 2018-2019 sezonuna ve uzun yıllara ait yağış değerleri (mm)

Dar ve geniş yapraklı yabancı otlar ile mücadelede, yabancı otların en hassas olduğu 2-4 yapraklı dönemde herbisit kullanıldı. Hasat işlemi Wintersteiger parsel biçerdöveri ile 20 Haziran 2019 tarihinde tamamlandı.



Şekil 2. 2018-2019 sezonuna ve uzun yıllara ait sıcaklık değerleri (^oC)

Araştırma sezonuna ilişkin yağış miktarı uzun yıllar ile kıyaslandığında mart ayında 1.9 kat ve nisan ayında 2.4 kat daha fazla yağış olduğu tespit edildi. Fakat, yağışın aylar bazında dağılımı kontrol edildiğinde düzensiz bir dağılım olduğu gözlendi (Şekil 1). Sıcaklık değerlerini gösteren iklim grafiğine göre mart ve nisan aylarında düşük, haziran ayında eşit, geriye kalan tüm aylarda uzun yıllar ortalamasının üzerinde sıcaklıkların yaşandığı tespit edildi (Şekil 2). Araştırmada, istatistiki analizler J.M.P 13.0 pro paket programında yapılmış olup, oluşan gruplar ile gruplar arası farklılıklar LSD ($p \leq 0.05$) testine göre belirlendi (Gomez & Gomez, 1984).

ARAŞTIRMA ve BULGULAR

Araştırmada, incelenen tüm özelliklerde genotipler arasında $p \leq 0.01$ seviyesinde önemli varyasyon olduğu belirlendi (Tablo 1).

Tablo 1. Araştırılan özelliklere ait veriler ve oluşan gruplar

Genotip	BU		BBS		BTS		BA		TV		NDVI	
H1	9.42	a	34.60	a	50.00	ab	2.36	bc	231.31	def	0.530	hıj
H2	8.52	bc	34.60	a	53.00	ab	2.40	b	334.00	a	0.610	b-e
H3	7.50	d-g	30.60	b-e	51.80	ab	2.18	bcd	230.31	d-g	0.560	f-ı
H4	9.44	a	33.00	abc	54.40	a	2.24	bc	135.31	kl	0.520	ıj
H5	7.70	c-g	29.80	c-f	48.00	a-d	1.84	fgh	172.00	ıj	0.580	d-g
H6	7.70	c-g	31.40	a-d	48.00	a-d	2.40	b	230.66	d-g	0.560	f-ı
H7	7.54	d-g	28.20	d-h	39.40	ef	1.94	d-g	235.31	de	0.580	d-g
H8	6.98	gh	29.80	c-f	43.00	cde	1.70	ghı	209.00	e-h	0.560	f-ı
H9	7.44	d-g	25.80	gh	40.00	ef	1.52	ıjk	170.00	ıj	0.530	hıj
H10	6.94	gh	26.60	fgh	32.40	gh	1.50	ıjk	73.31	m	0.507	j
H11	8.16	b-e	29.00	d-g	42.80	cde	2.12	cde	204.69	gh	0.550	g-j
H12	7.46	d-g	29.80	c-f	46.60	bcd	2.10	c-f	252.31	cd	0.590	c-g
H13	8.58	b	33.00	abc	53.00	ab	2.74	a	166.31	ıj	0.460	k
H14	7.36	efg	29.00	d-g	39.60	ef	1.72	ghı	295.31	b	0.580	d-g
H15	7.22	fgh	27.40	e-h	40.00	ef	1.74	ghı	147.69	jk	0.380	l
H16	7.56	d-g	30.60	b-e	47.60	bcd	1.94	d-g	261.69	c	0.630	bc
H17	8.74	ab	31.40	a-d	49.20	abc	1.96	d-g	335.31	a	0.570	e-h
H18	8.04	b-f	28.20	d-h	41.80	de	1.82	gh	207.69	fgh	0.600	c-f
H19	9.42	a	33.80	ab	47.60	bcd	2.40	b	289.28	b	0.680	a
H20	7.50	d-g	29.00	d-g	39.80	ef	1.86	e-h	218.00	efg	0.580	d-g
H21	6.50	h	25.00	hı	29.20	gh	1.42	jk	119.31	l	0.560	f-ı
Cemre	8.24	bcd	27.00	fgh	35.20	fg	1.76	ghı	313.69	ab	0.550	g-j
Dinç	6.92	gh	29.00	d-g	43.20	cde	1.66	hıj	182.69	hı	0.650	ab
Kale	5.36	ı	21.80	ı	27.80	h	0.96	l	109.31	l	0.550	g-j
Tekin	6.50	h	25.00	hı	35.20	fg	1.36	k	299.69	b	0.620	bcd
G.ortalama :	7.71		29.34		43.14		1.91		216.97		0.563	
LSD (0.05):	0.84**		3.56**		6.58**		0.28**		26.33**		0.044**	
CV (%) :	6.60		7.39		9.30		8.83		7.40		4.72	

G. ortalama: genel ortalama, BU: başak uzunluğu, BBS: başakta başakçık sayısı, BTS: başakta tane sayısı, BA: başak ağırlığı, TV: tane verimi, NDVI: normalize edilmiş vejetasyon farklılık indeksi

Çalışmada, başak uzunluğunun 5.36 ile 9.44 cm arasında değişim gösterdiği, deneme ortalamasının 7.71 cm olduğu, H4 (9.44 cm)'ün en uzun başak boyunu verdiği belirlendi (Tablo 1). Genotiplerin farklı başak uzunluğuna sahip olmasının en önemli sebebinin genetik farklılık olduğu vurgulanmıştır (Akman vd., 1999; Özsoy & Erbaş Köse, 2022). Başakta başakçık sayısının 21.80 ile 34.60 adet arasında farklılık gösterdiği, deneme ortalamasının 29.34 adet olduğu, H1 (34.60 adet/başak) ve H2 (34.60 adet/başak) ileri kademe hatlarının en fazla başakta başakçık sayısına sahip olduğu tespit edildi (Tablo 1). Önemli verim komponentlerinden olan başakta başakçık sayısının artırılmasının tane verimine pozitif yönde katkı sağladığı bildirilmiştir (Philipp vd., 2018; Bayhan vd., 2022). Başakta tane sayısının 27.80 ile 54.40 adet/başak, deneme ortalamasının 43.14 adet/başak ve H4 (54.40 adet/başak)'ün en yüksek tane sayısı değerini verdiği gözlendi. Başakta tane

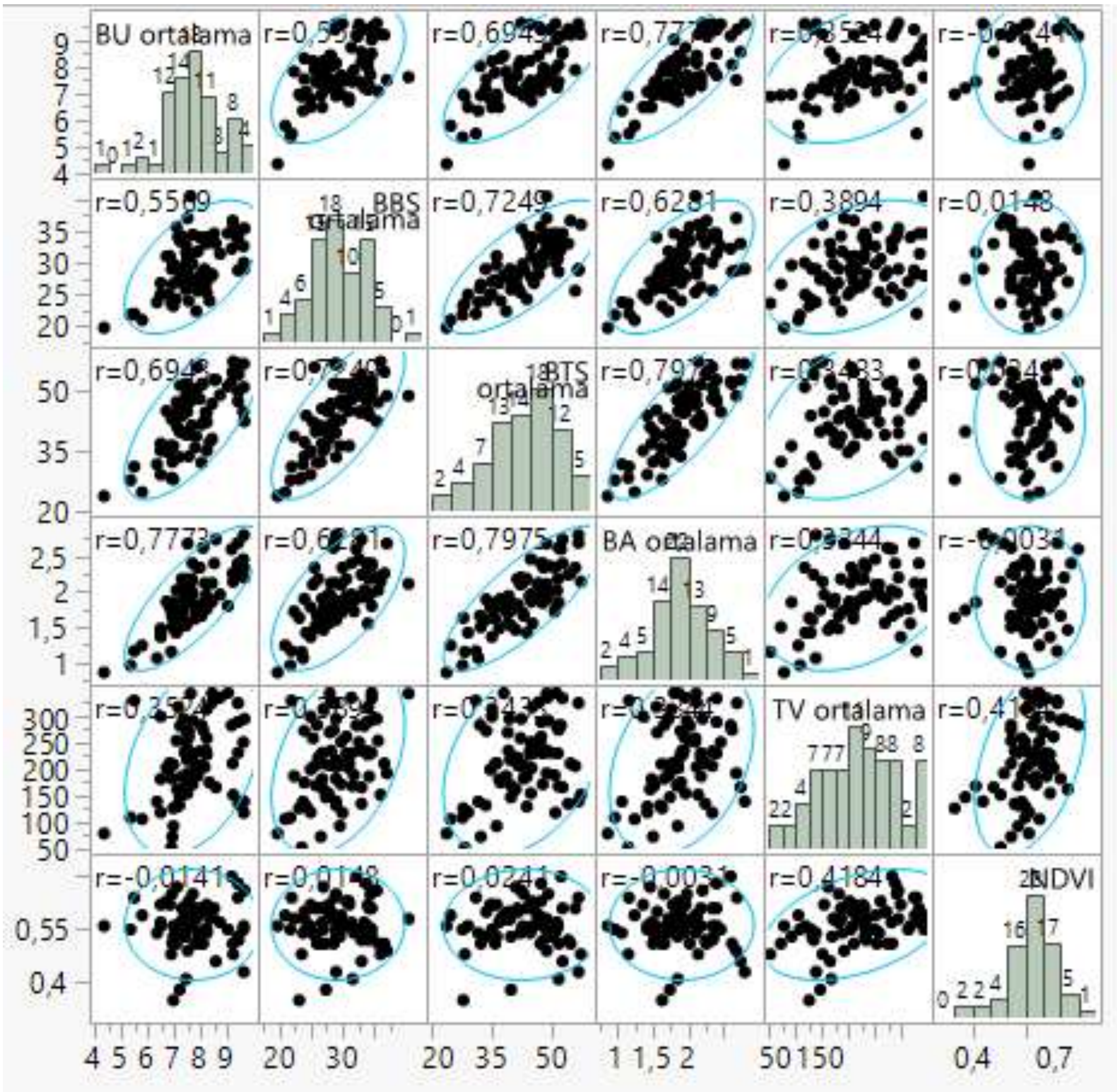
sayısının artan azot dozu uygulamalarına paralel olarak artış gösterdiği belirlenmiştir (Altuntaş vd., 2016; Ulupınar vd., 2020; Yıldız & Doğan, 2022).
Başak ağırlığının 0.96 ile 2.74 g arasında değiştiği, deneme ortalamasının 1.91 g olduğu, H13 (2.73 g) ileri kademe ekmeklik buğday hattının en yüksek başak ağırlığı değerini verdiği belirlendi. Farklı araştırıcılar tarafından buğdayda başak ağırlığı ile ilgili yapılan çalışmalarda ekim sıklığı arttıkça başak ağırlığının azaldığı belirlenmiştir (İpek, 2016; Sönmez, 2017; Yıldız & Doğan, 2022).
Araştırmada, tane verimi bakımından genotipler arasında geniş bir varyasyon olduğu tespit edilmiştir. Tane veriminin 73.31 ile 335.31 kg/da arasında farklılık gösterdiği belirlenmiştir. Deneme ortalamasının 216.97 kg/da olduğu, H2 (334.00 kg/da) ve H17 (335.31 kg/da) ileri kademe ekmeklik buğday hatları ile Cemre çeşidinin aynı grupta yer alarak tane verimi bakımından ön sırada yer aldığı gözlemlendi (Tablo 1). Buğday ıslah programlarında, çeşit geliştirmede tane verimi dikkate alınan en önemli özelliklerden biri olmakla beraber kalite hariç incelenen bütün parametrelerin bileşkesi konumundadır. Tane veriminin iklim, toprak yapısı, yetiştirme teknikleri ve genotipe bağlı olarak değiştiğini birçok araştırıcı bildirmiştir (Kırtok vd., 1988; Sharma, 1992; Öztürk & Akkaya 1996; Karaman, 2017).
Normalize edilmiş vejetasyon farklılık indeksinin (NDVI), 0.380 ile 0.680 arasında farklılık gösterdiği, deneme ortalamasının 0.563 olduğu, en yüksek NDVI değerinin H19 (0.680) ileri kademe ekmeklik buğday hattına ait olduğu belirlendi. Sulu, destek sulamalı ve yağışa dayalı olmak üzere 3 farklı şartlarda NDVI ile biyomas ağırlığı arasındaki ilişkinin incelendiği çalışmada, özellikle sapa kalkma başlangıcındaki NDVI değerleri ile biyomas arasında önemli ilişki olduğu tespit edilmiştir (Savaşlı vd., 2012; Karaman vd., 2014).

Tablo 2. İncelenen özelliklere ilişkin korelasyon katsayısı ve önemlilik ($p \leq 0,01$) seviyesi

Özellik	BU	BBS	BTS	BA	TV
BBS	0.5569**	-	-	-	-
BTS	0.6943**	0.7249**			
BA	0.7773**	0.6281**	0.7975**		
TV	0.3524**	0.3894**	0.3433**	0.3344**	
NDVI	-0.0141	0.0148	0.0241	-0.0031	0.4184**

BU: başak uzunluğu, BBS: başakta başakçık sayısı, BTS: başakta tane sayısı, BA: başak ağırlığı, TV: tane verimi, NDVI: normalize edilmiş vejetasyon farklılık indeksi

Aynı araştırıcılar, yağışa dayalı ve destek sulu koşullardaki NDVI ile birim alan tane verimi arasında önemli bir korelasyon olduğunu bildirmişlerdir (Marti vd., 2007; Savaşlı vd., 2012; Karaman vd., 2014; Karaman, 2017). Çalışmamızda benzer şekilde sapa kalkma dönemi NDVI değerleri ile tane verimi arasında pozitif ve önemli bir ilişki olduğu saptandı (Tablo 2). Korelasyon analizi ve scatter plot matriksine ilişkin sonuçları tüm verim bileşenlerinin tane verimi ile ilişkili olduğunu gösterdi. Ayrıca, fizyolojik özelliklerden NDVI'nın tane verimi ile pozitif ve önemli seviyede (r=0.4184**) ilişkili olduğu belirlendi (Tablo 2 ve Şekil 3).



BU: başak uzunluğu, BBS: başakta başakçık sayısı, BTS: başakta tane sayısı, BA: başak ağırlığı, TV: tane verimi, NDVI: normalize edilmiş vejetasyon farklılık indeksi
Şekil 3. İncelenen özelliklere ilişkin scatter plot matriksi

SONUÇ

Çalışma materyalini oluşturan H1, H2, H4, H6, H13, H17 ve H19 hatlarının tüm kontrol çeşitlerden üstün olduğu ve Diyarbakır koşullarında adaptasyon kabiliyetlerinin yüksek olduğu belirlendi. Özellikle H2, H17 ve H19 ileri kademe ekmeklik buğday hatlarının melezleme programları için gen havuzuna aktarılarak sonraki süreçlerde genitor olarak kullanılması önem arz etmektedir. Korelasyon analizi sonuçları tüm verim bileşenleri ile tane veriminin pozitif yönde ve önemli seviyede ilişkili olduğunu gösterdi. Tane veriminin sapa kalkma dönemi normalize edilmiş vejetasyon farklılık indeksi ile pozitif ilişkili olması seleksiyon açısından önem arz etmektedir. Son olarak, çalışmanın aynı materyal ile bir yıl daha tekrarlanmasının kesin karar vermek için faydalı olacağı düşünülmektedir.

KAYNAKLAR

Akman, Z., Yılmaz, F., Karadoğan, T. & Çarkçı, K. (1999). Isparta ekolojik koşullarına uygun yüksek verimli buğday çeşit ve hatlarının belirlenmesi. Türkiye 3. Tarla Bitkileri Kongresi, 15-20 Kasım, Adana, 366-371.

Altuntaş, A & Akgün, İ. (2016). Uşak koşullarında Kızıltan-91 buğday çeşidi üzerinde farklı azot dozu ve sıvı gübre uygulamalarının verim ve verim unsurlarına etkisi. Süleyman Demirel Üniversitesi Fen Bilimleri Enstitüsü Dergisi Cilt 20, Sayı 3, 496-503.

Atak, M. (1997). Photoperiod, vernalization, and seeding rate effects on anthesis date and agronomic performance of winter wheat (Triticum aestivum L.) Master Thesis University Of Nebraska Lincoln 61 p.

Bayhan, M., Özkan, R., Albayrak, Ö., Yıldırım, M. & Akıncı, C. (2022). Evaluation of performance of bread wheat (Triticum aestivum L.) genotypes under heat stress. Proccedings of International Congress and Workshop on Agricultural Structures and Irrigation, Mayıs, Diyarbakır, 268-279.

FAO, (2022). Food and Agriculture Organization of the United Nations, Wheat statistics. https://www.fao.org/faostat/en/#data/QCL

Geleta, B., Atak, M., Baenziger, P.S., Nelson, L.A. & Baltenesperger, D.D. (2002). Seeding Rate and Genotype Effect on Agronomic Performance and End-Use Quality of Winter Wheat. Crop Sci., 42:827-832.

Gomez, K.A. & Gomez, A.A. (1984). Statistical Procedures for Agricultural Research. 2nd Ed. John Wiley and Sons, Inc. New York, p. 641.

Güngör, H. & Dumlupınar, Z. (2019). Bolu koşullarında bazı ekmeklik buğday (Triticum aestivum L.) çeşitlerinin verim, verim unsurları ve kalite yönünden değerlendirilmesi. Türk Tarım ve Doğa Bilimleri Dergisi, 6(1), 44-51.

İpek, İ. (2016). Sakarya şartlarında farklı ekim sıklıklarında bazı buğday çeşitlerinin verim ve kalite değişimlerinin belirlenmesi. Namık Kemal Üniversitesi, Fen Bilimleri Enstitüsü, Yüksek Lisans Tezi, Tekirdağ.

Karaman, M. (2017). Makarnalık buğdayda fizyolojik ve morfolojik parametrelerin verim ve kalite ile olan ilişkisinin belirlenmesi. Dicle Üniversitesi Fen Bilimleri Enstitüsü, Doktora Tezi, s:15, Diyarbakır.

Karaman, M. (2022). GGE biplot tekniği ve scatter plot matrixi ile ekmeklik buğdayda (Triticum aestivum L.) genotip, verim ve verim komponentlerinin yorumlanması. MSU Fen Bil. Dergi., 10:1 931-937.

Karaman, M., Akıncı, C. & Yıldırım, M. (2014). Bazı ekmeklik buğday çeşitlerinde fizyolojik parametreler ile tane verimi arasındaki ilişkinin araştırılması. Trakya Üniversitesi Tarım Bilimleri Dergisi, 15(1):41-46.

Kırtok, Y., Genç, İ., Yağbasanlar, T., Çölkesen, M. & Kılınç, M. (1988). Tescilli bazı ekmeklik (T. aestivum L.) ve makarnalık (T. durum Desf.) buğday çeşitlerinin Çukurova koşullarında başlıca tarımsal karakterleri üzerinde çalışmalar. Çukurova Üniv. Zir. Fak. Dergisi, 3(3): 96-105.

Kızılgeçi, F., Tazebay, N., Namlı, M., Albayrak, Ö. & Yıldırım, M. (2017). The drought effect on seed germination and seedling growth in bread wheat (Triticum aestivum L.). International Journal of Agriculture, Environment and Food Sciences, 1:33-37.

Marti, J., Bort, J., Slafer, G.A. & Araus, J.L. (2007). Can wheat yield be assessed by early measurements of normalized difference vegetation Index? Annals of Applied Biology, 150 (2): 253-257.

Özkan, R. (2022). Diyarbakır'da yağışa dayalı koşullarda yetiştirilen ileri kademe ekmeklik buğday hatlarının değerlendirilmesi. ISPEC Journal of Agricultural Sciences, 6(3): 583-590.

Özsoy, B. & Erbaş Köse, Ö.D. (2022). Konyada'da yağışa dayalı ve sulamalı koşullarda farklı sıra arası mesafelerin buğday çeşitlerine etkisi: I. tane verimi ve verim unsurları. ISPEC Tarım Bilimleri Dergisi, 6(4): 777-785.

Öztürk A. (1996). Ekim sıklığı ve azotun kışlık buğday genotiplerinde fotosentez alanının büyüklüğü ve süresi ile verime üzerine etkileri. Atatürk Üniversitesi, Fen Bilimleri Enstitüsü, Tarla Bitkileri ABD, Doktora Tezi, Erzurum.

Öztürk, A. & Akkaya, A. (1996). Kışlık buğday genotiplerinde (Triticum aestivum L.) tane verim unsurları ve fenolojik dönemler üzerine bir araştırma. Atatürk Üniv. Zir. Fak. Dergisi, 27 (2): 187-202.

Philipp, N., Weichert, H., Bohra, U., Weschke, W., Schulthess, A.W. & Weber, H. (2018). Grain number and grain yield distribution along the spike remain stable despite breeding forhigh yield in winter wheat. PLoS One, 13:e0205452.

Savaşlı, E. Çekiç, C. Önder, O. Dayıoğlu, R. & Kalaycı, H.M. (2012). Eskişehir koşullarında bazı ekmeklik buğday çeşit ve hatlarının verim, biyolojik kütle ve vejetasyon indeksi yönünden değerlendirilmesi. Tarım Bilimleri Araştırma Dergisi, 5(2):33-37.

Sharma, R.C. (1992). Analysis of phytomass yield in wheat. Agronomy journal, 84(6):926-929.

Sönmez, A.C. & Olgun, M. (2020). Ekmeklik buğdayda (Triticum aestivum L.) farklı ekim sıklıklarının verim ve verim bileşenleri Üzerine Etkisinin Belirlenmesi. Turkish Journal of Agriculture - Food Science and Technology, 8(2):380-386.

Sönmez, C.A. (2017). Sulu ve kuru koşullarda yetiştirilen ekmeklik buğday çeşitlerinde farklı ekim sıklıklarının bazı fizyolojik, verim ve kalite özelliklerine etkisinin belirlenmesi. Eskişehir Osmangazi Üniversitesi Fen Bilimleri Enstitüsü, Doktora Tezi. Eskişehir.

Süzer, S. (2019). Buğday Tarımı. http://hayrabolutb.org.tr/media/zira at/Bugday-Tarimi.pdf

Ulupınar, Ü. ve Akgün, İ. (2020). Makarnalık buğday (Triticum durum Desf.)'da azot dozu uygulamalarının bazı tarımsal özellikler üzerine etkisi. Ziraat Fakültesi Dergisi, Türkiye 13. Ulusal, I. Uluslararası Tarla Bitkileri Kongresi Özel Sayısı:59-69, ISSN 1304-9984.

Yıldız C. F. & Dogan R. (2022). Nusrat ekmeklik buğday çeşidinde farklı azot dozları ve ekim sıklıklarının tane verimi, verim öğeleri ve kalite özelliklerine etkileri. Bursa Uludağ Üniv. Zir. Fak. Dergi., 36(2), 285-299.

KATMA DEĞERİ YÜKSEK ASPİR (Carthamus tinctorius L.) BİTKİSİNİN KULLANIMI VE ÖNEMİ
USE AND IMPORTANCE OF HIGH ADDED VALUE SAFFLOWER (Carthamus tinctorius L.) PLANTS

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ÖZET
Aspir (Carthamus tinctorius L.) yağ bitkisi olarak bilinmesine rağmen kullanım alanları bakımından bitkisel yağ üretimi ile sınırlı olmayan önemli bir endüstri bitkisidir. Geleneksel ve ileri tıpta çeşitli rahatsızlıklar için bitkisel ilaç yapımında, renkli çiçeklerinin olması ile boya sanayisine, kozmetik ürünlerde, çeşitli gıda imalatına, kanatlı hayvanların beslenmesinden biodizel üretimine kadar birçok farklı alanda kullanılmaktadır. Katma değeri yüksek aspir, bitkisi ekonomik önemiyle giderek daha fazla tanınmaktadır. Bu bitki birkaç temel nedenden dolayı değerlidir.Yağ üretimi bakımından aspir tohumları oldukça zengindir ve özellikle de doymamış yağ asitleri bakımından yüksektir; ayrıca bu da onları değerli bir yemeklik yağ ve endüstriyel ürün kaynağı haline getirir. Ayrıca, aspir kuraklığa dayanıklı bir üründür, bu da onu kurak bölgeler için uygun hale getirir ve sürdürülebilir tarım uygulamalarına katkıda bulunur. Aspir bitkisi yalancı safran olarak bilinmektedir ve çiçeklerinden, tekstil endüstrilerinde talep gören doğal boyalar üretmek için kullanılmaktadır. Genel olarak, yüksek katma değerli aspir bitkilerinin kullanımı ve önemi, ekonomik faydalarının ötesine geçerek çevresel sürdürülebilirlik ve sağlık, beslenme, tarım ve sanayideki çok yönlü kullanımlarından kaynaklanmakta ve onları modern tarımda hayati bir ürün haline getirir.

Anahtar Kelimeler: Carthamus tinctorius L., Aspir, Alternatif yağ bitkileri, Katma değer

ABSTRACT
Although safflower (Carthamus tinctorius L.) is known as an oil plant, it is an important industrial plant whose uses are not limited to vegetable oil production. It is used in traditional and modern medicine to produce herbal medicines for various ailments, in the dyeing industry for its colorful flowers, in cosmetic products, in the production of various foods, in poultry feed, and the production of biodiesel. As a high-value crop, safflower is increasingly recognized for its economic importance. Safflower seeds are rich in oil production and are exceptionally high in unsaturated fatty acids, making them a valuable source of edible oil and industrial products. In addition, safflower is a drought-tolerant crop, making it suitable for arid regions and contributing to sustainable agricultural practices. The safflower plant is known as false saffron, and its flowers are used to produce natural dyes that are in demand in the textile industry. Overall, the use and importance of high-value safflower crops go beyond their economic benefits and stem from their environmental sustainability and multiple uses in health, nutrition, agriculture, and industry, making them a vital crop in modern agriculture.
Key Words: Carthamus tinctorius L., Safflower, Alternative oil crops, Value added

GİRİŞ

Aspir (Carthamus tinctorius L.) bitkisi, Asteraceae familyasına ait olan tek yıllık, geniş yapraklı, otsu ve çok dallı olan endüstri bitkisidir. Ayrıca, yalancı safran ve boyacı safranı gibi isimleri olan aspir, dikenli ve dikensiz tipte, "sarı, kırmızı, turuncu ve beyaz" renklere sahip çiçekleri olan kuraklığa toleraslı ve yağ oranın % 27-45 olarak değişebilen bir endüstri bitkisidir (Singh ve Nimbkar, 2006; Gürsoy ve ark., 2018). Özellikle, M.Ö. ekiminin yapıldığı bilinmesi ve Mısır'da hemen hemen 3500 yıl önce aspir bitkisinin bu bölgede yayıldığı kabul edilmesinin yanısıra; orjinin ilk olarak Asya kıtasının güneyi olduğu, sonrasında ortadoğu bölgesi ve yaygın olarak Akdeniz ülkeleri olduğu bilinmekle birlikte dünyanın yer yerine yayılımının buradan olabileceği de kabul gördüğü bilinmektedir. Mevcut, Dünyada yayılış gösteren toplamda 25 yabani türleri bulunmakla birlikte bunların Carthamus lanatus ve C. dentatus gibi bir kaçı ülkemizin farklı bölgesinde doğal ortamda görülebilmektedir (Li ve Mündel, 1996; Golkar ve Karimi, 2019).

Aspir, insanoğlunun kullandığı en eski mahsullerinden birisidir. İlk olarak Çin'de 2.300 yıl öncesinde kullanılmış olduğu; ayrıca, aspir tohumunun 4.100 yıl önce Mısır da bulunan mezarlıklarda tespit edildiği bildirilmiştir. Aynı zamanda, aspir bitkisi üretimini yapan "ABD, Meksika, Etiyopya, Arjantin, Avustralya, Çin, Kenya, Kanada, İspanya, İtalya, Türkiye, Irak, İran, Fas ve Rusya" gibi ülkelerdir (Nazir, 2021; Sharma ve ark., 2022).

Genel olarak aspir bitkisinin yaygın isimleri, bulundukları ülkesine, bölgesine, diline ve kullanım alanına göre farklı olmuştur. C. tinctorius L. "Hindistan ve Pakistan'da" "kusum", Çin'de ise "honghua (kırmızı çiçek)" olarak isimlendirildiği bilinmektedir (Yue ve ark., 2013; Dinçel, 2024).

Aspir, önemli bir yağlı tohum bitkisi, kesme çiçek, tıbbi bitki, sebze ve hayvan yemi olarak geliştirilebilecek büyük bir potansiyele sahiptir. Dünya genelinde, aspir hemen hemen sadece çiçeklerinin farklı alanlarda kullanımından dolayı yetiştirilmiştir. Bunun sebebi aspirden toplanan çiçekler birçok hastalık tedavisinde kullanılmıştır. Ayrıca, çiçekler çay olarak tüketilmiştir. Buradaki temel neden, çiçekteki "aminoasitler, mineral maddeler ve bazı vitaminlerin (B1, B12, C ve E)" bulunmasıdır. Yapılan son araştırmalara göre Aspir bitkisinin sarı çiçeklerinde antioksidan maddesinin önemli oranda olduğu tespit edilmiştir. Aspir çiçekleri 2 farklı tipte boya maddesine sahiptirler; "suda erimeyen kırmızı renkli "Carthamin" ve suda eriyebilen sarı renkli" "Carthamidin" maddeleridir. Bu her bir boya maddesinin de gıda boyası olarak ve tekstil endüstrisinde kullanılmıştır (Landau ve ark., 2004; Sefaoğlu ve Özer, 2022).

Bunlara ek olarak, aspir bitkisinin tıbbi amaçla kullanılmasındaki önemli nokta; kadınlarda regl dönemlerindeki ağrılar, kalp damar hastalıkları, şişkinlikler ve ağrıların tedavisinde; klinik çalışmalarda tansiyonun düşürdüğü ve kan akışının artmasıyla oksijenin daha fazla alınması sağlandığı gözlenmektedir. Ayrıca, Ortadoğu ülkelerinde aspir bitkisi, ateş düşürücü olarak, kusmayı teşvik ettiği için zehirlenmelerde panzehir olarak ve ishal yapıcı olarak kullanılmıştır (Delshad ve ark., 2018; Öner ve Şeker, 2020; Eroğlu ve Demir, 2021).

Tüm dünyada yıllardır süren yağ açığı her yıl artan bir döviz kaybına sebep olmaktadır. Mevcut sorunların çözümü için yağ bitkisi durumundaki bitkilerin veriminin artırılmasının yanı sıra farklı çeşit yağlı tohumlu bitkilerin de üretiminin yapılması gerekmektedir. Aspir yağı insan beslenmesi için önemli olduğu kadar biyodizel hammaddesi olarak da büyük önem taşımaktadır (Ekin, 2005; Delshad ve ark., 2018).

Tohumlardan elde edilen yağ, doğrudan yemeklik olarak kullanılmaktadır. İnsan sağlığı için önemli olan toplam doymamış yağ asitleri oranı çok yüksektir. Ayrıca, bazı çeşitlerde yüksek oranda linoleik asit (Omega-6), bazı çeşitlerde ise daha yüksek oranda Oleik asit (Omega 9) bulunur. Son zamanlarda aspir çeşitleri amacına göre oleik asit tipi ve linoleik asit tipi olarak ıslah edilmektedir. Oleik asit (Omega 9) oranı yüksek olan çeşitler daha çok yemeklik yağ eldesi için kullanılmaktadır. Özellikle kızartmalık yağ olarak kullanımına daha uygundurlar.

Linoleik asit tipi olan aspirler ise daha çok diyetisyenlerin tercih ve tavsiye ettiği tip olan ve zayıflamaya yarayan aspir yağı eldesi için kullanılmaktadır.
Genel olarak aspir yağındaki yağ asitleri; oleik asit, linoleik asit, linolenik asit, palmitik asit ve stearik asit içermektedir. Aspir tohumu, "yağ, küspe, kuş yemi ve çeşitli endüstriyel ürünler" için hammadde olarak kullanılmaktadır. Ayrıca, yağı soğuk pres veya ekstraksiyon ile alındıktan sonra kalan küspe, çiftlik hayvanları için protein takviyesi olarak kullanılır. Genellikle küspe % 21-26 protein ve çok miktarda lif içermektedir (Sabzalian ve ark., 2008; Rahim ve ark., 2023).
Tüm dünyada ilgili bilimsel araştırmalarda, araştırmacıların, aspir bitkisinin agronomisini, fizyolojisini ve ekofizyolojisini detaylı olarak araştırmaları için aspir potansiyeli üzerinde ciddi anlamda durulması gerektiği öngörülmektedir. Ayrıca, aspir bitkisinin, yağlı tohum özelliğinin yanı sıra çiçeklerinin sahip olduğu önemli biyokimyasal içeriğin birçok alanda kullanımının artması için ve önemli seviyeye gelmesi için araştırmaların genişletilmesi gerekmektedir. Zaten son zamanlarda aspir bitkisinin endüstride hem tohum hem de çiçeklerinin çok kullanılmaya başlanması sonucunda önemi giderek daha iyi anlaşılmaktadır. Aynı zamanda, aspir bitkisinin öneminin farkına varılması, üretiminin ve ıslah araştırmalarının artmasına neden olmuştur. Yeni yeni çeşitler geliştirilmektedir.

Aspir bitkisinin Sistematiği ve morfolojik gelişimi;

Aspir bitkisi, Compositae veya yeni ismiyle Asteraceae familyasına ve Carthamus cinsine ait olan bir endüstri bitkisidir. Kültürü yapılan Carthamus tinctorius L.'nin kromozom sayısı 2n=24'tür. Mevcut bitki, dallanabilen, deve dikenine benzeyen tek yıllık veya yazlık otsu bir bitkidir, genel olarak sıcak-kuru iklimlerde yağlı tohum ve çiçekleri için yetiştirilen aspir bitkisi, tohumlarından yağ eldesi dışında çiçekleri, tıbbi amaçlı kullanımının yanı sıra boya endüstrisinde kullanılmaktadır. Aspir bitkisi, 35-200 cm yüksekliğe kadar çıkabilen ve 2-3 cm çapında çiçek tablaları üzerinde çiçekleri bulunan bitkilerdir. Ayrıca, yağışın fazla olduğu bölgelerde ve sera üretimi altında kesme çiçek veya sebze olarak da yetiştirilmektedirler. Yüksek rakımlarda bitki büyüme ve gelişmesinin uzama ve çiçeklenme dönemlerinde don olayı yaşanmaması şartıyla deniz seviyesinden 2000 m yüksekliğe kadar değişen rakımlarda yetiştirilebilirler. Bunlara ek olarak bitkinin çiçeklerinin renkleri çeşitlerine göre değişmekle birlikte, parlak sarı, turuncu veya kırmızı çiçeklidir (Chapman ve Burke, 2007; Mündel ve Bergman, 2010; Fan ve ark., 2014).
Aspir bitkisinin çimlenmesi sıcaklığa bağlı olarak 3-8 gün sürer ve 2-5°C gibi düşük sıcaklıklarda gerçekleşebilirler. Çimlenmeyi yavaş büyüyen rozet aşaması takip eder, bu aşamada toprak seviyesine yakın çok sayıda yaprak üretilir ve güçlü kazık kökler gelişir. Aspir, büyüme ve gelişmenin uzama ve çiçeklenme aşamalarında don olmaması koşuluyla -7-8°C arasında geniş bir sıcaklık aralığını tolere edebilmektedir. Aspir bitkisinde dallanma açısı 30-70° arasında değişmekte ve dallanma derecesi genetik ve çevresel etkileerle kontrol edilmektedir (Fan ve ark., 2014; Khalid ve ark., 2017). Çiçeklenme dönemi kültürel uygulamalara ve iklim koşullarına, özellikle de sıcaklığa bağlı olarak 4-6 hafta sürebilmektedir. Çiçekler boru şeklindedir ve genellikle %10'dan daha az çapraz tozlaşma ile büyük ölçüde kendine tozlaşma mevcuttur. Aspir tohumu %30-63 kabuk ve %42-65 çekirdekten oluşmaktadır. Tohum yağ içeriği çeşide ve yetiştirme ortamına bağlı olarak değişmektedir. Ayrıca, bitkide yaprak büyüklüğü çeşitler arasında ve hatta tek bir bitki içinde önemli ölçüde değişmektedir. Yapraklar genellikle alt gövdede derin ve tırtıklı olup kısa ve serttir. Ancak, alt yapraklar genellikle dikensizdir (Khalid ve ark., 2017). Çeşitler dikenli ve dikensiz olarak gruplandırılır. Dikenli olan çeşitlerde yağ oranı daha yüksektir.

Aspir bitkisinin kullanım alanları;

Aspir, çoğunlukla çiçek ve yüksek kaliteli yağı için yetiştirilen çok amaçlı bir yağlı tohum bitkisidir. Aspir bitkisinin kullanım alanları yaklaşık olarak 2.200 yıl önce Çin'de belirtilmiştir. Geleneksel olarak aspir, tohumları için, çiçekleiyle gıdaları renklendirmek ve tatlandırmak için, ilaç olarak ve özellikle daha ucuz kırmızı ve sarı boyalar yapmak için yetiştirilmiştir. Mısır'da aspirden elde edilen boya, pamuk ve ipeği renklendirmenin yanı sıra dini törenlerde kullanılan tören merhemi ve mumyaları bağlamadan önce yağlamak için kullanılmıştır. Aspirden elde edilen yağın çok amaçlı kullanımları mevcuttur. Bitkinin sap kısımları yakacak olarak kullanılmaktadır. Aynı zamanda, endüstrinin birçok alanında geniş yer edinen yağ mürekkep ve plastik yapımında, organik çözücü olarak, pestisit ve herbisit olarak, biyodizel üretimi gibi birçok alanda kullanımları olduğu bilinmektedir. Bunlara ek olarak, aspir bitkisi ruminant hayvanların beslenmesi için silaj veya kurumuş ot yapımında, yem sanayisinde, yüksek oranda protein olmasıyla hayvan küspesi için tercih edilen önemli bir bitkidir (Khalid ve ark., 2017; Gomashe ve ark., 2021).

Aspir bitkisinin Tıbbi amaçlı kullanımı;

Geleneksel Çin tıp kaynaklarında, aspir yaprakları kan dolaşımını ve balgamı azalttığı, kırıkların, ezilmelerin ve zorlanmaların iyileştirilmesi ve çeşitli kadın hastalıkları için bir kullanılmıştır. Aspir üretimi birçok tıbbi çözüm sağlamıştır. Bu nedenle Çin'de aspir tıbbi bir bitki olarak bilinir. Avrupa ve Orta Doğu'da, yaprakları bazen safran için bir katkı maddesi olarak kullanılır. Öğütülmüş aspir tohumları hardal yağı ile karıştırılarak romatizma ağrılarını azaltır. Keşmir'de, idrar yollarını temizlemek, karaciğeri iyileştirmek ve kurdeşeni azaltmak için bütün veya öğütülmüş tohumlardan oluşan bir karışım kullanılır. Ayrıca, aspir tohumunun idrar taşı tedavisinde kullanıldığı bildirilmiştir. Buna ek olarak, Afganistan ve Hindistan'daki kadınlar düşük ve kısırlığı önlemek için aspir çiçek ve yapraklarından yapılan bir çay kullanmaktadırlar. Belirtilen ülkelerde aktarlar Aspir bitkisinin tüm kısımlarını çeşitli rahatsızlıkları iyileştirmek için ve afrodizyak olarak satmaktadır. Aynı zamanda, Nisan 2007'de genetiği değiştirilmiş aspir bitkisinin insülin üretmek üzere yetiştirildiği bildirilmiştir. SemBioSys Genetics adlı bir ilaç şirketi şu anda transgenik aspir bitkilerini insan insülini üretmek için kullanmaktadır çünkü hormona olan küresel talep artmıştır. Aspirden elde edilen insan insülini şu anda insan denekler üzerinde PI/II denemelerindedir. Aspir bitkisinden elde edilen ve SemBioSys Genetics tarafından üretilen insülin (SBS-1000) ilk kez insanlara enjekte edilmiştir. Yüksek oleik asit tipi aspir yağının doymuş yağ oranı daha düşük, tekli doymamış yağ oranı ise zeytinyağından daha yüksektir. Yüksek oleik asit içeren yağ, koroner arter hastalığının önlenmesinde faydalı bir ajandır (Emongor, 2010; Gomashe ve ark., 2021).

Aspir bitkisinin hayvan yemi olarak kullanılması;

Aspir bitkisinin, saman veya silaj olarak depolanabilir olduğu bilinmektedir. Yemin hayvan için lezzetli olmasının yanında; yem değeri ve verimi yüksektir. Yeşil aspir yeminin in vivo sindirilebilirliği ve alımı, fiğ-yulaf karışımınınkine benzerdir. Avustralya sığırlarında aspir bitkisiyle tatmin edici büyüme oranlarının olduğu; ayrıca, Kanada koyunlarında ise doğurganlığı artırdığı gözlemlenmiştir. Buna ek olarak, aspir çiçeklenme aşamasında veya hemen sonrasında kesilirse önemli bir çiftlik hayvan yemi olarak kullanılmaktadır. Tomurcuklanma aşamasında hasat edilen aspir silolanabilir ve aspir silajı, yüksek verimli süt inekleri ve süt koyunlarının diyetinde süt performanslarını etkilemeden tahıl silajı yerine kullanılmıştır. Aspir küspesi yaklaşık %24 protein içerir ve lif oranı oldukça yüksektir. Besin takviyesi olarak da alınabilir. Bu nedenle, çiftlik hayvanları ve kümes hayvanları yemlerinde protein takviyesi olarak kullanılır. Aspir silajı, aspir kuraklığa toleranslı olduğu için birçok ülkede, özellikle yarı kurak ve kurak ülkelerde yem olarak yaygın bir şekilde benimsenme potansiyeline sahiptir.

Aspir tohumunun bir diğer kullanım alanı da kuş yemi olarak kullanılmasıdır. Aspir tohumu, kuş yemlerinde ayçiçeğine alternatif olarak da oldukça yaygın bir şekilde kullanılmaktadır. Kuş yemi endüstrisi, çizgili ve ince kabuklu türlerin genellikle yağ ve protein içeriği daha yüksek olmasına rağmen Aspir bitkisinin beyaz kabuklu veya normal kabuklu türünü kullanmayı tercih etmektedir (Phuduhudu ve ark., 2016; Khalid ve ark., 2017; Peiretti, 2017).

Aspir bitkisinin gıda amaçlı olarak kullanımı;
Gıda üreticileri ve gıda endüstrileri aspir yağını çok farklı alanlarda kullanmaktadır. Aspir yağı genellikle ayçiçek yağından daha sağlıklı bir seçenek olarak kabul edilmesinin yanı sıra; yağ iki türden oluşur: Oleik asit tipi, yani tekli doymamış yağ asidi (oleik asit) ve linoleik asit tipi, çoklu doymamış yağ asidi (linoleik asit) bakımından yüksek olan aspir yağlarıdır. Şu anda baskın yağ pazarı, oleik asit bakımından yüksek ve doymuş yağ asitleri bakımından çok düşük tohumlar üreten çeşitler içindir. Yaklaşık son 50 yıldır, bitki esas olarak tohumlarından elde edilen bitkisel yağ için yetiştirilmektedir. Aspir yağı ısıya dayanıklıdır, bu nedenle patates kızartması, cips ve diğer atıştırmalık yiyecekleri kızartmak için yemeklik yağ olarak kullanılır. Aspir yağı ayrıca gıda kaplamalarında ve bebek maması formülasyonlarında da kullanılır. Aspir yağı ayrıca salata soslarında ve margarin üretiminde de kullanılır. Aspir tohumundaki yağ %91 doymamış yağ asitleridir. Aspir yağının insan sağlığında kullanılması yağın kalitesi ve yağ asit kompozisyonlarının içermesinin yanısıra, "%30-35 karbonhidrat, %13-16 protein, %4-9 nem, %3-8 kül" içermektedir (Adamska ve Biernacka, 2021). Çiçekler zaman zaman safran yerine daha ucuz bir alternatif olarak yemeklerde kullanılır. Aspir yaprakları sebze olarak yenmektedir. Aspir yaprakları gıdaları renklendirmek için kullanılır. Pirinç, çorba, soslar, ekmek ve turşular çiçeklerden sarı ila parlak turuncu bir renk alır. Sentetik gıda renklendiricilerine ilişkin sağlık endişeleri aspir türevi gıda renklendiricilerine olan talebi artırabilir. Çin, gıdalarda kullanılmak üzere carthamin boyası üretmektedir. Aspir sarı (carthamidine) ve kırmızı (carthamin) pigmentleri, gıda ve kozmetiklerin renklendirilmesinde kullanılabilen güvenli ve doğal pigmentlerdir. Aspir yaprakları aynı zamanda hoş bir tada sahip bitki çayı olarak da kullanılır. İran'da peynir lorunun oluşumunu hızlandırmak için aspir tohumu macunu kullanılır. Kavrulmuş tohumlar, genellikle nohut, arpa veya buğdayla karıştırılarak Etiyopya ve Sudan'da atıştırmalık yiyecek olarak yenmektedir (Khalid ve ark., 2017; Adamska ve Biernacka, 2021).

SONUÇ
Aspir (Carthamus tinctorius L.) bitkisel yağ olarak kullanımı olan; kuraklığa, kıraç alanlara soğuğa toleranslı olması, yüksek adaptasyon kabiliyetli olan bir endüstri bitkisidir. Yağ bitkisi olma özelliği ön plana çıksada, bitkinin tıp alanındaki faydaları, birbirinden farklı pek çok birçok endüstriyel alanda kullanımına imkan vermektedir. Aspir bitkisinin birçok kullanım alanı olmasına rağmen hak ettiği önem verilmemiş ve ekim alanı ülkemizde yeterli seviyelere ulaşamamıştır. Aynı zamanda ekonomik açıdan da önemli bir ürün olan aspir bitkisinin ihmal edildiği, yeterli düzeyde kullanılmadığı bilinmektedir. Birçok alanda faydalı olduğu konusunda tüm dünyada farkındalık yaratılması gerekmektedir. Araştırmacıların aspir bitkisine olan ilgisini artırmak ve geliştirmek; agronomi, fizyoloji, hastalıklar ve patojenler, geliştirme yöntemleri, morfolojik, genetik çalışmalarla tohum verimini artırmak; kullanım alanlarını incelemek; ilaç hammaddesi olarak geliştirmek; farklı hastalıkların tedavisi için aspirden elde edilen ürünlerin geliştirilmesine yönelik klinik denemelerle ilgili konuları ele almak amacıyla multidisipliner çalışmalar yapılması öngörülmektedir. Bunlara ek olarak, kuru tarımda adaptasyonun çok rahat olmasının yanısıra, yazlık ve kışlık üretimi yapılabilen çeşitlerin olmasıyla farklı ekolojik bölgelerde yetiştirilebilmesi, nadas alanlarının tarımda yeniden kullanılması için alternatif olabilmesi, ülkemizde yağ açığının giderilmesinde kayda değer potansiyelinin olması Aspir bitkisinin dikkat çekilmesinde ana sebeplerdendir.

KAYNAKLAR

Adamska, I., & Biernacka, P. (2021). Bioactive Substances in Safflower Flowers and Their Applicability in Medicine and Health-Promoting Foods. International journal of food science, 2021(1), 6657639.

Chapman, M. A., & Burke, J. M. (2007). DNA sequence diversity and the origin of cultivated safflower (Carthamus tinctorius L.; Asteraceae). BMC plant Biology, 7, 1-9.

Delshad, E., Yousefi, M., Sasannezhad, P., Rakhshandeh, H., & Ayati, Z. (2018). Medical uses of Carthamus tinctorius L.(Safflower): a comprehensive review from traditional medicine to modern medicine. Electronic physician, 10(4), 6672.

Dinçel, N. G. K. (2024). Yağ Bitkileri İçinde Kıymetli Bir Alternatif; Aspir (Carthamus tinctorius L.). Bilecik Şeyh Edebali Üniversitesi Fen Bilimleri Dergisi, 11(1), 195-203.

Ekin, Z. (2005). Resurgence of safflower (Carthamus tinctorius L.) utilization: A global view. Journal of Agronomy, 4(2), 83-87.

Emongor, V. (2010). Safflower (Carthamus tinctorius L.) the underutilized and neglected crop: a review.

Eroğlu, K., & Demir, İ. (2021). Aspir (Carthamus tinctorious L.) tarımında çiftçi eğiliminin belirlenmesi Mucur ilçesi örneği. Kırşehir Ahi Evran Üniversitesi Ziraat Fakültesi Dergisi, 1(2), 67-80.

Fan, S., Lin, N., Shan, G., Zuo, P., & Cui, L. (2014). Safflower yellow for acute ischemic stroke: A systematic review of randomized controlled trials. Complementary Therapies in Medicine, 22(2), 354-361.

Golkar, P., & Karimi, S. (2019). Safflower (Carthamus tinctorius L.) Breeding. Advances in Plant Breeding Strategies: Industrial and Food Crops: Volume 6, 537-575.

Gomashe, S. S., Ingle, K. P., Sarap, Y. A., Chand, D., & Rajkumar, S. (2021). Safflower (Carthamus tinctorius L.): An underutilized crop with potential medicinal values. Annals of Phytomedicine, 10(1), 242-248.

Gürsoy, M., Başalma, D., & Nofouzi, F. (2018). Effects of safflower cultivars (Carthamus tinctorius L.) on yield and yield components of different row and row spaces. Selcuk Journal of Agriculture and Food Sciences, 32(1), 20-28.

Khalid, N., Khan, R. S., Hussain, M. I., Farooq, M., Ahmad, A., & Ahmed, I. (2017). A comprehensive characterisation of safflower oil for its potential applications as a bioactive food ingredient-A review. Trends in food science & technology, 66, 176-186.

Landau, S., Friedman, S., Brenner, S., Bruckental, I., Weinberg, Z. G., Ashbell, G & Leshem, Y. (2004). The value of safflower (Carthamus tinctorius) hay and silage grown under Mediterranean conditions as forage for dairy cattle. Livestock Production Science, 88(3), 263-271.

Li, D., & Mündel, H. H. (1996). Safflower, Carthamus Tinctorius L (Vol. 7). Bioversity International.

Mündel, H. H., & Bergman, J. W. (2010). Safflower. Oil Crops, 423-447.

Nazir, M., Arif, S., Ahmed, I., & Khalid, N. (2021). Safflower (Carthamus tinctorius) seed. Oilseeds: health attributes and food applications, 427-453.

Öner, E. K., & Şeker, T. (2020). Determination of yield and yield components of some safflower (Carthamus tinctorius L.) varieties.

Peiretti, P. G. (2017). Nutritional aspects and potential uses of safflower (Carthamus tinctorius L.) in livestock. Agricultural research updates, 19, 3-22.

Phuduhudu, D., Emongor, V. E., Oagile, O., & Oarabile, P. (2016). Evaluation of nutritional quality of safflower for use as animal feed.

Rahim, M. A., Ayub, H., Sehrish, A., Ambreen, S., Khan, F. A., Itrat, N. & Rocha, J. M. (2023). Essential components from plant source oils: A review on extraction, detection, identification, and quantification. Molecules, 28(19), 6881.

Sabzalian, M. R., Saeidi, G., & Mirlohi, A. (2008). Oil content and fatty acid composition in seeds of three safflower species. Journal of the American Oil Chemists' Society, 85(8), 717-721.

Sefaoğlu, F., & Özer, H. (2022). Response of safflower (Carthamus tinctorius L.) to planting rate and row spacing in a high altitude enviroment. Erciyes Tarım ve Hayvan Bilimleri Dergisi, 5(1), 1-10

Singh, V., & Nimbkar, N. (2006). Safflower (Carthamus tinctorius L.). Chapter, 6, 167-194.

Sharma, S., Pokharia, A. K., Kumar, A., Srivastava, A., & Yadav, R. (2022). Carthamus L.: Origin, distribution and its archaeological records in India. Journal of Palaeosciences, 71(2), 177-186.

Yue, S., Tang, Y., Li, S., & Duan, J. A. (2013). Chemical and biological properties of quinochalcone C-glycosides from the florets of Carthamus tinctorius. Molecules, 18(12), 15220-15254.

INVESTIGATION OF THE USABILITY OF HEMP FIBERS AS REINFORCEMENT MATERIAL IN PHOTOCURED POLYMER COMPOSITES

KENEVİR LİFLERİNİN FOTOKÜRLEMELİ POLİMER KOMPOZİTLERDE TAKVİYE MALZEMESİ OLARAK KULLANILABİLİRLİĞİNİN ARAŞTIRILMASI

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ABSTRACT
Introduction and Purpose
With the increasing quest for sustainable materials, the use of natural fibers in composite materials has become a significant area of research. Hemp fiber, known for its high strength, low density, and eco-friendliness, stands out in this field. On the other hand, polymers play a crucial role in composite production. However, many synthetically produced polymers emit volatile organic compounds (VOCs) during production and use. Photoinitiated systems, a greener polymerization method, are increasingly preferred for polymer composite production. This study investigates the engineering properties of polymer composites produced using hemp fiber reinforcement and eco-friendly photoinitiated polyester resins.
Materials and Methods
In this study, UV-cured polyester composites were reinforced with 1-5 mm long chopped micro fibrillated hemp fibers, obtained from the Kastamonu region, at weight ratios of 0,25%, 0,5%, and 1% of the resin. The produced composite sheets were subjected to density, hardness, tensile, flexural, compressive, and impact strength tests. Additionally, microstructural, and morphological analyses were performed using SEM.
Results
The results indicate that the use of hemp fibers in UV-cured polymer composites has great potential in improving mechanical properties and environmental sustainability. The natural and biodegradable properties of hemp fibers provide a significant advantage for future applications of these materials.
Key Words: Polymer; Composite; Hemp fiber; Photopolymerization; Reinforcement; Polyester

ÖZET
Giriş ve Amaç: Sürdürülebilir malzeme arayışının artmasıyla birlikte, doğal liflerin kompozit malzemelerde kullanımı önemli bir araştırma alanı haline gelmiştir. Kenevir lifi, yüksek mukavemeti, düşük yoğunluğu ve çevre dostu olması nedeniyle bu alanda ön plana çıkan bir malzemedir. Diğer taraftan polimerler kompozit üretiminde önemli bir yer tutmaktadır. Ancak sentetik olarak imal edilen birçok polimer gerek üretim gerekse kullanım sürecinde uçucu organik bileşikler (VOC) açığa çıkarmaktadır. Daha çevreci bir polimerizasyon yöntemi olan fotobaşlatıcılı sistemler polimer kompozit üretiminde hergeçen gün daha fazla tercih edilmektedir. Bu çalışma kapsamında doğal bir lif kaynağı olan kenevir lifi takviyeli ve çevre dostu fotobaşlatıcılı polyester reçineleri kullanılarak üretilen polimer kompozitlerin mühendislik özellikleri araştırılmıştır.

Materyal ve Yöntem: Çalışma kapsamında UV kürlemeli polyester kompozit içerisine Kastamonu bölgesinden temin edilen soyumluk lifler kullanılarak elde edilmiş 1-5 mm uzunluğunda kırpılmış mikrofibrile kenevir lifleri reçine ağırlığının %0,25, %0,5 ve %1 oranında takviye edilerek polimer kompozit levhalar üretilmiştir. Üretilen levhalardan alınan numuneler üzerinde yoğunluk, sertlik, çekme, eğilme, basınç ve darbe dayanımı deneyleri gerçekleştirilmiştir. Ayrıca mikro yapı ve morfolojik incelemeler için SEM analizleri gerçekleştirilmiştir.

Sonuçlar: Sonuç olarak, kenevir liflerinin UV kürlemeli polimer kompozitlerde kullanımı hem mekanik özelliklerin iyileştirilmesi hem de çevresel sürdürülebilirlik açısından büyük bir potansiyele sahiptir. Kenevir liflerinin doğal ve biyobozunur özellikleri, bu malzemelerin gelecekteki uygulamaları için önemli bir avantaj sağlamaktadır

Anahtar Kelimeler: Polimer; Kompozit; Kenevir lifi; Fotopolimerizasyon; Takviye; Polyester

GİRİŞ

Kompozit malzemeler, farklı malzemelerin ustaca bir araya getirilmesiyle üstün özelliklere sahiptirler ve bundan dolayı çeşitli endüstriyel uygulamalarda daha fazla tercih edilmektedirler [1]. Kompozit malzemelerin daha düşük maliyetlere ve daha çevre dostu ürünler olarak üretilebilmeleri, geri dönüşüme olanak sağlayabilmeleri ve dayanımı yüksek malzemeler olarak geliştirilebilmeleri konusunda önemli araştırmalar yapılmaktadır. Birçok etken göz önünde bulundurulduğu zaman araştırmacılar, yaygın kullanıma sahip olan kompozit malzemelerin, sürdürülebilir ve biyobozunur olmalarından dolayı doğal liflerle takviye edilen türlerinin üretimi üzerine yoğunlaşmışlardır [2].

Son yıllarda, çevresel sorunlar ve kanuni kısıtlamalar, endüstrileri çevre dostu ürünler yapmak için petrol bazlı malzemeyi tarım bazlı olanla değiştirmeye yöneltmiş, yeşil ürünler yapma amacıyla polimerleri güçlendirmek için doğal lifler kullanılmaya başlanmıştır [3]. Kenevir, keten, jüt, sisal vb. gibi doğal lifler, cam ve karbon lifleri gibi yaygın inorganik veya sentetik liflere göre bazı avantajlara sahiptir. Bu avantajlar daha düşük yoğunluk, işleme sırasında daha az makine aşınması, sağlık tehlikesi olmaması ve yüksek derecede esnekliktir. Genel olarak kenevir, keten, jüt, pamuk gibi lignoselülozik uzun liflerle güçlendirilmiş kompozitler, yüksek mukavemet/ağırlık ve yüksek sertlik/ağırlık oranlarına sahiptir ve bu da onları havacılık ve otomotiv uygulamalarında kullanışlı hale getirmektedir [4].

Günümüzde kompozit malzeme çalışmalarında doğal liflerin takviye malzemesi olarak kullanımına yönelik çok sayıda çalışma bulunmaktadır [5][6][7][1]. Bu bağlamda, kenevir bitkisi, sürdürülebilir ve yenilenebilir özellikleri ile birlikte üstün performans sergileyen bir malzeme olarak, endüstriyel ve ekonomik açıdan giderek daha fazla önem kazanmaktadır [8]. Endüstriyel kenevir bu amaçla kullanılan ve sentetik liflerle kıyaslanabilecek yeterli mekanik özelliklerine ek olarak iyi elektrostatik özellikler, emicilik, UV dirençli ve anti alerjik olma gibi özellikleriyle öne çıkan doğal bir liftir [9][10]. Sentetik liflerin çoğunluğunun petrol türevi hammaddelerden üretiliyor olması, bundan kaynaklanan çevresel etkiler, üretim zorluğu, maliyet, geri dönüştürülerek kullanım imkanının olmaması nedenleriyle doğal liflerin sağlayacağı katkılar konusunda beklentilerin yüksek olmasına neden olmaktadır. [5] .

Kenevir lifleri, düşük yoğunlukları (1,248 $g.cm^{-3}$) ve biyobozunur özellikleri nedeniyle sürdürülebilir kompozit malzeme üretiminde takviye malzemesi olarak kullanımı için oldukça avantajlıdır [11][12][13] . Dahası, sentetik cam lifinden yaklaşık %70 daha düşük maliyette olması yüksek özgül modül ve mukavemete sahip olması [14][15], (yaklaşık 310–7500 MPa çekme mukavemetine) keneviri, tüm doğal lifler arasında en güçlü liflerden biri yapmaktadır [16]. Bu durum, liflerin matrisle olan etkileşimi ve dağılımı ile doğrudan ilişkilidir [17]. Ayrıca, kenevir lifleri yakıldığında yanma sırasında minimum kalıntı bırakır ve çok düşük CO_2 emisyonuna sahiptir [18]. Kenevir liflerinin takviye malzemesi olarak kullanımı, ayrıca kompozitlerin termal ve akustik özelliklerini de iyileştirebilir. Bu özellikler, kenevir liflerinin doğal yapısından kaynaklanmaktadır ve bu durum, kenevir bazlı kompozitlerin çeşitli endüstriyel uygulamalarda kullanılabilirliğini artırmaktadır [19]. Kenevir lifinin mükemmel özellikleri nedeniyle, son on yılda kenevir lifi takviyeli kompozitler üzerindeki araştırmalar ilgi odağı haline gelmiştir [20].

Kenevir liflerinin polimerlerde takviye olarak kullanılması sayesinde reçine matrisin mekanik özelliklerin artmasıyla birlikte, elde edilen ürünün maliyeti de düşer. Son yirmi yıl boyunca, kenevir kompozit endüstrisi, teknolojik gelişmeler ve bu malzemeler için artan uygulamalar nedeniyle sürekli bir büyüme yaşamıştır [5].

Diğer taraftan polimer kompozit üretiminde matris malzemesi olarak termoset reçinelerinden polyester ve epoksinin kullanımı çok yaygındır. Bu reçineler polimerizasyonları sırasında çoğunlukla uçucu organik bileşikler (VOC) salınımı yapmaktadır. Ayrıca polimerizasyon için metil etil keton peroksit ve kobalt oktoat veya naftanat gibi kürleştirici ve hızlandırıcı olarak kullanılan katkılar tehlikeli madde sınıfında yer almaktadır. Bu durum kompozit üretiminde daha çevreci ve VOC salınımı yapmayan polimer reçinelerin kullanımını teşvik etmektedir [21]. Bunun sonucu olarak öncelikle matbaa ve sağlık sektöründe kullanılan fotobaşlatıcılı polimerler, polimer kompozit üretim sektöründe de kullanılmaya başlanmıştır. Bu bağlamda fotobaşlatıcı içeren UV kürlemeli yeni nesil polyester ve epoksi reçineleri geliştirilmiştir [22].

Fotokürlemeli polimerler, UV ışığı ile sertleşen polimerlerdir ve bu tür polimerlerin kullanımı, kompozitlerin üretiminde önemli avantajlar sunmaktadır. Fotokürleme süreci, hızlı ve etkili bir şekilde polimerizasyon sağlar, bu da üretim sürelerini kısaltır ve maliyetleri düşürür [23]

Fotopolimerizasyon, monomerleri uyarıp polimerizasyonu başlatan bir polimerizasyon çeşididir. Bu sistemlerde, elektronlar direkt olarak veya başka bir molekülle reaksiyon sonucu uyarılır ve sonrasında monomerler de uyarılarak polimerizasyon süreci başlatılır [24]. Aşağıdaki Şekil 1'de ışık enerjisine maruz bırakılan fotobaşlatıcının radikal oluşumu şematize edilmiştir.

$$PI \overset{hv}{\rightarrow} H^{+} + R^{\cdot +}$$

Şekil 1. Organik fotokimyasal reaksiyonlar

Fotopolimerizasyon, uygun ışık enerjisi varlığında bir fotobaşlatıcının radikal oluşturulması sonucu meydana gelen bir polimerizasyon sürecidir. Bu süreçte, radikal monomerdeki çift bağları açarak birbirlerine kimyasal bağlarla bağlanarak polimer oluşturur [25].

Fotopolimerizasyon reaksiyonlarında, radikal oluşumu ilk reaksiyon adımıdır. Bu fotokimyasal reaksiyon sonucu oluşan radikal oluşumu, polimerizasyona göre yüzlerce kat hızlı gerçekleşir. Bu nedenle, fotopolimerizasyon, endüstriyel olarak diğer polimerizasyon tekniklerine göre fazlasıyla tercih edilir [26].

Fotokürlemeli polimerlerin, hızlı kürlenme sürelerine sahip olması, polimerizasyonu için tek bileşene ihtiyaç duyması, uzun süre stoklanabiliyor olması, daha az VOC salınımına neden olması, kürlenme esnasında düşük enerji harcaması ve daha düşük sıcaklıklarda polimerizasyonunu gerçekleştirmesi, zahmetsiz ve kolay kullanımı en büyük avantajlarıdır [27][28][29][30].

Kenevir liflerinin fotokürlemeli polimer kompozitlerde kullanılması, bu malzemelerin mekanik özelliklerini artırmanın yanı sıra, çevresel sürdürülebilirlik açısından da önemli bir katkı sağlayacağı düşünülmektedir. [31]. Kenevir lifleri, biyobozunur bir malzeme olmasından dolayı polimer kompozitlerin çevresel etkilerini azaltmaktadır [32].

Çalışma kapsamında çevreci ve yeni nesil bir matris malzemesi olan fotobaşlatıcılı polyester reçineli kompozitlerde mikronize kenevir lifinin takviye olarak kullanılabilirliği, kompozitin mekanik ve fiziksel özelliklerine etkileri araştırılmıştır.

2. MATERYAL VE YÖNTEM

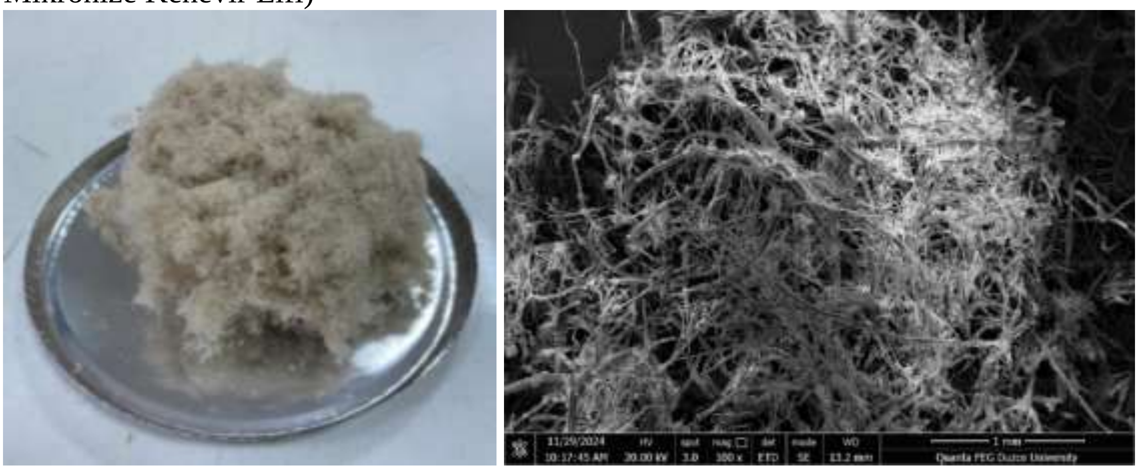
Polimer kompozit üretiminde matris malzemesi olarak; fotobaşlatıcı içeren, UV ile kürlenebilen orta düzeyde reaktivite ve viskoziteye sahip olan BOYTEK Firmasından temin edilen ortoftalik doymamış polyester reçinesi kullanılmıştır. İçerisinde ağırlığının %0.1'i oranında UV absorbe spektrumu 380 nm olan I. tip fotobaşlatıcılardan fosfin oksit bulunmaktadır. Kullanılan UV kürlemeli polyester reçinesine ait teknik özellikler Çizelge 3.1'de verilmiştir.

Çizelge 1. Polimer kompozit üretimlerinde kullanılan polyester reçinesine ait teknik özellikler

Özellik	**Ölçüm Birimi**	**Değer**
HDT	°C	95
Sertlik	Barcol	45
Viskozite (20 °C, sp4 50/5rpm)	cp	300-600
Katı Madde içeriği	%	55-62
Jel Süresi (20 °C, %lCo)	min	10-20
Raf Ömrü (25 "C'nin altında)	ay	6

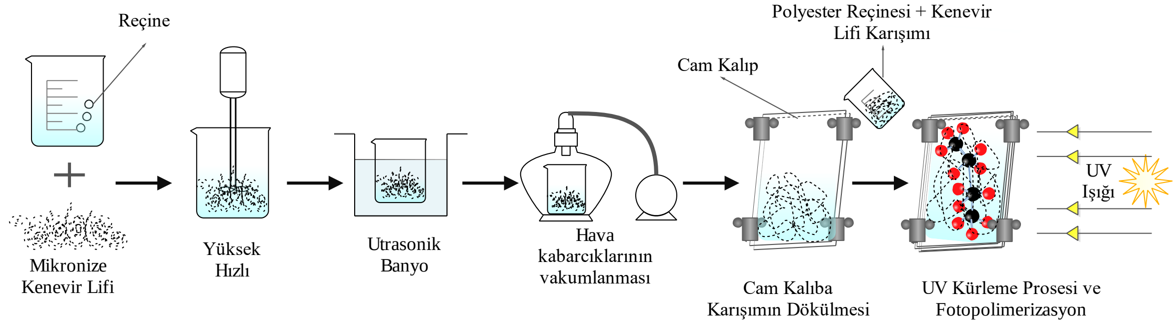
Takviye malzemesi olarak Kastamonu bölgesinde yetişen kurutulmuş kenevir saplarından elde edilen soyumluk lifler kullanılmıştır. Temin edilen bu lifler Şekil 1'de gösterilen mekanik liflendirme ve öğütme proseslerinden geçirildikten sonra mikronize kenevir lifi (MKL) elde edilmiştir. Şekil 2'de MKL üretimi ile ilgili proses görülmektedir. Ayrıca kompozit üretiminde takviye malzemesi olarak kullanılan MKL'ye ait görseller Şekil 3'te verilmiştir.

Şekil 2. Mikronize öğütülmüş kenevir lifinin üretim prosesi
(1: Kenevir sapı ve soyumluk lifi, 2: Kenevir lifleri, 3: Mekanik liflendirme, 4: Öğütücü, 5: Mikronize Kenevir Lifi)

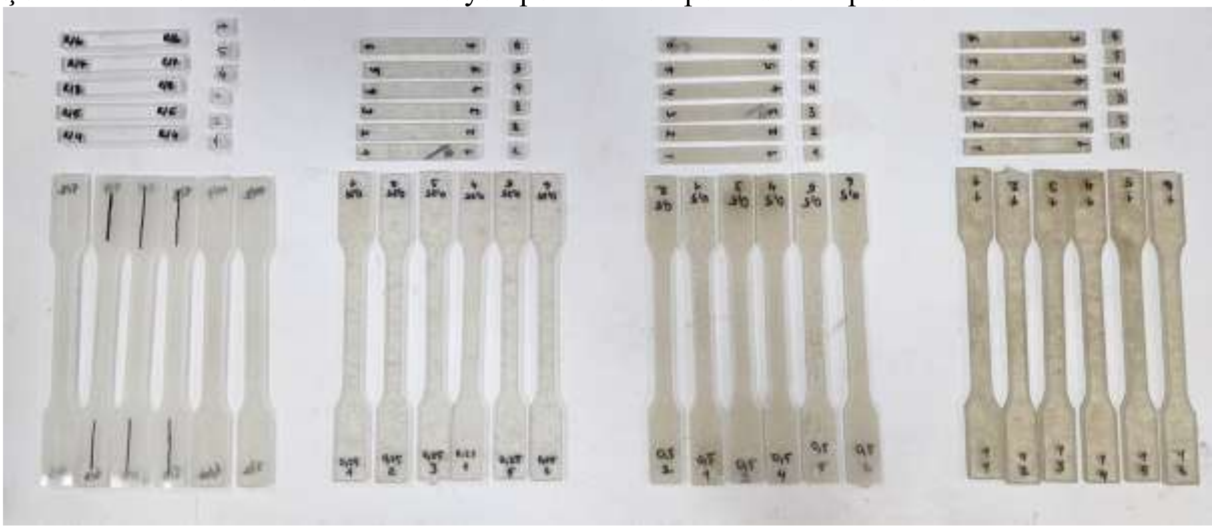


Şekil 3. Takviye malzemesi olarak kullanılan mikronize kenevir lifi

Kompozit malzeme üretim sürecinde fotobaşlatıcılı polyester reçine ağırlığının %0,25, %0,5 ve %1'i oranında MKL katılarak referans numune ile birlikte 4 farklı kompozit levha üretimi gerçekleştirilmiştir. Üretim sürecinde önce MKL ile reçine 2000rpm hızında dönen karıştırıcı ile homojen bir şekilde 5 dakika karıştırılmıştır. Disperse karşım içerisine hapsolan hava kabarcıklarının atılması amacıyla 5'er dakika ultrasonik banyo ve desikatörde vakumlama işlemi gerçekleştirilmiştir. Daha sonra karışım cam kalıplar içerisine dökülerek 380 nm dalga boyuna sahip UV kürleme lambasının önünde her iki yüzeyine 5 er dakikadan toplam 10 dakika fotopolimerizasyona tabi tutulmuştur (Şekil 4). Elde edilen MKL takviyeli polyester kompozit levhalardan Şekil 5'te belirtilen çekme, eğilme ve basınç deney numuneleri CNC'de kesilerek elde edilmiştir.



Şekil 4. Mikronize kenevir lifi takviyeli polimer kompozit üretim prosesi



Şekil 5. Farklı MKL takviyeli polimer kompozitlere ait çekme, eğilme ve basınç deney numuneleri

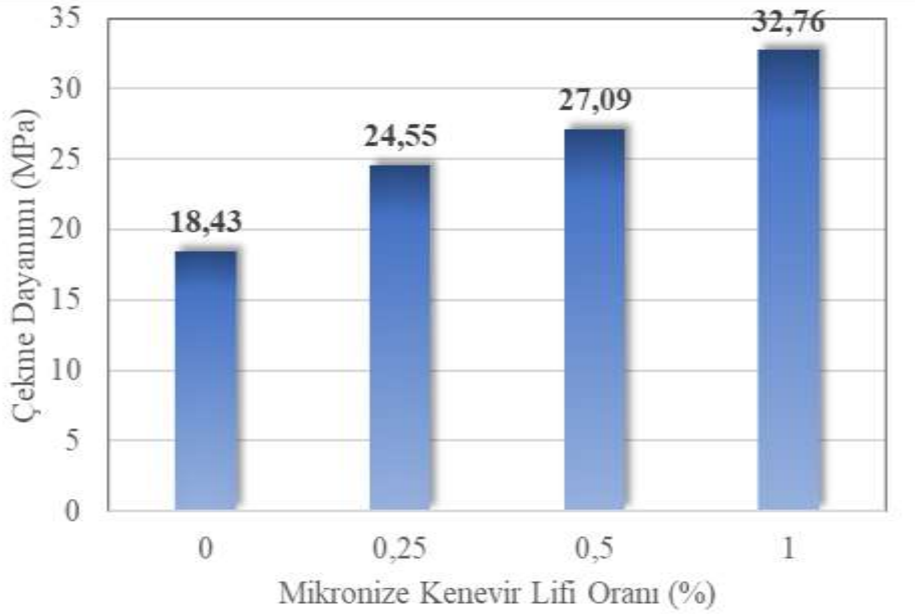
Çekme dayanımı deneyi papyon numuneler üzerinde 1 mm/min yükleme hızı ile TS EN ISO 527-1 [33] standardına uygun olarak, basınç dayanımı deneyi 10x10x4 mm ebadındaki kompozit örnekler üzerinde 2mm/min yükleme hızı ile TS EN ISO 604 [34] standardına uygun olarak, eğilme dayanımı deneyi ise 10x80x4 mm ebadındaki kompozit örnekler üzerinde 2 mm/min yükleme hızı ile TS EN ISO 178 [35] standardına uygun olarak 2,5 ton kapasiteli universal test cihazında gerçekleştirilmiştir.

Diğer taraftan üretilen kompozitlerin sertliklerinin belirlenmesinde TIME firması tarafından üretilen standlı TH-210 Dijital Shoremetre Shore-D sertlik cihazı ile ASTM D 2240 [36] Standardına göre sertlik ve TS EN ISO 1675 [37] standardına göre yoğunluk deneyleri gerçekleştirilmiştir. Ayrıca üretilen MKL takviyeli kompozitlerin mikroyapı incelemesi için SEM analizi gerçekleştirilmiştir.

BULGULAR VE TARTIŞMA

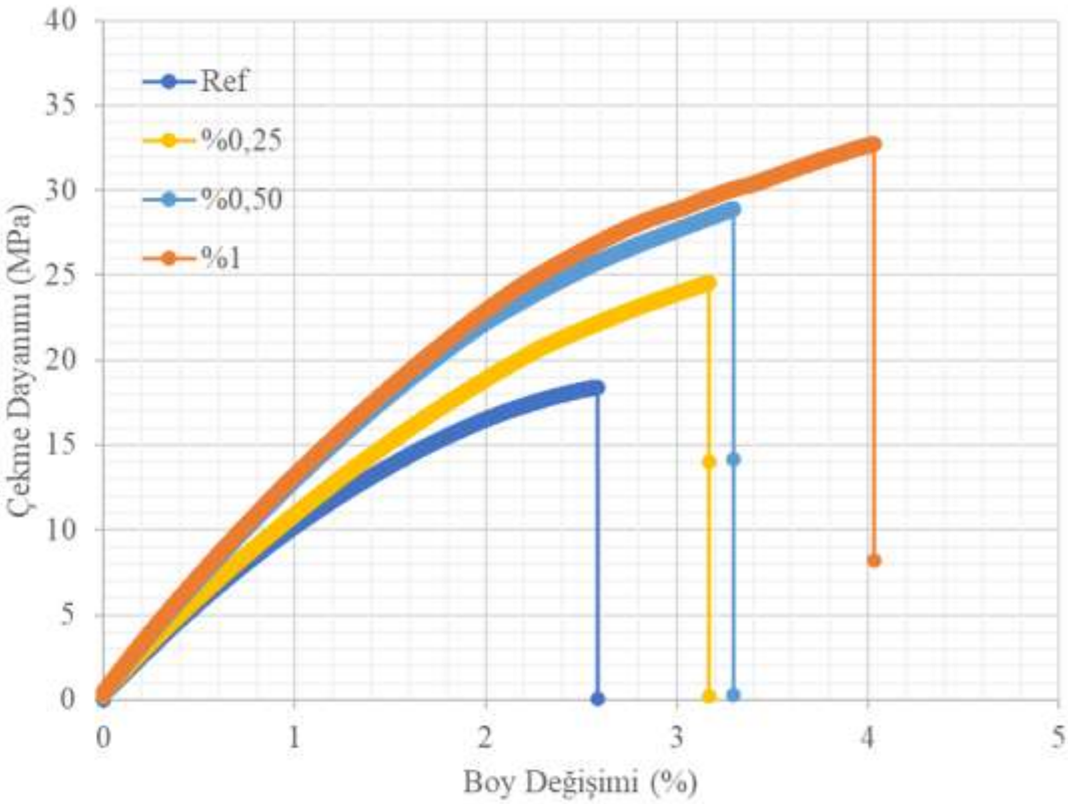
Çekme Dayanımı

Farklı oranlarda mikronize kenevir lifi takviyeli fotobaşlatıcı içeren polyester kompozitler üzerinde gerçekleştirilen Çekme deneyi sonucunda elde edilen ortalama çekme dayanımı değerlerine ait bar grafik Şekil 6'da görülmektedir.



Şekil 6. Ortalama çekme dayanımı değerlerine ait bar grafik

Çekme dayanımı değerlerinin MKL oranına bağlı olarak artış gösterdiği görülmektedir. En düşük çekme dayanımının referans numunede, en büyük çekme dayanımı değerlerinin ise %1 oranında MKL içeren polimer kompozitlerde meydana geldiği tespit edilmiştir. MKL katkı oranına bağlı olarak çekme dayanımı değerlerinin referans numuneye göre sırasıyla %33, 46, 77 oranında artış gösterdiği görülmektedir. Çekme dayanımı deneyi sürecinde elde edilen gerilme-uzama verilerine ait grafik Şekil 7'de verilmiştir.

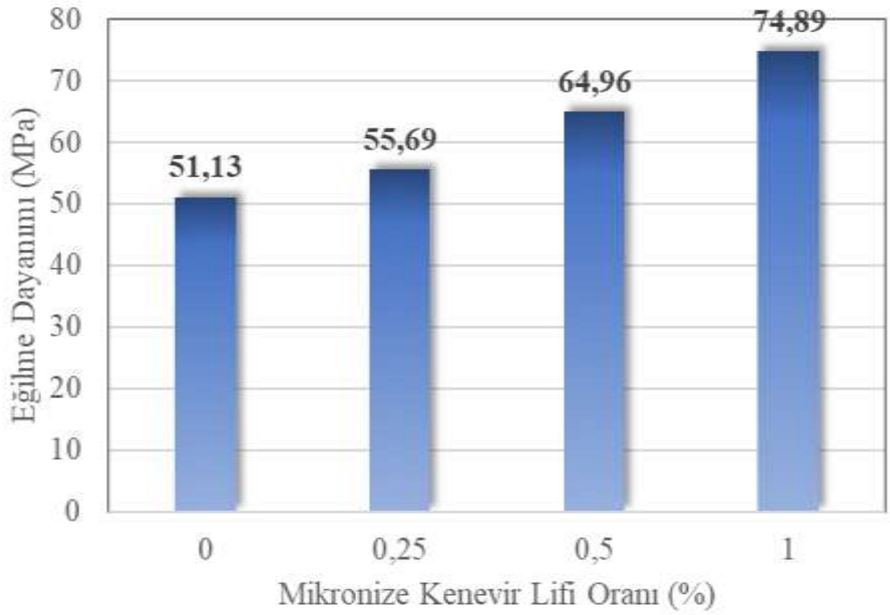


Şekil 7. Çekme dayanımı- boy değişim oranı grafiği

Şekil 7' de görülen çekme dayanımı-boy değişim oranı değerleri incelendiğinde MKL takviyesi olmayan referans numunenin en düşün çekme dayanımı ve boy değişim yüzdesine sahip olduğu, tüm kompozit numunelerinin gevrek bir kırılma gösterdiği, ancak MKL takviye oranındaki artış ile doğru orantılı olarak kopma uzuma yüzdelerinde bir artışın meydana geldiği görülmektedir. MKL lifi hem çekme dayanımı değerlerini arttırmış hemde üretilen kompozitin şekil değiştirme yeteneklerini iyileştirmiştir. Referans numuneye göre tüm MKL takviyeli kompozitlerde enerji yutma kapasitelerinde artış meydana geldiği, %1 MKL takviyeli kompozitin referans numuneye göre 2 kat daha büyük enerji yutma kapasitesine sahip olduğu görülmektedir.

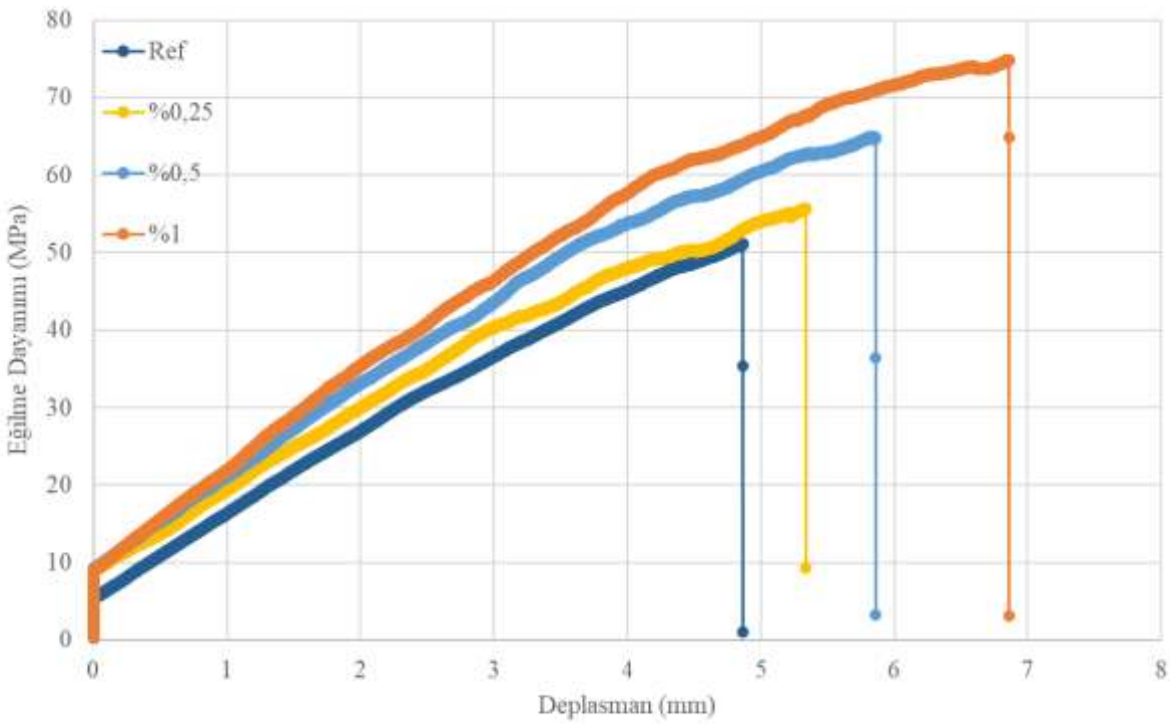
Eğilme Dayanımı

Hazırlanan MKL takviyeli kompozitler üzerinde gerçekleştirilen eğilme deneyinde elde edilen ortalama eğilme dayanımı değerleri Şekil 8'de verilmiştir. Eğilme dayanımı değerlerinin MKL katkılama oranına bağlı olarak değiştiği görülmektedir.



Şekil 8. Ortalama eğilme dayanımı değerlerine ait bar grafik

Eğilme dayanımı değerlerinde MKL takviye oranına bağlı olarak önemli değişimlerin meydana geldiği, en küçük eğilme dayanımının 51,13 MPa ile referans numunede, en büyük eğilme dayanımının ise 74,89 MPa ile %1 MKL takviyeli kompozitlerde meydana geldiği görülmektedir. Eğilme dayanımı değerlerinin referans numuneye göre sırasıyla %9, %27 ve %46 oranında artış gösterdiği tespit edilmiştir. Ayrıca eğilme dayanımı deneyinden elde edilen Dayanım-Deplasman grafiği Şekil 9'da verilmiştir.

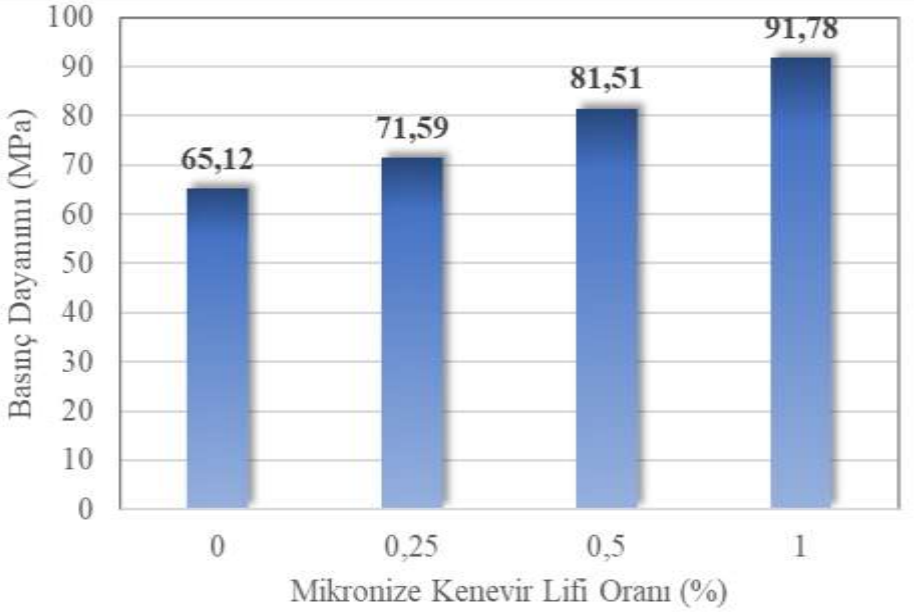


Şekil 9. Eğilme dayanımı-deplasman verilerine ait grafik

3 nokta eğilme dayanımı deneyinde orta noktada oluşan deplasman değerleri incelendiğinde MKL takviye oranındaki artışla doğru orantılı olarak deplasman değerlerinin arttığı, referans numunede 4,8mm olarak görülen deplasman miktarının %1 MKL takviyeli kompozitte 6,8 mm ye kadar yükseldiği görülmektedir.

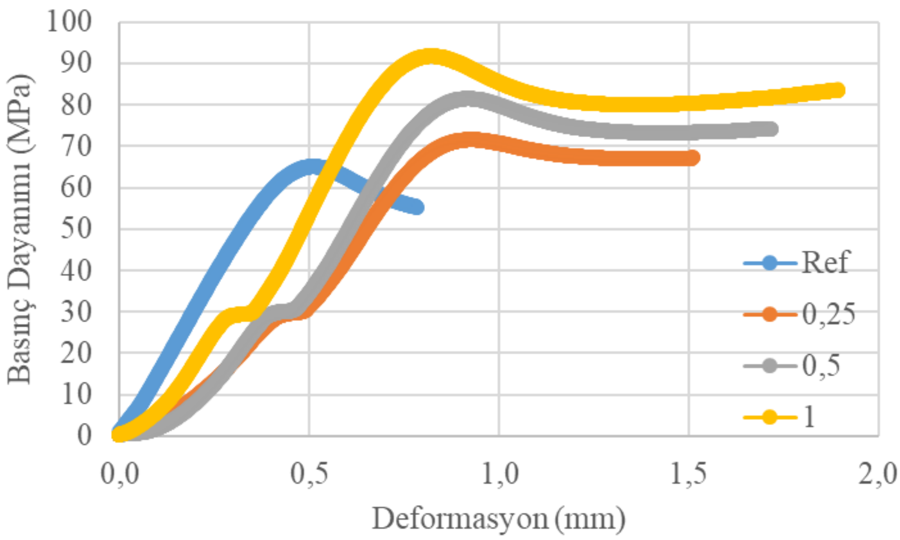
Basınç Dayanımı

MKL katkılı olarak üretilen polyester kompozitler üzerinde gerçekleştirilen basınç deneyinden elde edilen ortalama basınç dayanımı değerleri Şekil 10'da verilmiştir. Basınç dayanımı değerlerinde MKL takviye miktarına bağlı olarak önemli değişimlerin meydana geldiği görülmektedir.



Şekil 10. Ortalama basınç dayanımı değerleri

Basınç dayanımı değerinin MKL takviye oranı ile doğru orantılı olarak arttığı, en küçük basınç dayanımının 65,12 MPa ile referans numunede meydana geldiği, en büyük basınç dayanımının ise %1 MKL takviyeli numunede ortaya çıktığı görülmektedir. Referans numuneye göre basınç dayanımı değerlerinin MKL takviye oranına bağlı olarak sırasıyla %10, %25 ve %41 oranında artış gösterdiği tespit edilmiştir. Ayrıca basınç deneyi sırasında elde edilen dayanım-deformasyon grafikleri Şekil 11'de verilmiştir.

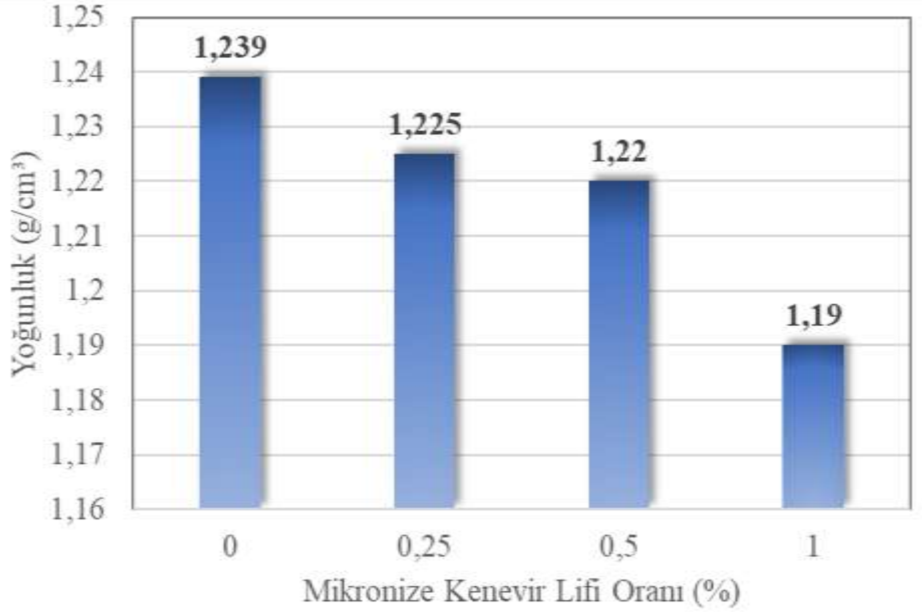


Şekil 11. Basınç dayanımı-deformasyon grafiği

Şekil 11 incelendiğinde referans numunede diğer MKL takviyeli kompozitlere kıyasla daha gevrek bir kırılmanın meydana geldiği, MKL takviye oranına bağlı olarak basınç dayanımı değerlerinin artmasına paralel olarak deformasyon değerlerinin de arttığı ve daha sünek bir davranış gösterdikleri görülmektedir. MKL nin matris ile iyi bir aderans göstermesinden dolayı mikro çatlakları köprülemesi nedeniyle hem dayanım hem de deformasyon verilerinde iyileşmelerin meydana geldiği görülmektedir.

Yoğunluk

Hazırlanan kompozit örnekleri üzerinde gerçekleştirilen yoğunluk deneyi sonucunda elde edilen ortalama yoğunluk değerlerine ait bar grafik Şekil 13'te verilmiştir. Elde edilen veriler incelendiğinde MKL takviye oranına bağlı olarak yoğunluk değerlerinde sınırlı da olsa bir değişim meydana geldiği görülmektedir.

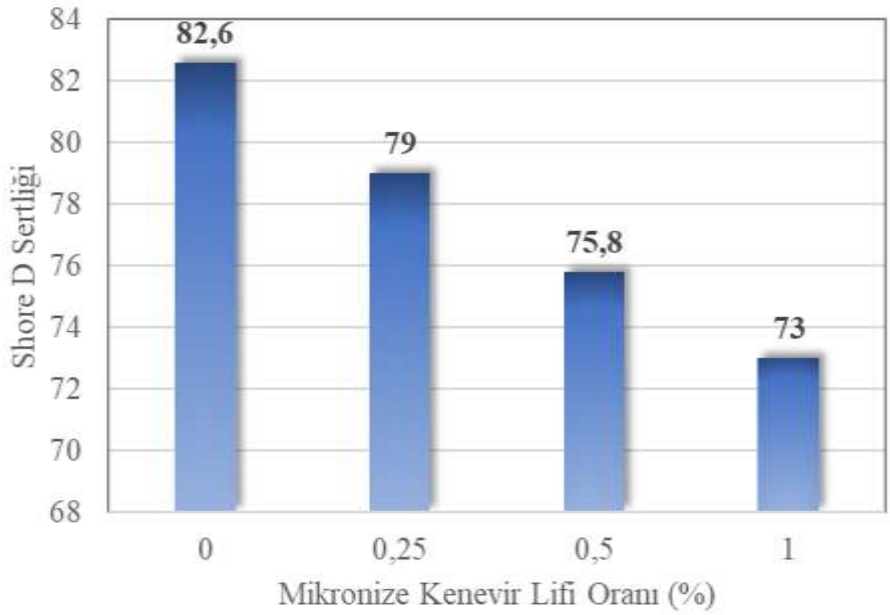


Şekil 13. Ortalama yoğunluk değerlerine ait bar grafik

Referans numunelerinin en büyük yoğunluk değerlerine sahip olduğu, %1 MKL takviye edilen kompozitlerin ise en küçük yoğunluk değerine sahip olduğu görülmektedir. Referans numuneye göre MKL takviyeli kompozitlerin yoğunluk değerlerin sırasıyla %1, %2 ve %4 oranında azalma gösterdiği tespit edilmiştir.

Shore D Sertliği

Hazırlanan kompozit örnekler üzerinde gerçekleştirilen Shore D sertlik deneyi sonucunda elde edilen ortalama sertlik değerlerine ait grafik Şekil 14'te görülmektedir. Shore D sertlik değerlerinin MKL takviye oranına bağlı olarak azalmaktadır.

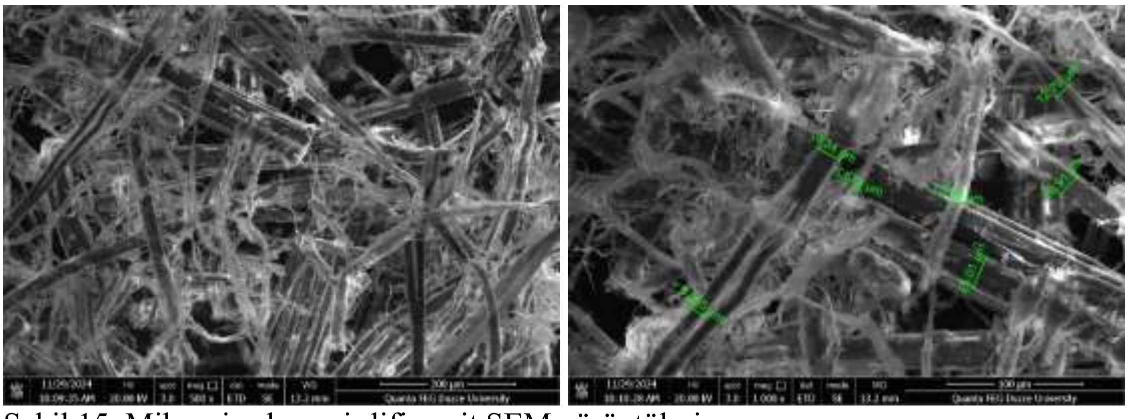


Şekil 14. Ortalama Shore D sertlik değerleri

En büyük sertlik değerine referans numunede meydana geldiği, en küçük sertlik değerinin ise %1 MKL takviyeli kompozitlerde olduğu, MKL takviye oranına bağlı olarak referans numuneye göre sertlik değerlerinin sırasıyla %4, %8 ve %12 oranlarında azalma meydana geldiği tespit edilmiştir. En büyük sertliğe sahip olan referans numunenin ölçülen mekanik özelliklerin tamamında MKL takviyeli kompozitlere kıyasla yüksek sertliğinden dolayı daha gevrek kırılma göstermesi sertlik değerlerindeki değişimi doğrulamaktadır.

SEM Analizi

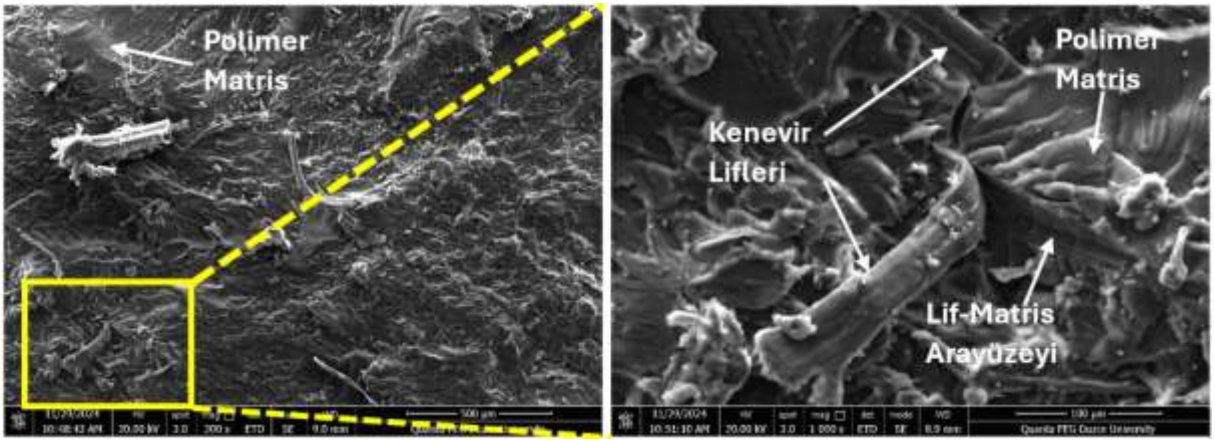
Kompozit üretimlerinde takviye malzemesi olarak kullanılan mikronize kenevir lifi ve üretilen MKL takviyeli kompozit örnekler üzerinde mikroyapı incelemesi amacıyla SEM analizi gerçekleştirilmiştir. MKL'ye ait SEM görüntüleri Şekil 15'te verilmiştir.



Şekil 15. Mikronize kenevir lifine ait SEM görüntüleri

Mikronize edilmiş kenevir liflerinin ortalama lif çapının 5-30 mikron aralığında değiştiği, lif boylarının ise 500 mikron ile 3000 mikron aralığında olduğu görülmektedir. Görüntülerde ana lif gövdesinin etrafında fibrillenmiş lifçiklerin olduğu görülmektedir. Bu fibrillenmiş yapının polimer matris ile lifin aderansında olumlu katkı sağladığı düşünülmektedir.

Ayrıca UV ile kürlenen polimer kompozit numuneden alınan kırılmış yüzey görüntülerinde ise matris yapı içerisinde MKL'lerin homojen bir dağılım gösterecek şekilde disperse olduğu, matris ile iyi bir aderans sağladığı, lif-matris arayüzeylerinde herhangi bir aderans probleminin olmadığı Şekil 16'da görülmektedir.



Şekil 16. MKL takviyeli UV kürlemeli polyester kompozitin mikroyapısı

SONUÇ VE ÖNERİLER

Çevreci ve biyokaynaklı malzemelerin kullanıldığı kompozit üretimlerine olan ilginin her geçen gün daha da artmaktadır. Çalışma kapsamında VOC salınımı olmayan fotobaşlatıcılı polyester reçinesinin matris malzemesi ve biyokaynaklı bir lif olan kenevir lifinin mikronize edilerek takviye malzemesi olarak kullanıldığı bir kompozit malzeme üretilmiştir. Mikronize kenevir lifleri polyester reçine ağırlığının %0, %0,25, %0,5 ve %1'i oranında karışım içerisine katılarak 4 farklı kompozit üretimi gerçekleştirilmiştir. Üretilen kompozitler üzerinde çekme, eğilme ve basınç dayanımı deneylerinin yanında Shore D sertlik ve yoğunluk deneyleri gerçekleştirilmiştir. Ayrıca mikro yapı incelemesi için SEM analizleri yapılmıştır.

Deneysel çalışmalar sonucunda MKL takviyeli fotobaşlatıcılı polyester reçine ile üretilen kompozitlerde fotopolimerizasyonun başarılı bir şekilde gerçekleştiği, %1'e kadar MKL katkılamanın fotopolimerizasyona engel teşkil etmediği tespit edilmiştir.

Kompozit örnekleri çekme, eğilme ve basınç dayanımı değerlerinde MKL takviye oranı arttıkça önemli değişimlerin meydana geldiği, referans numuneye göre MKL takviye oranlarında çekme dayanımı değerlerinde sırasıyla %33, 46, 77 oranında artış gösterdiği, eğilme dayanımı değerlerinde sırasıyla %9, %27 ve %46 oranında artış gösterdiği, basınç dayanımı değerinde sırasıyla %10, %25 ve %41 oranında artış gösterdiği tespit edilmiştir.

Yoğunluk ve sertlik değerlerinin ise MKL oranındaki artışla ters orantılı olarak sınırlı da olsa azalmaların meydana geldiği, referans numuneye göre MKL takviye oranlarında yoğunluk değerlerinin sırasıyla %1, %2 ve %4 oranında azalma gösterdiği, sertlik değerlerinin sırasıyla %4, %8 ve %12 oranlarında azalma meydana geldiği tespit edilmiştir.

SEM analizlerine göre MKL'lerin matris yapı içerisinde homojen bir dispersiyon gösterdiği, lif matris arayüzeylerindeki aderansın yeterli düzeyde olduğu, mikronize kenevir liflerinin çeperindeki fibrillenmiş yapının polimer matris ile lifin aderansında olumlu katkı sağladığı görülmektedir.

Sürdürülebilir kaynaklardan temin edilen malzemelerle çevreci üretim teknolojileri ile üretilecek olan kompozitlerin üretilmesi büyük önem taşımaktadır. Elde edilen sonuçlar değerlendirildiğinde, kenevir lifinin kompozit üretiminde kullanılabileceği ve önemli iyileşmeler sağlanacağı tespit edilmiştir. Diğer taraftan farklı oranlardaki kenevir liflerinin kullanıldığı, farklı üretim prosesleri ile kompozit üretilebilirliğine yönelik çalışmaların yapılması ile üstün mekanik ve fiziksel özelliklere sahip kompozitlerin geliştirilmesine katkı sağlayacağı düşünülmektedir.

KAYNAKÇA

[1] N. Shah, J. Fehrenbach, and C. A. Ulven, "Hybridization of Hemp Fiber and Recycled-Carbon Fiber in Polypropylene Composites," 2019.

[2] M. U. Wahit, N. I. Akos, and W. A. Laftah, "Influence of Natural Fibers on the

Mechanical Properties and Biodegradation of Poly (lactic acid) and Poly (e -caprolactone) Composites : A Review," pp. 24–26, 2012, doi: 10.1002/pc.
[3] M. M. Kabir, H. Wang, K. T. Lau, and F. Cardona, "Chemical treatments on plant-based natural fibre reinforced polymer composites : An overview," Compos. Part B, vol. 43, no. 7, pp. 2883–2892, 2012, doi: 10.1016/j.compositesb.2012.04.053.
[4] A. Elkhaoulani, F. Z. Arrakhiz, K. Benmoussa, R. Bouhfid, and A. Qaiss, "Mechanical and thermal properties of polymer composite based on natural fibers : Moroccan hemp fibers / polypropylene," Mater. Des., vol. 49, pp. 203–208, 2013, doi: 10.1016/j.matdes.2013.01.063.
[5] T. H. Okçuer, "Endüstriyel Kenevirden Kompozit Malzeme Geliştirlmesi," Aksaray Üniversitesi, 2021.
[6] T. Haghighatnia, A. Abbasian, and J. Morshedian, "Hemp fiber reinforced thermoplastic polyurethane composite : An investigation in mechanical properties," Ind. Crop. Prod., vol. 108, no. September, pp. 853–863, 2017, doi: 10.1016/j.indcrop.2017.07.020.
[7] K. Prukkaewkanjana, S. Thanawan, and T. Amornsakchai, "High performance hybrid reinforcement of nitrile rubber using short pineapple leaf fi ber and carbon black," Polym. Test., vol. 45, pp. 76–82, 2015, doi: 10.1016/j.polymertesting.2015.05.004.
[8] D. Melek Demirbek and M. Oktav Bulut, "Kenevir Liflerinin Eldesi, Özellikleri ve Kompozit Uygulama Alanları," Int. J. Nat. Appl. Sci. JONAS, vol. 4, no. 2, pp. 176–191, 2021.
[9] Y. Chen, L. Sun, I. Negulescu, Q. Wu, G. Henderson, and Y. Chen, "Comparative Study of Hemp Fiber for Nonwoven Composites Comparative Study of Hemp Fiber for Nonwoven Composites," vol. 7881, 2008, doi: 10.1300/J237v12n01.
[10] M. M. Kostic, B. M. Pejic, K. A. Asanovic, V. M. Aleksic, and P. D. Skundric, "Effect of hemicelluloses and lignin on the sorption and electric properties of hemp fibers," Ind. Crop. Prod., vol. 32, no. 2, pp. 169–174, 2010, doi: 10.1016/j.indcrop.2010.04.014.
[11] N. Lu and S. Oza, "Thermal stability and thermo-mechanical properties of hemp-high density polyethylene composites: Effect of two different chemical modifications," Compos. Part B Eng., vol. 44, no. 1, pp. 484–490, 2013, doi: 10.1016/j.compositesb.2012.03.024.
[12] M. Ramesh, K. Palanikumar, and K. H. Reddy, "Plant fibre based bio-composites: Sustainable and renewable green materials," Renew. Sustain. Energy Rev., vol. 79, no. February, pp. 558–584, 2017, doi: 10.1016/j.rser.2017.05.094.
[13] K. Palani Kumar et al., "Evaluation of mechanical properties of coconut flower cover fibre-reinforced polymer composites for industrial applications," Prog. Rubber, Plast. Recycl. Technol., vol. 37, no. 1, pp. 3–18, 2021, doi: 10.1177/1477760619895011.
[14] L. Y. Mwaikambo and M. P. Ansell, "Mechanical properties of alkali treated plant fibres and their potential as reinforcement materials. I. hemp fibres," J. Mater. Sci., vol. 41, no. 8, pp. 2483–2496, 2006, doi: 10.1007/s10853-006-5098-x.
[15] F. Vilaseca, A. López, X. Llauró, M. A. Pèlach, and P. Mutjé, "Hemp strands as reinforcement of polystyrene composites," Chem. Eng. Res. Des., vol. 82, no. 11, pp. 1425–1431, 2004, doi: 10.1205/cerd.82.11.1425.52038.
[16] A. Shahzad, "Hemp fiber and its composites – a review," 2011, doi: 10.1177/0021998311413623.
[17] İ. Kartal and Y. Boztoprak, "Investigation of Mechanical Properties of Vinyl Ester Composites Reinforced With Boron Nitride Particles," El-Cezeri J. Sci. Eng., vol. 6, no. 1, pp. 43–50, 2019, doi: 10.31202/ecjse.450790.
[18] K. Palanikumar, E. Natarajan, K. Markandan, C. K. Ang, and G. Franz, "Targeted Pre-Treatment of Hemp Fibers and the Effect on Mechanical Properties of Polymer Composites," Fibers, vol. 11, no. 5, 2023, doi: 10.3390/fib11050043.
[19] A. Manral and P. K. Bajpai, "Static and dynamic mechanical analysis of geometrically different kenaf/PLA green composite laminates," Polym. Compos., vol. 41, no. 2, pp. 691–

706, 2020, doi: 10.1002/pc.25399.
[20] M. Ramesh, K. Palanikumar, and K. H. Reddy, “Comparative evaluation on properties of hybrid glass fiber-sisal/jute reinforced epoxy composites,” Procedia Eng., vol. 51, no. NUiCONE 2012, pp. 745–750, 2013, doi: 10.1016/j.proeng.2013.01.106.
[21] A. Subaşı, “Grafen Nanotüp ve Cam Elyafla Güçlendirilmiş Led ile Kürlenen Polyester Kompozit Üretiminin Araştırılması,” Düzce Üniversitesi, 2023.
[22] A. Subaşı, A; Emiroğlu, Mehmet; Demir, “Polarization and relaxation mechanisms in glass fiber-reinforced LED-cured polyester composites incorporating graphene nanotubes,” vol. 295, no. May 2023, 2023, doi: 10.1016/j.mseb.2023.116614.
[23] T. P. Mohan and K. Kanny, “Mechanical properties and failure analysis of short kenaf fibre reinforced composites processed by resin casting and vacuum infusion methods,” Polym. Polym. Compos., vol. 26, no. 2, pp. 189–204, 2018, doi: 10.1177/096739111802600207.
[24] E. Andrzejewska, “Photopolymerization kinetics of multifunctional monomers,” Prog. Polym. Sci., vol. 26, pp. 605–665, 2001.
[25] E. Andrzejewska, Chapter 2 - Free Radical Photopolymerization of Multifunctional Monomers. Elsevier Inc., 2016.
[26] Y. Yagci, S. Jockusch, and N. J. Turro, “Photoinitiated polymerization: advances, challenges, and opportunities,” Macromolecules, vol. 43, pp. 6245–6260, 2010, doi: 10.1021/ma1007545.
[27] S. B. P. Kardar, M. Ebrahimi, “Study the effect of nano-alumina particles on physical–mechanical properties of UV cured epoxy acrylate via nano-indentation,” Prog. Org. Coatings, vol. 62, no. 3, pp. 321–325, 2008.
[28] T. H. Karaca, B. Çiçek, T. Aydoğmuş, and Y. Sun, “The effect of graphene-nanoplatelet and nano- teflon on mechanical properties of UV photo-resin 3D printer products,” Polym. Technol. Mater., vol. 61, no. 12, pp. 1298–1307, 2022, doi: 10.1080/25740881.2022.2061862.
[29] B. Jiang, X. Shi, T. Zhang, and Y. Huang, “Recent advances in UV / thermal curing silicone polymers,” Chem. Eng. J., vol. 435, no. P1, p. 134843, 2022, doi: 10.1016/j.cej.2022.134843.
[30] F. Cheng, Y. Fan, N. He, Y. Song, J. Shen, and Z. Gong, “Castor oil based high transparent UV cured silicone modified polyurethane acrylate coatings with outstanding tensile strength and good chemical resistance,” vol. 163, no. August 2021, 2022, doi: 10.1016/j.porgcoat.2021.106624.
[31] Y. Seki, “The effects of oxidative modification on the surface properties, thermal degradation behavior and structural characterization of coir fibers,” Tekst. ve Muhendis, vol. 25, no. 111, pp. 189–195, 2018, doi: 10.7216/1300759920182511102.
[32] R. İlhan and E. Feyzullahoğlu, “Natural Fibers and Filler Materials Used in Glass Fiber Reinforced Polyester (GFRP) Composite Materials,” El-Cezeri J. Sci. Eng., vol. 6, no. 2, pp. 355–381, 2019, doi: 10.31202/ecjse.519072.
[33] Plastics - Determination Of Tensile Properties - Part 1: General Principles, TS EN ISO 527-1, 2019.
[34] Plastics - Determination of compressive properties, TS EN ISO 604, 2006.
[35] Plastics -Determination of Flexural Properties, TS EN ISO 178, 2019.
[36] Standard Test Method for Rubber Property—Durometer Hardness, ASTM D 2240, 2021.
[37] Plastics-Liquid Resins-Determination Of Density By The Pyknometer Method, TS EN ISO 1675, 2023.

KATMA DEĞERI YÜKSEK MANTARLARIN KULLANIMI

USE OF MUSHROOMS WITH HIGH-ADDED VALUE

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ÖZET
Mantarlar, insanoğlu için önemli bir besin maddesi olmasından dolayı, kullanımı çok eskiye dayanmasıyla içerdikleri besin değerleri bakımından; protein ve vitaminlerin yanı sıra; önemli bir oranda karbonhidrat, lif ve mineral madde kaynağı olarak bilinmektedir. Ayrıca; mantarlar yağ oranı düşük seviyededir. Bunların yanı sıra, protein kaynağı açısından zengin bir besin maddesi olarak kullanılan yenilebilir mantarlar; aynı zamanda geleneksel protein kaynaklarına önemli bir alternatif olarak gösterilebilir. Tıbbi mantarlar, yenilebilir mantarların aksine doğrudan gıda olarak kullanılamayan ancak içerdikleri bileşenler nedeniyle farmasötik yani ilaç sentezi gibi alanlarda kullanılan mantarlardır. Yenilebilir mantarlar ve tıbbi mantarlar, besleyici, enfeksiyon önleyici, stres giderici, antioksidan özellikleri nedeniyle gıda, insan sağlığını ve uzun ömürlülüğünü iyileştirmek için ilaç ve kozmetik gibi birçok sanayi alanında değerli bir kaynak olarak kullanılmaktadırlar. Mantarların üretimi ve tüketimi, lezzetlerine ek olarak besinsel avantajları da göz önüne alındığında her yıl artmaktadır ve dünya nüfusu tarafından giderek daha fazla takdir görmektedir. Bunlara ek olarak, Türkiye'den yurt dışına ihraç edilen tıbbi ve yenilebilen mantarların büyük çoğunluğunu doğal mantarlar oluşturmaktadır. Çoğunlukla Avrupa ülkeleri ve Japonya tarafından talep edilen doğal mantarlar ülkemize önemli döviz girdisi sağlayabilecek hem yenilenebilir ve hem de sürdürülebilir bir kaynak olarak görülmelidir.
Anahtar Kelimeler: Mantar, Tıbbi mantar, Türkiye, Yenilebilir mantar

ABSTRACT
Mushrooms are an important nutrient for human beings because they are important for human beings in terms of the nutritional values they contain with their ancient use; in addition to protein and vitamins, they are an important source of carbohydrates, fiber, and mineral substances. Moreover, mushrooms are low in fat. In addition, edible mushrooms, used as a nutrient-rich protein source, can also be shown to be an important alternative to traditional protein sources. Medicinal mushrooms, unlike edible mushrooms, are mushrooms that cannot be used directly as food but are used in areas such as pharmaceuticals, i.e., drug synthesis, due to the components they contain. Edible and medicinal mushrooms are a valuable resource in many industries, such as food, pharmaceuticals, and cosmetics, to improve human health and longevity due to their nutritional, anti-infective, stress-relieving, and antioxidant properties. The production and consumption of mushrooms are increasing yearly due to their nutritional benefits and taste, and the world's population increasingly appreciates them. In addition, most of the medicinal and edible mushrooms exported from Türkiye to other countries are natural mushrooms. Natural mushrooms, mainly demanded by European countries and Japan, should be seen as a renewable and sustainable resource that can bring important foreign exchange inflows to our country.
Key Words: Mushroom, Medicinal mushroom, Türkiye, Edible mushroom

GİRİŞ

Yenilebilen makromantarlar insan sağlığının devamı için protein ve enerji kaynakları olarak önemli miktarda kullanılmaktadırlar. Mantarlar, protein, mineral ve lifli yapıda olmaları; yağ ve kalori bakımından düşük olmalarından dolayı önemli bir gıda maddesi olarak kabul edilmektedirler. Tüm dünyada giderek artan mantar tüketiminin yanı sıra, besin içeriği gibi avantajlarına bakıldığında, mantarların üretimleri ve tüketimleri her geçen yılda kayda değer şekilde artmaktadır (Royse ve ark., 2017; Thakur, 2020; El-Ramady ve ark., 2022).

Mantar üretim sürecinde, endüstri için yüksek çevresel etki ve yönetim maliyetleri ile birlikte büyük miktarda yan ürün ortaya çıkmaktadır. Yan ürünler arasında şapkalar, stipler, şekil veya boyut açısından ticari standartlara uymayan mantarlar ve kullanılmış mantar substratı bulunmaktadır. Substrat, mantar misellerinden, maddelerin parçalanması için mantarlardan salgılanan hücre dışı enzimlerden ve kullanılmayan lignoselülozik substratlardan oluşur. Bu yan ürünler yüksek besin değerine sahiptir ve çeşitli uygulamalarda değerlendirilebilirler (Sharma, 2018; Ferdousi ve ark., 2020).

Günümüzde, döngüsel ekonomi gibi endüstriyel ekoloji kavramları, yeni ürün ve uygulamaların geliştirilmesi için atıkları hammadde olarak kullanan inovasyon için öncü ilkeler olarak kabul edilmektedir. Mantar üretiminden kaynaklanan büyük miktarda atık, hem ekonomik hem de çevresel açıdan ciddi yönetim sorunlarını da beraberinde getiren değerli organik maddelerin büyük bir kaybını temsil etmektedir. Substratlardan uygulamaları hakkında bir kaç inceleme mevcut olsa da, mantar yan ürünlerinden biyoaktif bileşiklerin ekstraksiyonu ve gıda, hayvan yemi, gübre, biyoremediasyon, enerji üretimi ve biyo-bazlı malzemeler gibi farklı alanlardaki potansiyel uygulamaları hakkında henüz hiçbir inceleme mevcut değildir (Higgins ve ark., 2017; Ferdousi ve ark., 2020).

Mantar Üretimi;

Bilindiği üzere doğal ortamda binlerce mantar türü bulunmakta; fakat, sadece 25 türü gıda olarak yaygın bir şekilde kullanılmakta ve ticari olarak yetiştirilmektedir. Farklı kültür mantarları arasında örneğin; Lentinula, dünyadaki kültür mantarlarının yaklaşık %23'sine katkıda bulunan ana cinstir ve Pleurotus dünya üretiminin yaklaşık %19'unu oluşturmaktadır. Agaricus hacmin %15'ine sahiptir. Saprofit mantarların, optimum koşullarda spesifik enzimlerin etkisiyle selüloz ve lignini parçalayarak biyokütle geliştirdiği uzun zamandır bilinmektedir. Genel olarak, mantar üretimi iki tür fermantasyon tekniğinden oluşmaktadır şöyleki; katı substrat fermantasyonu veya daldırılmış sıvı fermantasyon aşamaları. Katı substrat fermantasyonu, gıda ve nutrasötik amaçlar için bütün mantarların seçilen üretim yöntemidir. Batık sıvı fermantasyon, katı substratlar üzerinde meyve gövdesi üretimi için sıvı spawn (mantarın çoğaltılması için kullanılan miselyum ile aşılanmış substrat), gıda, besin takviyesi ve farmasötik uygulamalar için biyokütle üretimi ve atık biyokütlenin dönüştürülmesi ve enzim üretimi gibi farklı uygulamalar için miselyum çoğaltımında kullanılır (Sánchez, 2004; Fan ve ark., 2008; Sharma, 2018).

Mantar kültürü, lignoselülozik atıkların geri dönüşümünü sağlayan biyoteknolojik bir süreçtir, çünkü bunlar insan tüketimi için bir gıdaya dönüştürülür. Katı substrat fermantasyonu, mantar miseli de dahil olmak üzere tüm bileşenlerle birlikte polietilen torbalarda yetiştiricilere mantar substratı tedarik etmeyi içeren en çok tercih edilen mantar üretim tekniğidir. Meyve gövdesi daha sonra fruktifikasyon sürecinin bir sonucu olarak geniş miselyumdan oluşur ve mantarlar birkaç hafta içinde üretilir (Rosmiza ve ark., 2016; Raman ve ark., 2018).

Mantarların Besinsel Faydaları;

İnsanoğlunun tüketimi için gıda gruplarının çoğu, hem bitkisel hem de hayvansal kökenlidirler. Mantarlar, bitkisel ve hayvansal ürünlerin üyesi değil, ayrı bir alem olarak bilinmektedir. Mantarların, yan etkisi olmadağı sürece sık olarak yenilebilen yiyecek türlerinden birisidir. Mantarların dengeli bir beslenmenin tüm temel bileşenlerini içerdiği iyi bilinmektedir. Ayrıca, mantarlar lifli yapıları yanısıra, sindirilebilir esansiyel amino asit, zengin protein, vitamin ve mineraller açısından zengindir, ancak düşük miktarda yüksek kaliteli doymamış yağ ve suda çözünür karbonhidrat içerirler (Stengler, 2005; Singh, 2017). Bunlara ek olarak, folik asit, B vitamini kompleksi, fosfor, potasyum, kalsiyum, bakır, demir ve diğer temel besin elementleri açısından zengindir. Çeşitli mantar türlerindeki farklı minerallerin miktarları değerlendirmiş ve aynı miktarda farklı oranlarda sonuçlar bulunmuştur. Farklı mantar türlerinin metabolize edilebilir enerji içeriği 150-300 Kcal/100g kuru mantar arasında değişmektedir. Genel olarak, yenilebilir mantarlar yağ ve kalori bakımından düşüktür, vitamin ve mineraller bakımından zengindir, bitkisel kökenli diğer gıdalardan daha fazla protein içerir (Barroetaveña ve Toledo, 2016; Gupta ve ark., 2018).

Mantarların Tıbbi Faydaları;

Genel olarak mantarların yüksek tıbbi özelliklerinin olduğu bilinmektedir. Ayrıca, yenilebilir mantarların yaklaşık olarak %7'sinin tıbbi özelliklere sahip olduğu ve sağlıktaki ilaçlarda, çaylarda, çorbalarda ve bitkisel karışımlarda bulunabiliyorlar. Yenilebilir mantarlar, tıbbi değerleri nedeniyle bazı farmasötik ürünlerin üretiminde önemli bir bileşen olarak kullanılmıştır. Mantarların tıbbi potansiyeli binlerce yıldır bilinmekte, ancak tedavi edici özellikleri çoğunlukla dokunulmamış ve keşfedilmemiş durumdadır. Dünya çapında Shiitake (Lentinula edodes) ve Reishi (Ganoderma lucidum) mantarları tıbbi değerleriyle tanınmakta ve antitümör, anti-HIV ve anti-hepatit B gibi antiviral özelliklere sahip oldukları ve serum kolesterolünü kan dolaşımından uzaklaştırdıkları söylenmektedir. Reishi mantarı 'ölümsüzlük mantarı' olarak bilinmektedir. Mantar, kan basıncını normalleştirmede, kan kolesterolünü ve kan şekeri seviyesini düşürmede, karaciğeri korumada, bazı kanser türlerini kontrol etmede, vücudun bağışıklık sistemini güçlendirmede ve dolayısıyla genel zindeliği teşvik etmede çok etkili olan doğal bileşenler içerir (Falandysz ve Borovička, 2013; Gupta ve ark., 2018; Parepalli ve ark., 2021).

Mantarların Ekonomik Faydaları;

Mantarlar, hızlı sosyo-ekonomik kalkınmayı teşvik etmek için umut verici kaynaklardan birini oluşturmaktadır. Mantar yetiştiriciliği bir milli gelir kaynağı olmasının yanı sıra yoksulluğun azaltılması için ve dar gelirli aileler için de önemli bir kaynaktırlar. Mantar yetiştiriciliğinin yanı sıra ciddi bir emek istemekte olup pazarlama faaliyetlerinde çok sayıda doğrudan ve dolaylı istihdam fırsatı yaratır. Aynı zamanda, mantar yetiştiriciliği düşük sermaye, önemli bir teknik bilgi gerekmektedir. Yetiştiricilikte kapalı bir ortamda küçük ölçekte mantar yetiştirmek mümkündür ve düşük yatırımla kolayca yüksek getiri elde edilebilir; Buna ek olarak, mantar yetiştiriciliği sadece kırsal kesimdeki kadınları güçlendirmekle kalmaz, aynı zamanda yoksulluğun düşük seviyelere gelmesine yardımcı olur (Kumla ve ark., 2013; Bonet ve ark., 2014).

SONUÇ

Mantarların üretilmesi farklı alanlarda uygulamaları olan çok çeşitli yan ürünler içerirler. Günümüzde gıda sektörü çevresel konularla yakından ilgilenmekte ve gıda sisteminde geliştirilen faaliyetlerden kaynaklanan atık ve kayıpları azaltmak için stratejiler geliştirmeyi planlanmaktadır. Bu yaklaşımlarda, ekonomik büyüme ve çevresel koruma sağlayabilecek ve döngüsel bir ekonomiye katkıda bulunabilecek tarımsal-endüstriyel atıklara katma değer kazandırmaktır. Mantar yan ürünleri, işlevsel ve besinsel özellikleri nedeniyle kullanılabilecek önemli bileşiklerin umut verici kaynaklarıdır. Mantar üretimi ve işlenmesi sırasında ortaya çıkan yan ürünler için katma değerli çözümler elde etmek amacıyla farklı alanlarda araştırmalar geliştirilmiştir. Biyoaktif bileşikler elde edilmiş ve nutrasötik ve farmasötik formülasyonların geliştirilmesinde uygulanmıştır. Gelecekteki araştırmaların, biyoaktif bileşiklerin ekstraksiyonu ve farklı uygulamalara yönelik değerlendirilmesinin teknolojik fizibilitesini ve ekonomik sürdürülebilirliğini anlamak için endüstriyel ölçekli ekstraksiyon yöntemlerinin araştırması gerekmektedir.

KAYNAKLAR

Barroetaveña, C., & Toledo, C. V. (2016). The nutritional benefits of mushrooms. Wild plants, mushrooms and nuts: Functional food properties and applications, 65-81.

Bonet, J. A., GonzÁlez-Olabarria, J. R., & Martínez De Aragón, J. (2014). Mushroom production as an alternative for rural development in a forested mountainous area. Journal of Mountain Science, 11, 535-543.

El-Ramady, H., Abdalla, N., Badgar, K., Llanaj, X., Törős, G., Hajdú, P., ... & Prokisch, J. (2022). Edible mushrooms for sustainable and healthy human food: nutritional and medicinal attributes. Sustainability, 14(9), 4941.

Falandysz, J., & Borovička, J. (2013). Macro and trace mineral constituents and radionuclides in mushrooms: health benefits and risks. Applied microbiology and biotechnology, 97, 477-501.

Fan, L., Soccol, C. R., & Pandey, A. (2008). Mushroom production. Current developments in solid-state fermentation, 253-274.

Ferdousi, J., Riyadh, Z. A., Hossain, M. I., Saha, S. R., & Zakaria, M. (2020). Mushroom production benefits, status, challenges and opportunities in Bangladesh: A review. Annual Research & Review in Biology, 34(6), 1-13.

Higgins, C., Margot, H., Warnquist, S., Obeysekare, E., & Mehta, K. (2017, October). Mushroom cultivation in the developing world: A comparison of cultivation technologies. In 2017 IEEE Global Humanitarian Technology Conference (GHTC) (pp. 1-7). IEEE.

Gupta, S., Summuna, B., Gupta, M., & Annepu, S. K. (2018). Edible mushrooms: cultivation, bioactive molecules, and health benefits. Bioactive molecules in food, 1, 1-33.

Kumla, J., Suwannarach, N., Jaiyasen, A., Bussaban, B., & Lumyong, S. (2013). Development of an edible wild strain of Thai oyster mushroom for economic mushroom production. Chiang Mai Journal of Science, 40(2), 161-172.

Parepalli, Y., Chavali, M., Sami, R., Khojah, E., Elhakem, A., El Askary, A., ... & El-Chaghaby, G. (2021). Evaluation of some active nutrients, biological compounds and health benefits of reishi mushroom (Ganoderma lucidum).

Raman, J., Lee, S. K., Im, J. H., Oh, M. J., Oh, Y. L., & Jang, K. Y. (2018). Current prospects of mushroom production and industrial growth in India. Journal of Mushroom, 16(4), 239-249.

Rosmiza, M. Z., Davies, W. P., Aznie, R. C., Jabil, M., & Mazdi, M. (2016). Prospects for increasing commercial mushroom production in Malaysia: challenges and opportunities. Mediterranean Journal of Social Sciences, 7(1), 406-415.

Royse, D. J., Baars, J., & Tan, Q. (2017). Current overview of mushroom production in the world. Edible and medicinal mushrooms: technology and applications, 5-13.

Sánchez, C. (2004). Modern aspects of mushroom culture technology. Applied microbiology and biotechnology, 64, 756-762.

Sharma, K. (2018). Mushroom: Cultivation and processing. Int. J. of Food Processing Technology, 5(2), 9-12.

Singh, R. (2017). A review on different benefits of mushroom. IOSR Journal of Pharmacy and Biological Sciences, 12(1), 107-111.

Stengler, M. (2005). Health benefits of medicinal mushrooms. Basic Health Publications, Inc.

Thakur, M. P. (2020). Advances in mushroom production: Key to food, nutritional and employment security: A review. Indian Phytopathology, 73, 377-395.

EFFECT OF ELEVATION ON PLANT SECONDARY METABOLITES

YÜKSELTMENİN BİTKİ İKİNCİL METABOLİTLERİ ÜZERİNDEKİ ETKİSİ

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ÖZET
Bitkiler, çevresel stres faktörlerine uyum sağlamak için bir dizi kimyasal bileşik üretir. Bu bileşiklerin önemli bir kısmını sekonder metabolitler oluşturur. Sekonder metabolitler, bitkilerde fotosentez, solunum veya hücre bölünmesi gibi hayati süreçlerle doğrudan ilgili değildir. Ancak çevresel koşullara uyum sağlama, savunma mekanizmalarını geliştirme ve tozlaşmayı kolaylaştırma gibi işlevleri vardır. Flavonoidler, alkaloitler, fenolik bileşikler ve terpenoidler gibi metabolitler, bitkilerin ekolojik adaptasyonlarında kritik roller üstlenir. Bu bileşiklerin sentezi, genetik faktörler kadar çevresel faktörlerden de etkilenir. Bu metabolitlerin üretim miktarları ve çeşitliliği, çevresel koşullardan, özellikle de rakım gibi abiyotik faktörlerden güçlü bir şekilde etkilenir (Körner, 2007). Yükseklik, bu çevresel faktörlerin başında gelir ve sıcaklık, ultraviyole (UV) radyasyonu, oksijen seviyeleri gibi değişkenleri içerir (Karagöz, 2020).
Bitkiler, çevresel koşullara adapte olabilmek için bir dizi biyokimyasal ve fizyolojik mekanizma geliştirmiştir. Bu mekanizmalar arasında, bitkilerin sekonder metabolitleri üretmesi, çevresel strese karşı adaptasyonun önemli bir parçasını oluşturur (Croteau ve ark., 2000). Sekonder metabolitler, bitkilerin savunma, allelopati, ultraviyole (UV) radyasyondan korunma ve rekabet gibi ekolojik işlevlerinde kritik bir rol oynar (Dixon, 2001).
Anahtar Kelimeler: Sekonder metabolit, oksidatif stres, Yükseklik, Fenolik bileşikler.

SUMMARY
Plants produce a number of chemical compounds to adapt to environmental stressors. A significant portion of these compounds constitute secondary metabolites. Secondary metabolites are not directly involved in vital processes such as photosynthesis, respiration or cell division in plants. However, they have functions such as adapting to environmental conditions, developing defense mechanisms and facilitating pollination. Metabolites such as flavonoids, alkaloids, phenolic compounds and terpenoids play critical roles in the ecological adaptations of plants. The synthesis of these compounds is affected by environmental factors as well as genetic factors. The production amounts and diversity of these metabolites are strongly affected by environmental conditions, especially abiotic factors such as altitude (Körner, 2007). Altitude is one of these environmental factors and includes variables such as temperature, ultraviolet (UV) radiation, and oxygen levels (Karagöz, 2020).
Plants have developed a number of biochemical and physiological mechanisms to adapt to environmental conditions. Among these mechanisms, the production of secondary metabolites by plants forms an important part of adaptation to environmental stress (Croteau et al., 2000). Secondary metabolites play a critical role in the ecological functions of plants such as defense, allelopathy, protection from ultraviolet (UV) radiation, and competition (Dixon, 2001).

Key Words: Secondary metabolite, oxidative stress, Altitude, Phenolic compounds.

GİRİŞ

Yüksekliğin Bitki Metabolizmasına Etkisi

Yüksekliğe bağlı çevresel değişimler, bitkilerin fizyolojisi ve kimyasal yapısında belirgin değişikliklere yol açar. Örneğin, yüksek rakımlarda sıcaklık genellikle düşerken, UV radyasyonu ve radyasyon yoğunluğu artar. Artan UV radyasyonu, flavonoidlerin ve fenolik bileşiklerin üretimini teşvik edebilir.Çünkü bu bileşikler UV ışınlarına karşı koruma sağlar. Bu durum, yüksek rakımlarda yetişen bitkilerin daha yoğun fenolik içeriklere sahip olmasını açıklar (Körpe & Arslan, 2019).Başka bir örnekte , UV-B radyasyonu yüksek rakımlarda daha yoğun olduğundan, bu bölgelerde yetişen bitkilerde flavonoidler ve fenolik bileşikler gibi UV emici sekonder metabolitlerin üretimi artar (Rozema ve ark., 1997). Rakım, sıcaklık, atmosferik basınç, UV-B radyasyonu ve oksijen seviyeleri gibi çevresel faktörlerin bir kombinasyonunu içerir. Bu değişiklikler, bitkilerin metabolik süreçlerini etkiler. Yüksekliğe bağlı olarak bitkilerde görülen değişiklikler şunları içerebilir:

Fenolik Bileşiklerin Artışı

Fenolik bileşikler, bitkilerde savunma mekanizması ve antioksidan özelliklere sahiptir. Yüksek rakımlarda artan oksidatif stres, fenolik bileşiklerin sentezini artırır. Özellikle Artemisia türlerinde yapılan bir araştırma, yüksek rakımlarda fenolik bileşik içeriğinin daha yüksek olduğunu göstermiştir (Tüfekçi, 2021).

Flavonoidler

Flavonoidler, UV ışınlarına karşı koruyucu bir rol oynar. Bu nedenle, yüksek rakımlarda bitkilerde flavonoid sentezi önemli ölçüde artar. Örneğin, yüksek rakımlı Alpin bölgelerde yetişen bazı bitkilerin flavonoid içeriklerinin, alçak rakımlarda yetişen bitkilere kıyasla daha yüksek olduğu bulunmuştur (Zhou et al., 2018).

Yüksek rakımlarda artan UV-B radyasyonu, fenolik bileşiklerin ve flavonoidlerin birikimini teşvik eder. Bu bileşikler, UV ışınlarına karşı bir filtre görevi görerek bitki dokularını korur (González ve ark., 2004).

Alkaloid Üretimi

Alkaloidler, yüksek rakımlarda artan biyotik streslere (ör. otçul hayvanlar) karşı bitki savunmasında önemli rol oynar. Örneğin, Peru'nun yüksek rakımlı bölgelerinde yetişen Lupinus türlerinde alkaloid içeriğinin arttığı rapor edilmiştir (Mewis ve ark., 2012).

Terpenoidlerin Rolü

Terpenoidler, yüksek rakımlarda çevresel stres faktörlerine karşı bitkilerin direnç mekanizmasını güçlendiren bir diğer önemli sekonder metabolit sınıfıdır. Bazı aromatik bitkilerde, yüksek rakımın terpenoid bileşiklerin üretimini artırdığı gözlenmiştir (Ardıç, 2020).

Terpenoidler, uçucu bileşikler olarak hem savunma hem de adaptasyon mekanizmalarında yer alır. Rakıma bağlı sıcaklık düşüşü ve oksijen azlığı, bu bileşiklerin üretimini etkileyebilir (Streb ve Feierabend, 1999).

Mekanizmalar

Yüksekliğin sekonder metabolitler üzerindeki etkilerinin altında yatan başlıca mekanizmalar şunlardır:

1.UV-B Radyasyonu

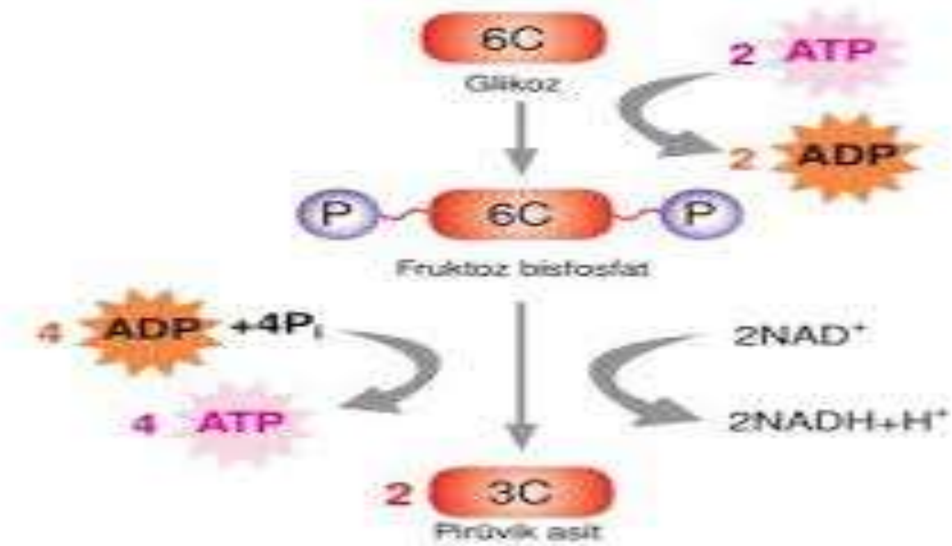
Yüksek rakımlarda, atmosferin incelmesiyle UV-B radyasyonuna maruz kalma artar. Bu durum, bitkilerde DNA hasarını önlemek ve oksidatif stresi azaltmak için fenolik bileşiklerin üretimini artırır (Körner, 2003).

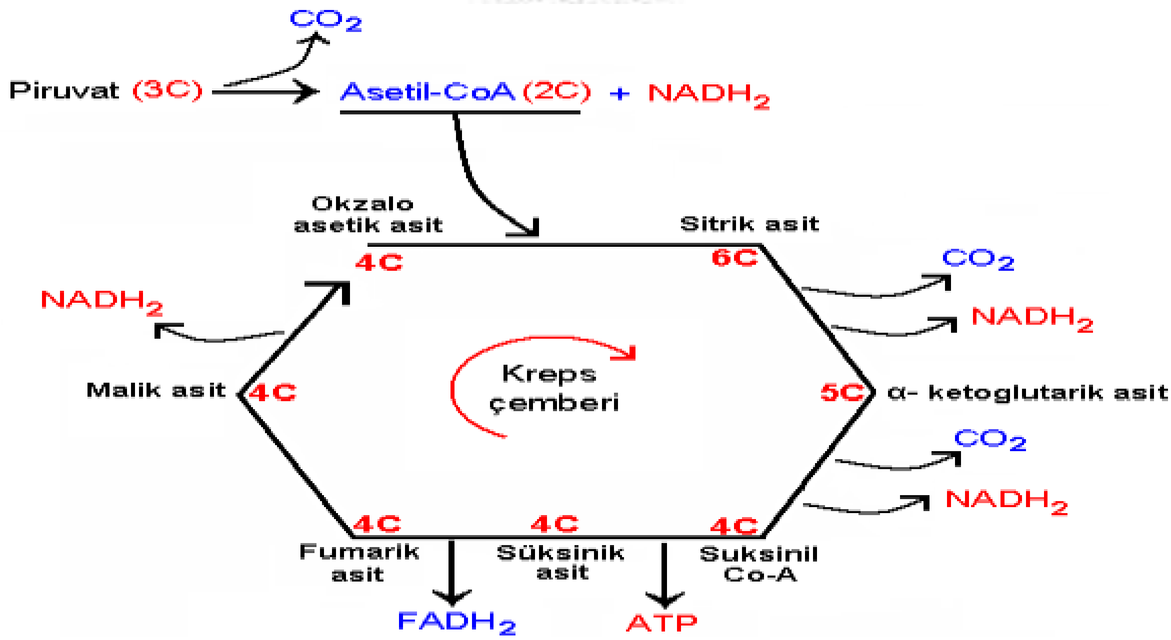
Oksijen Kısıtlaması

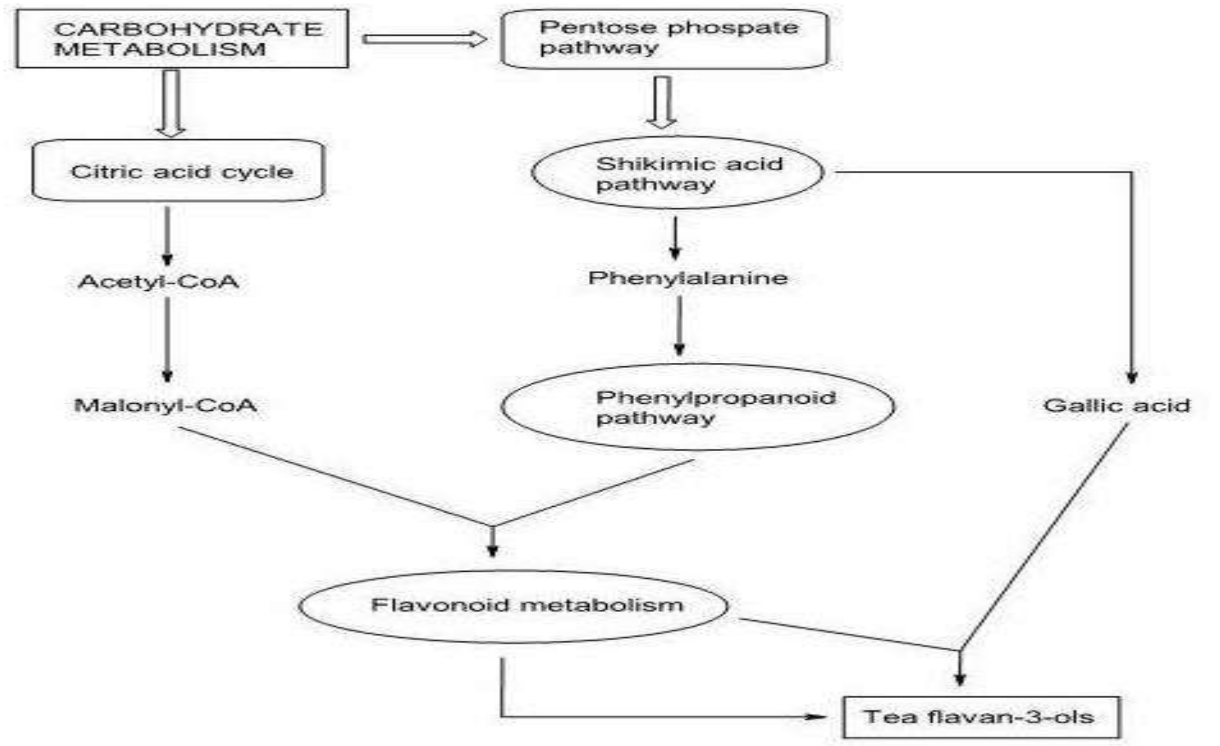
Atmosferik oksijenin azalması, bitki hücrelerinde farklı oksidatif stres tepkilerini tetikleyebilir. Bu durum, sekonder metabolit üretiminin düzenlenmesinde rol oynayan genlerin ekspresyonunu etkiler (Jaleel ve ark., 2009).

Sıcaklık Stresi

Yüksek rakımlarda sıcaklığın düşmesi, bazı metabolik yolların hızlanmasına neden olabilir. Özellikle soğuk stresine dayanıklı türlerde artan prolin üretimi, sekonder metabolitler için dolaylı bir sinyal görevi görebilir (Chaves ve ark., 2009).







Şekil 1.4 : Çay bitkisinde flavon – 3 – ols 'un genellikle ileri sürülen biyosentetik alt yolu

Adaptif Stratejiler

Yüksekliğe bağlı sekonder metabolit değişimleri, bitkilerin stres yönetiminde adaptif bir strateji olarak değerlendirilir. Örneğin, UV radyasyonunun etkisiyle flavonoid sentezinde artış görülmesi, DNA hasarını önlemeye yönelik bir mekanizma olarak açıklanabilir. Benzer şekilde, düşük sıcaklıklar ve hipoksi koşulları, antioksidan bileşiklerin üretimini artırarak bitkilerin bu koşullara dayanıklılığını artırır (Kaya et al., 2021).

Uygulama Alanları

Yüksek rakımın etkisiyle değişen sekonder metabolit üretimi, çeşitli uygulama alanları sunar. Örneğin:

• Tıbbi Bitkiler: Sekonder metabolitlerdeki değişiklikler, tıbbi bitkilerin farmakolojik etkilerini artırabilir. Yüksek rakımlarda yetişen bitkilerden elde edilen alkaloid ve fenolik bileşikler, kanser önleyici ve antioksidan özellikler gösterebilir (Gairola ve ark., 2010).

• Tarım ve Gıda: Rakıma bağlı metabolit değişiklikleri, bitkisel ürünlerin tat, aroma ve besin değerini etkileyebilir (González ve ark., 2004).

Sonuç

Yükseklik, bitki sekonder metabolitlerinin sentezini ve çeşitliliğini önemli ölçüde etkiler. Artan UV radyasyonu, sıcaklık değişiklikleri ve oksijen seviyeleri, bitkilerin kimyasal yapısında adaptif değişimlere yol açar. Bu değişimlerin anlaşılması, tarım, ilaç ve gıda endüstrisinde sekonder metabolitlerin kullanımını optimize etmek için önemlidir. Gelecekteki araştırmalar, yüksekliğin etkilerini farklı bitki türlerinde daha kapsamlı bir şekilde inceleyerek bu alandaki bilgi birikimini artırabilir. Ayrıca yüksekliğin bitki sekonder metabolitler üzerindeki etkilerinin moleküler düzeyde daha iyi anlaşılmasını sağlayarak, çevresel değişikliklere dayanıklı ürünlerin geliştirilmesine katkıda bulunabilir.

Kaynakça

1. Ardıç, S. (2020). Bitki kimyasal bileşenleri ve çevresel stres ilişkisi. İstanbul: Bilimsel Kitaplar.
2. Chaves, M. M., Flexas, J., & Pinheiro, C. (2009). Photosynthesis under drought and salt stress: Regulation mechanisms from whole plant to cell. Annals of Botany, 103(4), 551–560.
3. Croteau, R., Kutchan, T. M., & Lewis, N. G. (2000). Natural products (secondary metabolites). Biochemistry and Molecular Biology of Plants, 1250–1318.
4. Dixon, R. A. (2001). Natural products and plant disease resistance. Nature, 411(6839), 843–847.
5. González, A., Susana, F., & María, R. (2004). Effects of high altitude on plant phenolics. Plant Biology, 6(2), 125–130.
6. Jaleel, C. A., Manivannan, P., & Wahid, A. (2009). Drought stress in plants: A review on morphological characteristics and pigments composition. International Journal of Agriculture & Biology, 11(1), 100–105.
7. Karagöz, A. (2020). Çevresel stres faktörlerinin bitki metabolizmasına etkileri. Ankara Üniversitesi Yayınları.
8. Kaya, Ö., Yılmaz, T., & Demir, N. (2021). Rakım ve bitki adaptasyon stratejileri. Türk Biyoloji Dergisi, 18(2), 45-56.
9. Körner, C. (2007). The use of ‘altitude’ in ecological research. Trends in Ecology & Evolution, 22(11), 569–574.
10. Körpe, D., & Arslan, M. (2019). Rakımın bitki fenolik bileşikleri üzerindeki etkileri. Botanik Araştırmaları Dergisi, 45(2), 123-132.
11. Rozema, J., Björn, L. O., & Bornman, J. F. (1997). The role of UV-B radiation in terrestrial ecosystems. Plant Ecology, 128(1), 182–191.
12. Tüfekçi, H. (2021). Yüksek rakım bitkilerinde sekonder metabolit değişimleri. Tarım ve Çevre Dergisi, 27(3), 78-85.
13. Zhou, H., Liu, Y., & Wang, Z. (2018). Elevation influences on flavonoid synthesis in alpine plants. Journal of Plant Ecology, 12(1), 34-42.

NOVEL TECHNIQUES IN NUTRITION AND FOOD SCIENCE: A COMPREHENSIVE REVIEW ON THE ROLE OF OLIVES

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Abstract

Olives (*Olea europaea*) are fundamental to the Mediterranean diet and have been the subject of extensive research due to their rich composition of bioactive compounds, such as polyphenols, monounsaturated fatty acids, and powerful antioxidants. These compounds are linked to numerous health benefits, including heart health support, anti-inflammatory effects, and antioxidant protection. Recent advancements in nutrition and food science have paved the way for the development of cutting-edge processing and preservation techniques. These innovations focus on maximizing the bioavailability, stability, and nutritional value of olives and olive-derived products, which are sensitive to traditional processing methods that can lead to nutrient loss. This review presents an in-depth exploration of these novel processing and preservation methods, such as ultrasound-assisted extraction, supercritical fluid extraction, and pulsed electric fields, each demonstrating the potential to retain and even enhance the nutritional profile of olives. Additionally, innovative preservation technologies, including high-pressure processing and cold plasma technology, are examined for their roles in extending shelf life without compromising the quality of bioactive compounds. The implications of these advancements are far-reaching, with potential applications in the health, food technology, and nutraceutical industries. By optimizing the health-promoting compounds found in olives, these novel techniques not only support consumer health but also open new opportunities for the development of functional foods and supplements. This comprehensive review underscores the significance of these emerging technologies and outlines their current applications, potential health benefits, and future prospects in transforming the olive industry into a cornerstone of health-oriented food science. Furthermore, as consumer interest in health-conscious products grows, the adoption of these technologies could significantly enhance the marketability of olives and their derivatives.

Keywords: Antioxidants, Functional Foods, Food Processing Techniques, Monounsaturated Fatty Acids, Olive.

1. Introduction

The olive tree (*Olea europaea*), native to the Mediterranean basin, has been cultivated for thousands of years, making it one of the oldest cultivated plants in human history. Its long-standing cultivation reflects not only its agricultural value but also its substantial economic and cultural significance across various Mediterranean civilizations [13]. The olive tree symbolizes peace and prosperity, and its fruit, olives, have been a dietary staple in the region, integral to both traditional and modern Mediterranean cuisine.

In recent years, scientific research has broadened to encompass a more comprehensive understanding of olives, extending beyond their traditional health benefits. Researchers are now investigating innovative technological processes that enhance the bioavailability and stability of bioactive compounds present in olives, thereby maximizing their health-promoting properties [10; 20]. This includes methods that improve the extraction and preservation of these compounds during processing, which is crucial because many beneficial nutrients can be lost in traditional processing methods.

Olives are particularly rich in monounsaturated fatty acids, with oleic acid being the predominant fatty acid in both olives and olive oil. Numerous studies indicate that these monounsaturated fats contribute significantly to heart health. They help in promoting favorable cholesterol levels by increasing high-density lipoprotein (HDL) cholesterol while lowering low-density lipoprotein (LDL) cholesterol. Additionally, the anti-inflammatory properties of oleic acid can reduce the risk of cardiovascular diseases, as chronic inflammation is a known risk factor for heart-related ailments [9].

The health benefits of olives are further augmented by the presence of phenolic compounds, including oleuropein, hydroxytyrosol, and tyrosol. These compounds are recognized for their potent antioxidant properties, which play a crucial role in neutralizing harmful free radicals in the body. Free radicals are unstable molecules that can cause oxidative stress, leading to cellular damage and an increased risk of chronic diseases such as cancer, diabetes, and neurodegenerative disorders [4]. The antioxidant and anti-inflammatory activities of these phenolics contribute significantly to the reduction of chronic disease risk, making olives and olive oil essential components of a health-promoting diet.

The burgeoning body of evidence surrounding the health benefits of olive products has sparked a wave of research aimed at developing innovative methods to harness and maximize these benefits. This includes exploring novel extraction techniques, such as ultrasound-assisted extraction and supercritical fluid extraction, which can preserve the integrity of these bioactive compounds during processing. Moreover, advancements in food technology are paving the way for the incorporation of olives into functional foods and nutraceuticals, thus broadening their applications in health and wellness [10].

Overall, the increasing recognition of olives as a functional food underscores the need for ongoing research into their health benefits, optimal processing methods, and potential applications in promoting public health.

2. Nutritional Profile and Bioactive Components of Olives

Olives are rich in beneficial compounds such as monounsaturated fatty acids, phenolic compounds, vitamins, and minerals [15]. The primary phenolics in olives, including oleuropein, hydroxytyrosol, and tyrosol, have been shown to possess powerful antioxidant properties, aiding in the neutralization of free radicals [26]. Research also indicates that oleuropein may have neuroprotective and anti-carcinogenic effects, making olives a valuable component in preventative health care [6]. Additionally, olives contain vitamin E and carotenoids, both of which contribute to skin health and protection against oxidative stress [23].

3. Novel Extraction Techniques for Olive Processing

3.1. Ultrasound-Assisted Extraction (UAE)

UAE uses high-frequency sound waves to rupture cell walls, thereby enhancing the extraction of phenolic compounds and antioxidants from olives [7]. Studies have shown that UAE preserves bioactive compounds more effectively compared to traditional methods, as it requires lower temperatures and shorter processing times [8]. This method also shows potential for improving the stability of polyphenols, which can be sensitive to thermal degradation during conventional processing [25].

3.2. Supercritical Fluid Extraction (SFE)

SFE utilizes supercritical CO_2 as a solvent, providing an environmentally friendly alternative that avoids harmful chemicals. It is highly effective in extracting lipophilic compounds such as oleuropein and hydroxytyrosol, thereby enhancing the nutritional value of olive oils [24]. SFE has been documented to yield higher purity extracts with preserved sensory qualities, particularly beneficial for high-quality virgin olive oils [21].

3.3. Pulsed Electric Field (PEF)

PEF technology applies short bursts of electrical energy to olives, permeabilizing cell membranes and facilitating compound release. This technique has been found to improve the recovery of phenolics in olive oil, leading to higher antioxidant levels [22]. Additionally, PEF processing enhances the flavor profile of olive oil by preserving volatile compounds typically lost during conventional extraction [1].

4. Preservation Techniques for Olives and Olive Oil

4.1. High-Pressure Processing (HPP)

HPP is a non-thermal technique that uses high pressure to inactivate microbial contaminants, thus extending the shelf life of olive products while preserving bioactive compounds [17]. This method has been shown to maintain antioxidant levels in olive oil, offering an alternative to heat pasteurization, which can degrade phenolic compounds [3].

4.2. Cold Plasma Technology

Cold plasma is an emerging non-thermal preservation method that uses ionized gas to deactivate surface microorganisms, thus reducing the need for chemical preservatives [16]. Research shows that this technique effectively maintains the integrity of polyphenols and fatty acids, prolonging the shelf life of fresh olives and processed products [5].

5. Health Applications of Olive Bioactives

The health-promoting properties of olives are supported by extensive research linking olive phenolics to a reduced risk of cardiovascular diseases, cancer, and neurodegenerative disorders [10]. For example, hydroxytyrosol has demonstrated efficacy in reducing oxidative stress markers and improving endothelial function [27]. Oleuropein, a major compound in olives, has also been found to exhibit anti-inflammatory and antimicrobial properties, making it suitable for both dietary and pharmaceutical applications [19].

5.1. Functional Foods and Nutraceuticals

Olive extracts are being incorporated into functional foods and nutraceuticals due to their bioactive content. Studies have shown that supplementation with olive phenolics can improve lipid profiles and reduce inflammatory markers in individuals with metabolic syndrome [14]. Furthermore, olive-derived products are being explored for gut health benefits, as they promote a healthy gut microbiota, potentially impacting metabolic and immune functions [11].

6. Future Perspectives and Challenges

While novel techniques show significant promise, scaling these technologies for industrial applications remains challenging due to cost constraints and regulatory requirements [12]. Additionally, consumer acceptance and perception of technologically processed foods must be considered when introducing these methods to the market [2; 18]. Further research should focus on optimizing these techniques to ensure high bioactive retention without compromising consumer safety and product quality.

Conclusion

Advancements in food processing and preservation technologies are enhancing the health benefits of olives, making this valuable nutrient source more accessible and beneficial for consumers. With their rich bioactive compounds, olives are emerging as a functional food and nutraceutical ingredient that supports health. These innovative techniques are driving a significant transformation in the olive industry by further optimizing the nutritional value, bioavailability of bioactive components, and preservation of nutrients during storage. For instance, methods such as ultrasound-assisted extraction and high-pressure processing not only increase the extraction efficiency of beneficial compounds but also maintain their stability over time. As research progresses, olives are expected to be utilized more effectively not only in the food sector but also in health, nutrition, and pharmaceutical industries, reaching a wider audience. Thus, olives will continue to hold an important place in modern food technologies, with their profound impact on consumer health, potentially aiding in the prevention of chronic diseases and promoting overall wellness.

References

1. Abenoza, M., Benito, M., Saldaña, G., Álvarez, I., Raso, J., Sánchez-Gimeno, A. C. (2013). Effects of pulsed electric field on yield extraction and quality of olive oil. Food and Bioprocess Technology, 6, 1367-1373. https://doi.org/10.1007/s11947-012-0817-6

2. Adebo, O. A., Njobeh, P. B., Adeboye, A. S., Adebiyi, J. A., Sobowale, S. S., Ogundele, O. M., & Kayitesi, E. (2018). Advances in fermentation technology for novel food products. Innovations in technologies for fermented food and beverage industries, 71-87. https://doi.org/10.1007/978-3-319-74820-7_4

3. Andreou, V., Kourmbeti, E., Dimopoulos, G., Psarianos, M., Katsaros, G., Taoukis, P. (2022). Optimization of virgin olive oil yield and quality applying nonthermal processing. Food and Bioprocess Technology, 15(4), 891-903. https://doi.org/10.1007/s11947-022-02788-2

4. Bendini, A., Cerretani, L., Carrasco-Pancorbo, A., Gómez-Caravaca, A. M., Segura-Carretero, A., Fernández-Gutiérrez, A., & Lercker, G. (2007). Phenolic molecules in virgin olive oils: a survey of their sensory properties, health effects, antioxidant activity and analytical methods. An overview of the last decade. Molecules, 12(8), 1679-1719. https://doi.org/10.3390/12081679

5. Birania, S., Attkan, A. K., Kumar, S., Kumar, N., & Singh, V. K. (2022). Cold plasma in food processing and preservation: A review. Journal of Food Process Engineering, 45(9), e14110. https://doi.org/10.1111/jfpe.14110

6. Bucciantini, M., Leri, M., Nardiello, P., Casamenti, F., & Stefani, M. (2021). Olive polyphenols: Antioxidant and anti-inflammatory properties. Antioxidants, 10(7), 1044. https://doi.org/10.3390/antiox10071044

7. Chemat, F., Rombaut, N., Sicaire, A. G., Meullemiestre, A., Fabiano-Tixier, A. S., & Abert-Vian, M. (2017). Ultrasound assisted extraction of food and natural products. Mechanisms, techniques, combinations, protocols and applications. A review. Ultrasonics sonochemistry, 34, 540-560. https://doi.org/10.1016/j.ultsonch.2016.06.035.
8. Contreras, M. D. M., Gómez-Cruz, I., Romero, I., Castro, E. (2021). Olive pomace-derived biomasses fractionation through a two-step extraction based on the use of ultrasounds: Chemical characteristics. Foods, 10(1), 111. https://doi.org/10.3390/foods10010111
9. Covas, M. I. (2007). Olive oil and the cardiovascular system. Pharmacological Research, 55(3), 175-186. https://doi.org/10.1016/j.phrs.2007.01.010
10. Covas, M. I. (2008). Bioactive effects of olive oil phenolic compounds in humans: reduction of heart disease factors and oxidative damage. Inflammopharmacology, 16, 216-218. https://doi.org/10.1007/s10787-008-8019-6
11. Farràs, M., Martinez-Gili, L., Portune, K., Arranz, S., Frost, G., Tondo, M., & Blanco-Vaca, F. (2020). Modulation of the gut microbiota by olive oil phenolic compounds: implications for lipid metabolism, immune system, and obesity. Nutrients, 12(8), 2200. https://doi.org/10.3390/nu12082200
12. Galanakis, C. M. (2013). Emerging technologies for the production of nutraceuticals from agricultural by-products: a viewpoint of opportunities and challenges. Food and bioproducts processing, 91(4), 575-579. https://doi.org/10.1016/j.fbp.2013.01.004
13. Kailis, S. G., Harris, D. (2007). Producing Table Olives. Landlinks Press.
14. Lockyer, S., Yaqoob, P., Spencer, J. P., & Rowland, I. (2012). Olive leaf phenolics and cardiovascular risk reduction: physiological effects and mechanisms of action. Nutrition and Aging, 1(2), 125-140. https://doi.org/10.3233/NUA-2012-0011
15. Manna, C., D'Angelo, S., Migliardi, V., Napoli, D. (2015). Health benefits of olive oil polyphenols: Current findings and future directions. Nutrition Research Reviews, 28(1), 52-60.
16. Pankaj, S. K., Bueno-Ferrer, C., Misra, N. N., Milosavljević, V., O'donnell, C. P., Bourke, P., Keener, K. M., Cullen, P. J. (2014). Applications of cold plasma technology in food packaging. Trends in Food Science & Technology, 35(1), 5-17. https://doi.org/10.1016/j.tifs.2013.10.009
17. Patras, A., Brunton, N. P., Da Pieve, S., & Butler, F. (2009). Impact of high pressure processing on total antioxidant activity, phenolic, ascorbic acid, anthocyanin content and colour of strawberry and blackberry purées. Innovative Food Science & Emerging Technologies, 10(3), 308-313. https://doi.org/10.1016/j.ifset.2008.12.004
18. Perito, M. A., Di Fonzo, A., Sansone, M., & Russo, C. (2020). Consumer acceptance of food obtained from olive by-products: A survey of Italian consumers. British Food Journal, 122(1), 212-226. https://doi.org/10.1108/BFJ-03-2019-0197
19. Rigacci, S. (2015). Olive oil phenols as promising multi-targeting agents against Alzheimer’s disease. Natural compounds as therapeutic agents for Amyloidogenic diseases, 1-20. https://doi.org/10.1007/978-3-319-18365-7_1
20. Servili, M., Esposto, S., Fabiani, R., Urbani, S., Taticchi, A., Mariucci, F., Selvaggini, R., Montedoro, G. F. (2009). Phenolic compounds in olive oil: Antioxidant, health and organoleptic activities according to their chemical structure. Inflammopharmacology, 17, 76-84. https://doi.org/10.1007/s10787-008-8014-y
21. Temelli, F. (2009). Perspectives on supercritical fluid processing of fats and oils. The Journal of Supercritical Fluids, 47(3), 583-590. https://doi.org/10.1016/j.supflu.2008.10.014
22. Toepfl, S., Siemer, C., Saldaña-Navarro, G., Heinz, V. (2014). Overview of pulsed electric fields processing for food. In Emerging technologies for food processing (pp. 93-114). Academic Press. https://doi.org/10.1016/B978-0-12-411479-1.00006-1

23. Tuck, K. L., Hayball, P. J. (2002). Major phenolic compounds in olive oil: metabolism and health effects. The Journal of nutritional biochemistry, 13(11), 636-644. https://doi.org/10.1016/S0955-2863(02)00229-2
24. Uwineza, P. A., Waśkiewicz, A. (2020). Recent advances in supercritical fluid extraction of natural bioactive compounds from natural plant materials. Molecules, 25(17), 3847. https://doi.org/10.3390/molecules25173847
25. Vilkhu, K., Mawson, R., Simons, L., Bates, D. (2008). Applications and opportunities for ultrasound assisted extraction in the food industry—A review. Innovative Food Science & Emerging Technologies, 9(2), 161-169. https://doi.org/10.1016/j.ifset.2007.04.014
26. Visioli, F., Bellosta, S., Galli, C. (1998). Oleuropein, the bitter principle of olives, enhances nitric oxide production by mouse macrophages. Life sciences, 62(6), 541-546. https://doi.org/10.1016/S0024-3205(97)01150-8
27. Weinbrenner, T., Fito, M., de la Torre, R., Saez, G. T., Rijken, P., Tormos, C., Coolen, S., Albaladejo, M. F., Abanades, S., Schroder, H., Marrugat, J., & Covas, M. I. (2004). Olive oils high in phenolic compounds modulate oxidative/antioxidative status in men. The Journal of nutrition, 134(9), 2314-2321. https://doi.org/10.1093/jn/134.9.2314

MANAGEMENT OF MICROPLASTIC POLLUTION IN SOILS: MITIGATION STRATEGIES AND REMOVAL TECHNIQUES

TOPRAKLARDA MİKROPLASTİK KİRLİLİĞİNİN YÖNETİMİ: AZALTIM STRATEJİLERİ VE GİDERİM TEKNİKLERİ

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Özet

Plastiklerin bozulmaya karşı dayanıklılığı, yüksek performansı ve düşük maliyeti, modern yaşamın vazgeçilmez bir parçası haline gelmelerini sağlamış, ancak yoğun kullanım ve su ve karasal ekosistemlerde birikim ciddi çevresel sorunları da beraberinde getirmiştir. Üretilen plastiklerin çok büyük bir kısmı, doğrudan ya da dolaylı olarak çevreye salınmakta ve zamanla daha küçük parçalara ayrışarak mikroplastiklere dönüşmektedir. Tarım arazilerinde, atık çamur kullanımı, atık su ile sulama, plastik malç, atmosferik taşınım, polimer bazlı gübre ve pestisit uygulamaları yoluyla giren mikroplastikler zaman içerisinde birikmektedir. Mikroplastiklerin yüksek yüzey alanı, organik kirleticiler ve ağır metaller gibi zararlı bileşenleri adsorbe etmelerine neden olarak, bu kirleticilerin toprakta kalıcılığını ve biyo-yarayışlılıklarını artırmaktadır. Toprağın işlevlerini yerine getirmesinde etkili olan çeşitli fiziksel, kimyasal ve biyolojik özelliklerini olumsuz etkileyen mikroplastikler, bitki gelişimini ve nihayetinde tarımsal üretimin güvenliğini tehdit etmektedir. Mikroplastikler, doğal ortamda neredeyse parçalanmadan uzun süre kalabildiğinden, organizmalar tarafından kolaylıkla bünyelerine alınmakta ve besin zinciri boyunca insan da dahil olmak üzere çeşitli organizmalarda birikebilmektedir. Bu nedenle, son yıllarda toprakta biriken mikroplastiklerin olumsuz etkilerinin azaltılması ve mikroplastiklerin tamamen giderilmesine yönelik yöntemlerin yer aldığı çalışmalar daha da önem kazanmıştır. Topraktaki mikroplastiklerin çeşidine ve miktarına bağlı olarak başarısı değişen yöntemler arasında en dikkat çekenleri, karbonca zengin bir materyal olan biyokömür kullanımı ile toprağın yapısının iyileştirilmesi, iyi tarım uygulamalarının adapte edilmesi, plastik malç yerine doğal bitki artıklarının veya biyoparçalanabilir malçların kullanımı sayılabilir. Mikroplastik kirliliğinin etkilerinin azaltılmasının yanında, topraktan mikroplastiklerin giderilmesi için de piroliz, hidroliz, biyolojik ve ultrasonik mekanik bozunma gibi çeşitli yöntemler araştırmalara konu olmaktadır. Bu kapsamda, mevcut derleme, tarım arazilerinde biriken mikroplastik kirliliğini azaltmaya yönelik stratejileri üzerine odaklanmıştır.

Anahtar Kelimeler: Mikroplastik kirliliği, Azaltım teknikleri, Tarımsal Sürdürülebilirlik, Gıda Güvenliği, Tarım toprakları

Abstract
Resistance to degradation, high performance, and low cost of plastics made them an indispensable part of modern life. However, their intensive use and accumulation in aquatic and terrestrial ecosystems have led to serious environmental issues. A significant portion of the plastics produced are directly or indirectly released into the environment, and eventually breaking down into smaller fragments, known as microplastics. In agricultural lands, microplastics accumulate over time through practices through application of sewage sludge, irrigation with wastewater, the use of plastic mulch, atmospheric deposition, polymer-based fertilizers and pesticides. The high surface area of microplastics enables them to adsorb harmful components such as organic pollutants and heavy metals, increasing the persistence and bioavailability of these contaminants in the soil. This negatively impacts various physical, chemical, and biological properties of the soil that are crucial for its functionality, thereby posing threats to plant growth and ultimately, the safety of agricultural productivity. Since microplastics can persist in the natural environment for long periods without degrading, they are easily taken up by organisms and accumulate throughout the food chain, including in humans. For this reason, recent studies have increasingly focused on mitigating the adverse effects of microplastics in soil,and developing methods for their complete removal. Depending on the type and amount of microplastics in the soil, several strategies have been proposed with various degrees of success, including the use of biochar, a carbon-rich material to improve soil structure, the adoption of good agricultural practices, and the use of natural plant residues or biodegradable mulches as alternative to plastic mulch. In addition to reducing the impacts of microplastic pollution, various methods such as pyrolysis, hydrolysis, biological degradation, and ultrasonic mechanical degradation have been explored for the removal of microplastics from soils. This review focuses on strategies to mitigate microplastic pollution accumulating in agricultural soils.
Keywords: Microplastic pollution, Mitigation strategies, Agricultural sustainability, Food Safety, Agricultural soils

Giriş

Plastikler, dayanıklılıkları, düşük maliyetleri ve geniş uygulama alanları sayesinde modern yaşamın ayrılmaz bir parçası haline gelmiş ve bu durum çeşitli sektörlerde yoğun bir şekilde tercih edilmelerine yol açmıştır (Bucknall, 2020). Polistiren, polivinil klorür, polietilen ve polikarbonat gibi plastik türleri, yüksek üretim hacimleri ve günlük yaşamda yaygın kullanımlarıyla dikkat çeken materyaller arasında yer almaktadır (Seewoo ve ark., 2024). Bununla birlikte, bu plastik malzemelerin kontrolsüz şekilde bertaraf edilmesi ve geri dönüşüm süreçlerine yeterince dahil edilememesi, çevresel ortamlarda ciddi bir plastik birikimine yol açmaktadır (Hahladakis ve ark., 2018). Çevreye atılan bu plastik atıklar, ultraviyole radyasyonu, ışık ve suyun mekanik etkileri gibi çeşitli çevresel faktörlerin etkisiyle parçalanmakta, çapları 5 mm'den daha küçük hale gelerek mikroplastiklere dönüşmektedir (Sun ve ark., 2022).

Mikroplastikler, toprak, su ve atmosfer gibi farklı çevresel ortamlarda yaygın olarak tespit edilmekte ve ekosistemlerde geniş bir dağılım göstermektedir (Wang ve ark., 2020). Bu partiküllerin çevredeki yaygın varlığı ve biyolojik sistemlerle etkileşim kurabilme kapasiteleri, mikroplastiklerin yalnızca yerel değil, küresel ölçekte de çevresel bir sorun haline gelmesine neden olmaktadır (Sridharan ve ark., 2021). Özellikle tarımsal alanlar gibi toprak ekosistemlerinde, mikroplastiklerin çevresel dinamikler üzerindeki etkileri belirgin bir şekilde görülmekte ve bu durum hem ekolojik dengeyi hem de tarımsal üretim güvenliğini tehdit etmektedir (Boots ve ark., 2019). Tarımsal üretimdeki çeşitli uygulamalar, mikroplastiklerin toprakta birikmesine neden olmaktadır. Örtü altı tarımda kullanılan plastik örtüler, atık kompost ve çamur gibi toprak iyileştiriciler, sulama amacıyla kullanılan atık sular ve polimer bazlı pestisitler gibi tarımsal girdiler, mikroplastiklerin toprak ekosistemine doğrudan geçiş yollarını oluşturmaktadır (Hechmi ve ark., 2024; Lwanga ve ark., 2022; Surendran ve ark., 2023). Araştırmalar, yıllık mikroplastik salınımının tarım topraklarında, okyanuslara salınan miktarın 4 ila 23 katına ulaşabileceğini ortaya koymuştur (Horton ve ark., 2017).

Mikroplastiklerin toprak ekosistemlerinde birikimi, toprağın kalitesinin azalmasına ve zamanla tarımsal üretimin sürdürülebilirliği ciddi şekilde tehdit etmektedir (Ya ve ark., 2021). Toprak matrisine dahi olan mikroplastikler, toprak hacim ağırlığı, gözeneklilik, su tutma kapasitesi, hidrolik iletkenlik ve agregat stabilitesi gibi temel fiziksel – özellikler üzerinde olumsuz etkilere yol açabilmektedir (Wang ve ark., 2022; Qiu ve ark., 2022). Ayrıca, mikroplastikler, toprakta karbon, azot ve fosfor döngüleri gibi jeokimyasal süreçlerde değişikliklere neden olmakta; pH ve elektriksel iletkenlik gibi kimyasal toprak özellikleri üzerinde olumsuz etkiler oluşturabilmektedir (Ma ve ark., 2023; Yao ve ark., 2022). Toprak özelliklerinde meydana gelen bu değişimler, hem toprak sağlığını hem de bitki büyüme ve gelişimini olumsuz etkileyerek tarımsal verimliliğin azalmasına yol açmaktadır (Khalid ve ark., 2020).

Mikroplastiklerin küçük boyutları, toprak faunası üzerinde doğrudan etkiler yaratmaktadır (Lin ve ark., 2020). Mikroplastiklerin, özellikle solucanlar ve diğer toprak organizmaları tarafından yutulması, bu organizmaların bağırsaklarında mekanik tıkanmalara, dokusal bozulmalara ve hatta ölümlere yol açabilmektedir (Chen ve ark., 2024). Mikroplastikler aynı zamanda yüzeylerinde toksik maddeleri, ağır metalleri ve organik kirleticileri adsorbe edebilmekte ve bu durum mikroplastiklerin taşıyıcı bir vektör olarak davranmasına neden olmaktadır (Cao ve ark., 2021). Mikroplastikler ve bunlara bağlı kirleticilerin sinerjik etkileri, çevresel toksisiteyi artırarak yalnızca ekosistemlerin işlevselliğini bozmakla kalmamakta, aynı zamanda insan sağlığı üzerinde de ciddi tehditler oluşturabilmektedir (Yu ve ark., 2022). Bu bağlamda, mikroplastiklerin ekosistemler ve insan sağlığı üzerindeki etkilerinin anlaşılması, mikroplastik kirliliğinin yönetimine ve etkili azaltma stratejilerinin geliştirilmesine yönelik çalışmalarda kritik bir öneme sahiptir.

Konvansiyonel atık yönetimi, mikroplastiklerin çeşitli kaynaklardan çevresel ortamlara yayılma dinamikleri gibi karmaşık etmenler nedeniyle, mikroplastik kirliliğinin etkili bir şekilde azaltılmasında sıklıkla yetersiz kalmaktadır (Zhou ve ark., 2020). Bu nedenle, toprakta biriken mikroplastiklerin ekosistem üzerindeki etkilerinin derinlemesine anlaşılması, mikroplastik kirliliğine yönelik etkin yönetim stratejilerinin geliştirilmesi açısından kritik bir öneme sahiptir. Bu çalışma, mikroplastiklerin ekosistem işlevselliği ve tarımsal verimlilik üzerindeki potansiyel etkilerini incelemeyi ve mikroplastik kirliliğinin yönetimi için sürdürülebilir ve uygulanabilir stratejileri ele alarak, bu alandaki bilgi boşluklarını doldurmayı amaçlamaktadır.

Toprakta Mikroplastik Kirliliğinin Etkilerini Azaltmaya Yönelik Stratejiler ve Uygulamalar

Kaynaktan Önleme

Toprakta mikroplastik kirliliğinin azaltılmasında en etkili yaklaşımlardan biri, bu kirliliğin oluşumunun kaynağında kontrol altına alınmasıdır (Schuhen ve Sturm, 2020). Bu yöntem, mikroplastiklerin çevreye salınımını kaynağında engellemeyi amaçlayarak sorunun temel nedenlerine odaklanmaktadır. Plastik üretim süreçlerinde gerçekleştirilecek düzenlemeler, mikroplastik kirliliğinin önlenmesinde temel bir öneme sahiptir (Munhoz ve ark., 2022). Gıda ambalajları, kozmetik ve temizlik ürünlerinde kullanılan çubuklar ve mikroboncuklar gibi tek kullanımlık plastiklerin yasaklanması veya kullanımının sınırlandırılması, mikroplastik kirliliğinin azaltılmasında etkili bir yaklaşım olarak öne çıkmaktadır (Kumar ve ark., 2021). Mikroboncuklar, Yeni Zelanda, Kanada, ve ABD gibi bazı ülkelerde yasaklanmıştır (Venus, 2020). Ancak, tek kullanımlık ürünlerin yasaklanması, halk sağlığı üzerindeki olası etkileri göz önünde bulundurularak dikkatlice değerlendirilmelidir (Chen ve ark., 2021). Özellikle, taze et gibi bozulabilir gıda maddelerinin ambalajları yasaklanmamalı, bunun yerine bu ürünlerin ambalaj tasarımları mikroplastiklerin, çevresel etkilerini azaltacak şekilde iyileştirilmelidir (Prata ve ark., 2019).

Mikroplastik kirliliğinin önlenmesinde, tüketici düzeyinde alınacak önlemlerde büyük bir öneme sahiptir (Mitrano ve Wohlleben, 2020). Tek kullanımlık plastiklerin yasaklanması veya bunların yerine yeniden kullanılabilir alternatif malzemelerin teşvik edilmesi, mikroplastik kirliliğini önemli ölçüde azaltabilir (Cowan ve ark., 2021). Özellikle polistiren, polikarbonat ve polivinil klorür gibi çevre ve sağlık açısından daha zararlı etkileri olan plastiklerin tehlikeli olarak sınıflandırılması ve bunların geri dönüştürülebilir ya da daha güvenli alternatiflerle değiştirilmesi, bu alandaki öncelikli adımlar arasında yer almalıdır (Rochman ve ark., 2013). Ayrıca, tekstil endüstrisi, mikroplastik kirliliğinin önemli kaynaklarından biri olup, çevreye salınan mikroplastiklerin yaklaşık %35'ini oluşturmaktadır (Xu ve ark., 2020). Sentetik özelikteki giysilerinçamaşır makinelerinde yalnızca bir yıkama işlemi ile, çevreye 0.7 milyondan fazla mikrofiberin salınmasına yol açtığı bildirilmiştir (Wang ve ark., 2024). Bu bağlamda, sentetik kumaşlar yerine pamuk ve yün gibi doğal liflerin kullanımının arttırılması teşvik edilmelidir (Liu ve ark., 2021). Ayrıca, çamaşır makinelerine mikrofiber filtrelerinin entegre edilmesi gibi teknolojik yenilikler, mikrofiber salınımını önemli ölçüde azaltma potansiyeline sahiptir (Periyasamy, 2023).

Yasal düzenlemeler ve politikaların hayata geçirilmesi, kaynaktan önleme stratejisinin temel unsurlarından biri olmaktadır (Da Costa ve ark., 2020). Mikroplastik içeren ürünlerin üretiminin sınırlandırılması veya tamamen yasaklanması, bunların ithalatı ve satışının yasaklanması, bu bağlamda etkili bir çözüm olarak değerlendirilmektedir (Usman ve ark., 2022). Aynı şekilde, atık su arıtma tesislerinin ileri teknolojiye sahip sistemlerle donatılması, toprak ve su kaynaklarına mikroplastiklerin karışmasını engelleyebilmektedir (Di Giacomo ve Romano, 2022). Zira, atık su arıtma sistemlerinden elde edilen atık çamurlarının tarımda toprak iyileştirici olarak kullanılması ve sulamanın atık suyla yapılması, mikroplastiklerin çevreye yayılmasını kolaylaştırmaktadır (Hechmi ve ark., 2024). Bu nedenle, atık su arıtma tesislerinde mikroplastiklerin etkin bir şekilde ayrıştırılması, toprak kirliliğini önleyerek gıda güvenliği, çevre ve insan sağlığı üzerindeki mikroplastiklerin zararlı etkilerinin azaltılmasına önemli ölçüde katkı sağlayabilir (Xu ve ark., 2021).

Atık Bertarafının Etkin Yönetimi

Toprakta, mikroplastik kirliliğinin azaltılmasında atık bertaraf yöntemlerinin iyileştirilmesi kritik bir rol oynamaktadır (Yang ve ark., 2021). Bu bağlamda, plastik üretim ve tüketim süreçlerine müdahale ederek atık oluşumunu azaltmak, geri dönüşüm oranlarını artırmak ve entegre atık yönetim sistemlerini geliştirilip etkin bir şekilde uygulanmasını sağlamak gerekmektedir (Kumar ve ark., 2021). Etkin bir atık yönetimi, çevredeki plastiklerin miktarını azaltarak bunların mikroplastiklere dönüşümünü engellemektedir (Amesho ve ark., 2023). Tayvan'da plastik atıkların yönetimine yönelik yasaklar ve atıkların ayrıştırılmasını zorunlu kılan düzenlemeler, atık miktarının azaltılmasında ve çevresel temizlik koşullarının iyileştirilmesinde önemli katkılar sağlamıştır. Bu politikalar sonucunda, kişi başına düşen günlük atık miktarı 0.9 kg'dan 0.48 kg'a düştüğü, ve bunun sonunda çevre kirliliği üzerindeki olumsuz etkilerin azaldığı bildirilmiştir(Liu ve ark., 2013).

Atık Yönetiminde Sürdürülebilir Geri Dönüşüm Stratejileri

Plastiklerin geri dönüşümü, küresel ölçekte yıllık 3.5 milyar varil petrole denk enerji tasarrufu sağlama potansiyeline sahip olmasına rağmen, üretilen plastik atıkların yalnızca %9'u geri dönüştürülmekte, %12'si yakılarak bertaraf edilmekte ve %79'u doğrudan toprağa gömülmektedir (Chen ve ark., 2021; Garcia ve Robertson, 2017). Bu durum, plastik atıkların çevresel etkilerini arttırmakta ve toprak kirliliği üzerinde ciddi bir tehdit oluşturmaktadır

(MacLeod ve ark., 2021). Toprakta biriken plastik kalıntılar, ultraviyole ışınları, sıcaklık değişimleri, mekanik aşınma ve biyolojik bozunma gibi çevresel etmenlerin etkisiyle 5 mm'den daha küçük mikroplastiklere dönüşekerek toprakta daha ciddi bir çevresel kirlilik sorununa yol açmaktadır (Zhou ve ark., 2020). Bununla birlikte, geri dönüştürülemeyen plastiklerin kontrolsüz bertarafı, ekonomik kayıplar, artan emisyonlar ve çevresel zararlara yol açaraksürdürülebilir çevre yönetimi açısından önemli bir sorun teşkil etmektedir (Lokhandwala ve ark., 2024). Bu nedenle uygun yöntemlerle plastiklerin geri kazanımı veya yasaklanması elzem bir durum teşkil etmektedir.
Bazı araşttırmalar plastiklerin geri dönüştürülerek özellikle asfalt yol kaplamaları gibi kentsel altyapı projelerinde kullanımının umut verici bir çözüm olacağını bildirmiştir (Hao ve ark., 2024; Lamba ve ark., 2022). Geri dönüştürülmüş plastik malzemelerin asfalt yol kaplamalarına entegre edilmesiyle plastikle modifiye edilmiş yolların inşa edilmesi, hem plastik atıkların değerlendirilmesini hem de inşaat malzemelerinin performansının artırılmasını sağlamaktadır (Walker ve Xanthos, 2018). Ancak plastiğin yol yapımında kullanılması, lastik aşınması ve hava koşullarına bağlı yol yüzeyi yıpranmaları nedeniyle toprakta mikroplastik birikimine neden olabilmektedir (Enfrin ve ark., 2022). Plastik modifikasyonlu yol bölümleri dünya genelinde uygulanmış olsa da, bu yolların gerçek dünya koşullarındaki performansına dair yapılan çalışmalar sınırlıdır ve plastikle modifiye edilen yolların toprakta mikroplastik kirliliğine katkısı hâlâ tam olarak bilinmemektedir (Abd Karim ve ark., 2023). Bu nedenle, plastik atıkların yönetimi ve geri dönüşümüne dair daha etkili stratejiler geliştirilmesi, toprakta mikroplastik kirliliğinin azaltılmasında kritik bir rol oynamaktadır.

Biyobozunur Plastiklerin Geliştirilmesi

Biyobozunur plastikler, enzimler ve mikroorganizmalar aracılığıyla organik bileşiklere, örneğin CO_2, H_2O, CH_4 ve biyokütleye dönüşebilen polimerler olarak tanımlanmaktadır (Alshehrei, 2017). Bu plastikler, doğal ve sentetik polimerler olmak üzere iki ana kategoriye ayrılmaktadır (Rogovina, 2016). Doğal polimerler, biyolojik kaynaklardan, özellikle yenilenebilir materyaller olan bitkiler ve biyokütlelerden sentezlenen protein bazlı plastikler, nişasta bazlı plastikler, selüloz bazlı plastikler, polilaktik asit ve polihidroksi-alkanoatlar gibi bileşenleri içermektedir (Kurek ve Benbettaieb, 2021). Buna karşın, sentetik polimerler, petrol ve doğalgaz gibi yenilenemeyen kaynaklardan üretilen polibütilen adipat tereftalat, polikaprolakton ve polibütilen süksinat gibi bileşenleri kapsamaktadır (Čolnik ve ark., 2020).
Biyobozunur plastikler, yüksek parçalanabilirlik özellikleri sayesinde, genellikle biyolojik olarak parçalanabilir çöp torbaları, gıda ambalajları ve tarımsal malç ürünlerin üretiminde tercih edilmektedir (Mazhandu ve ark., 2020). Özellikle örtü altı tarımda yaygın olarak kullanılan plastik malç filmleri, tarımsal verimliliği artırmak amacıyla tercih edilmektedir (El-Beltagi ve ark., 20222). Ancak bu plastik malzemeler, ultraviyole ışınları ve toprak işleme gibi mekanik etkenlerle etkileşime girdiklerinde mikroplastiklere dönüşerek tarımsal topraklarda birikim gösterebilmektedir(Tian ve ark., 2022).
Biyolojik olarak parçalanan biyobozunur plastikler ve biyolojik olarak parçalanmayan mikroplastikler arasındaki farklı özellikler, toprak parametrelerinde farklı değişikliklere yol açabilmektedir (Wang ve ark., 2024). Örneğin, kumlu bir toprağa %0.5, %1 ve %2 konsantrasyonlarında düşük yoğunluklu polietilen ve nişasta bazlı biyobozunur plastikler uygulandığında, tüm biyobozunur mikroplastik uygulamalarında toprak su penetresyonunun arttığı, ancak en belirgin artışın %1'lik konsantrasyonda gözlemlendiği bildirilmiştir. Buna karşın, düşük yoğunluklu polietilen mikroplastiklerin konsantrasyonlarının artışı, su penetresyon süresini azaltığı ortaya konmuştur. Ayrıca, yüksek yoğunluklu polietilen mikroplastiklerinin en yüksek elektriksel iletkenliğe sahip olduğu, biyobozunur mikroplastiklerin ise en düşük elektriksel iletkenliğe sahip olduğu rapor edilmiştir (Qi ve ark.,

2020). Zhou ve ark, (2021) tarafından yapılan bir çalışmada ise toprağa biyobozunur (Poli3-hidroksibutirat-ko-3-hidroksivalerat) mikroplastik eklenmesi sonucunda, kontrol grubuna kıyasla biyobozunur mikroplastik eklenen uygulamalarda, mikrobiyal biyokütle karbonun %12 oranında ve çözünmüş organik karbon içeriğinin ise %54 oranında arttığı tespit edilmiştir.

Bu bulgular, toprakta mikroplastik kirliliğinin azaltılmasında biyobozunur plastiklerin kullanımının önemli bir çözüm sunduğunu göstermektedir (Shen ve ark., 2020). Geleneksel plastikler çevrede uzun süre kalıp zamanla mikroplastiklere dönüşürken, biyobozunur plastikler çevresel etkileri azaltma potansiyeline sahiptir (Qi ve ark., 2020). Biyobozunur plastikler, biyolojik olarak parçalanabilir olmaları, düşük toksisite seviyeleri ve geniş malzeme kaynaklarına sahip olmaları nedeniyle mikroplastik kirliliğiyle mücadelede etkili bir alternatif sunmaktadır (Chia ve ark., 2020). Dünya genelinde biyobozunur plastikler, mikroplastik kirliliğini önlemek amacıyla uygulanan stratejilerin ayrılmaz bir parçası haline gelmiştir (Moshood ve ark., 2022). Ancak biyobozunur plastiklerin etkinliğini artırmak ve yaygın kullanımını sağlamak için, dayanıklı, ucuz ve çok çeşitli uygulama alanlarına uygun yeni nesil ürünlerin geliştirilmesi büyük önem taşımaktadır (Rujnić-Sokele ve Pilipović, 2017). Ayrıca, biyobozunur plastikler, geleneksel plastiklerle karşılaştırıldığında daha yüksek üretim maliyetine sahip olup, üretim süreçleri daha karmaşık bir yapıya sahiptir (do Val Siqueira ve ark., 2021). Biyobozunur plastiklerin üretim maliyetlerinin düşürülmesi ve selüloz, nişasta gibi diğer biyolojik olarak parçalanabilir sentetik malzemelerin fonksiyonel özelliklerinin iyileştirilmesi amacıyla optimizasyon çalışmalarının gerçekleştirilmesi gerekmektedir (Fan ve ark., 2022). Bu tür iyileştirmeler, söz konusu malzemelerin daha yaygın bir kullanım alanına sahip olmasını mümkün kılacaktır.

Toprakta Mikroplastik Kirliliğinin Azaltılmasında Biyokömür Kullanımı

Mikroplastik ile kirlenmiş topraklara biyokömür uygulanması, son yıllarda artan bir ilgiyle araştırılmaktadır (Munir ve ark., 2021; Wu ve ark., 2024; Zou ve ark., 2024). Tarımsal ve hayvansal atıkların, yüksek sıcaklıkta oksijensiz ortamda işlenmesiyle elde edilen biyokömür, toprağın fiziksel, kimyasal ve biyolojik özelliklerini iyileştirerek toprak verimliliğini artıran etkili bir toprak düzenleyicisi olarak önemli bir rol oynamaktadır (Yuan ve ark., 2015). Yapılan araştırmalar, biyokömürün toprağa ilavesinin, dışsal stres faktörlerinin neden olduğu toprak mikrobiyal topluluklarında ve besin döngülerindeki bozulmaları iyileştirebileceğini ve toprak ortamlarındaki mikroplastik kirliliğini etkili bir şekilde azaltabileceğini göstermektedir (Han ve ark., 2024; Ran ve ark., 2023). Polietilen mikroplastik ile kirlenmiş toprağa farklı sıcaklık (550 ve 700 °C) ve farklı biyokömür türleri (yağlı tohum kolza samanı ve ağaç peleti) eklenerek toprakların bazı kimyasal ve mikrobiyal özellikleri incelenmiştir. Araştırmada, kontrol grubu (%1 mikroplastik) ve dört farklı uygulama grubu (%1 mikroplastik + 550 °C'de üretilen yağlı tohum kolza samanı biyokömürü, %1 mikroplastik + 700 °C'de üretilen yağlı tohum kolza samanı biyokömürü, %1 mikroplastik + 550 °C'de üretilen ağaç peleti biyokömürü, %1 mikroplastik + 700 °C'de üretilen ağaç peleti biyokömürü) yer almıştır. Sonuçlara göre, birinci ve ikinci grup uygulamaları toprak pH'sı ve KDK üzerinde olumlu etkiler gösterirken, ikinci ve dördüncü grup uygulamalarında toprak enzim aktiviteleri artmış, özellikle ikinci grup uygulamasında üreaz enzimi aktivitesinin %146 oranında arttığı belirlenmiştir (Palansooriya ve ark., 2022).

Piroliz yoluyla elde edilen ve kararlı bir karbon formu taşıyan biyokömür, iklim değişikliğinin etkilerinin azaltılmasına yönelik bir strateji olarak kabul edilmektedir (Sri Shalini ve ark., 2021). Li ve ark, (2022) tarafından yapılan bir çalışmada, yalnızca polietilen mikroplastik ve polietilen mikroplastik ile buğday samanı biyokömürü eklenen toprakta, mikroplastik ve biyokömürün birlikte uygulanmasının, yalnızca mikroplastik uygulanmasına kıyasla, toprakta N_2O, CO_2 ve CH_4 emisyonlarını sırasıyla %24.8, %6.2 ve %65.2 oranında azalttığı bildirilmiştir.

Biyokömür ayrıca, atık su arıtma tesislerinden elde edilen atık su ve atık çamurun toprakta kullanımına bağlı olarak oluşan mikroplastik birikimini azaltmak amacıyla, atık su arıtma tesislerinde mikroplastik azaltım verimliliklerinin artırılmasında da kullanılmaktadır (Seetasang ve Iwai, 2024; Wang ve ark., 2020). Hsieh ve ark, (2022), atık su arıtma tesislerinde mikroplastiklerin azaltım verimliliklerini artırmak için üç farklı biyokütle (lignin, selüloz ve odun yongaları) ve iki farklı piroliz sıcaklığı (400 °C ve 700 °C) kullanarak altı farklı biyokömür türü üretmiş ve bunları ince geçirgen tabakalar halinde kum kolonlarına dönüştürmüştür. Araştırmalar, biyokömürün yüksek adsorpsiyon kapasitesi sayesinde, 1 µm çapındaki mikroplastiklerin yavaş (4 m/gün) ve hızlı (160 m/gün) akış hızlarında tutulmasının önemli ölçüde arttığını ortaya koymuştur. En yüksek mikroplastik tutma performansının ise, 700 °C'de üretilen odun yongası biyokömüründe gözlemlendiği belirtilmiştir. Bu bulgular, biyokömürün toprakta mikroplastik kirliliğini azaltmaya yönelik çevre dostu bir materyal olarak kullanılabileceğini göstermektedir.

Mikroplastik Üretimi ve Kullanımına Yönelik Ulusal ve Uluslararası Düzenlemeler

Mikroplastikler, karasal ve deniz ekosistemi üzerinde etkiler yaratarak, insan sağlığı için önemli bir tehdit olmakta ve üretimi ile kullanımı giderek artan bir sorun haline gelmektedir (Ghosh ve ark., 2023). Ancak karasal ekosistemlerde mikroplastiklere ilişkin yasal veriler sınırlı olmakla birlikte, mikroplastiklere ilişkin mevcut politikalar, atık çamuru, atık su, plastik malç filmleri ve plastik kaplı gübreler aracılığıyla tarım arazilerinin kirlenmesine yönelik etkili düzenlemeleri göz ardı etmektedir (Igalavithana ve ark., 2022; Zeb ve ark., 2024). Bu durum, mikroplastiklerin tarım arazileri ve diğer potansiyel toksik elementlerle kirlenmesini engellemeye yönelik politika ve yönetim odaklı önlemlerin geliştirilmesi ve gıda güvenliğini temin etmeye yönelik düzenlemelerin oluşturulması gerekliliğini ortaya koymaktadır (Chia ve ark., 2023). AB ülkeleri, atık çamurunun tarım arazilerinde mikroplastik kirliliğine önemli bir katkı sağladığını kabul etmiş ve bu durum, üye ülkelerin sürdürülebilir atık çamuru yönetimi için kapsamlı bir strateji geliştirmelerini zorunlu kılmıştır. Bu düzenleme ile AB ülkeleri, atık çamuru ile mikroplastikler arasındaki ilişkiyi tanımış ve gereksiz durumlar dışında atık çamurunun tarım arazilerine uygulanmasını kesinlikle yasaklamıştır (Usman ve ark., 2022).

Birleşmiş Milletler Çevre Programı (UNEP), 11-15 Mart 2019 tarihleri arasında Kenya'da gerçekleştirilen, Birleşmiş Milletler Çevre Meclisi'nin dördüncü oturumunda, plastikler ve mikroplastiklerin çevreye salınımını kontrol altına almayı, alternatif çözümler sunmayı ve bu kirleticilerin olumsuz etkilerini durdurmayı amaçlayan birçok karar almış. Bu kararlar, 2030 Sürdürülebilir Kalkınma Hedefleri çerçevesinde, karasal ve sucul ekosistemlerden kaynaklanan plastikler ile mikroplastiklerin önlenmesi ve azaltılmasının önemini vurgulamaktadır (UNEP, 2020).

Dünya Sağlık Örgütü (WHO), 2019 yılında mikroplastik kirliliğinin, çevre ve insan sağlığı üzerindeki olası etkilerini değerlendirerek mikroplastik kirliliğinin azaltılması ve insanlar tarafından alınımının engellenmesi için bir çağrıda bulunmuştur (WHO, 2019). Aynı yıl, Avrupa Parlamentosu ve Konseyi, belirli plastik ürünlerin çevre ve insan sağlığı üzerindeki olumsuz etkilerini azaltmaya yönelik olarak AB 2019/904 sayılı direktifi kabul etmiştir (European Commission, 2019). Ayrıca, Güneydoğu Asya Ülkeleri Birliği (ASEAN), plastiklerin neden olduğu çevresel sorunlarla mücadele etmek amacıyla, ASEAN Üye Devletleri tarafından 2021-2025 dönemi için Deniz Atıklarıyla Mücadeleye Yönelik ASEAN Bölgesel Eylem Planı kabul edilerek uygulanmaya konulmuştur (Worldbank Asean, 2021).

Türkiye, 1 Ocak 2019 tarihinde yürürlüğe giren düzenleme ile plastik poşetlerin kullanımının sınırlandırılması ve çevre kirliliğinin azaltılmasını hedeflemiş; bu kapsamda plastik poşetler için Geri Kazanım Katılım Payı ödemesi ve ücretlendirme uygulaması getirilmiştir (Çevre Yönetimi Genel Müdürlüğü, 2019). Bunun yanı sıra, Türkiye, Birleşmiş Milletler Çevre Programı tarafından 2017 yılında başlatılan Plastik Atıkların Azaltılması ve Yönetimi girişimine katılmakta olup (Anonim, 2022), 2018 yılında Endonezya'da düzenlenen G20 zirvesinde denizlerdeki plastik kirliliğiyle mücadeleye yönelik kabul edilen Bali Eylem Planı'na da taraf olmuştur (Çevre Şehircilik ve İklim Değişikliği Bakanlığı, 2018). Ek olarak, Türkiye, çevreye zarar veren plastik kirliliği gibi küresel çevresel sorunlara karşı mücadelede önemli bir adım olarak, 2015 yılında Paris İklim Anlaşması'nda taraf olmuştur (Anonim, 2021).

Toprakta Mikroplastik Miktarını Azaltmaya Yönelik Yöntemler ve Yaklaşımlar

Atık Su Arıtma Tesislerinde Mikroplastik Tutulumu

Atık su arıtma tesisleri, mikroplastiklerin çevresel ortamlara taşınımının önlenmesinde stratejik bir öneme sahiptir (Sol ve ark., 2020). Özellikle tarım alanlarında, arıtma tesislerinden elde edilen organik maddece zengin arıtma çamurunun toprak iyileştiricisi olarak kullanılması ve sulama amacıyla atık suyun kullanılması, mikroplastiklerin toprak ekosistemlerine taşınmasında önemli bir aktarım yolu oluşturmaktadır (Arab ve Nayebi, 2024). Örneğin, yapılan araştırmalar, Kuzey Amerika'da üretilen atık çamurun yaklaşık yarısının tarımsal topraklarda organik gübre olarak kullanıldığını ve bu çamurun içerdiği mikroplastik miktarının 44.000 ile 430.000 ton arasında değiştiğini ortaya koymaktadır (Masiá ve ark., 2020). Bu nedenle, atık su arıtma süreçlerinde mikroplastiklerin etkin bir şekilde giderilmesi, toprak ekosistemlerini mikroplastik kirliliğine karşı koruma potansiyeli taşımaktadır (Ahmed ve ark., 2024). Atık su arıtma tesislerinde mikroplastiklerin azaltma verimliliğinin artırılması, yalnızca toprak kirliliğinin azaltılmasına değil, aynı zamanda sucul ekosistemlerdeki potansiyel olumsuz etkilerinde önlenmesine önemli katkılar sunmaktadır (Zhang ve Chen, 2020). Bu durum, tarımsal sürdürülebilirliği güçlendiren etkili bir çevresel yönetim stratejisi olarak değerlendirilebilir. Mikroplastiklerin atık sudan etkin bir şekilde giderilmesi, farklı arıtma teknolojilerinin uygulanmasıyla mümkün olmaktadır.

Biyoremediasyon Yöntemi

Biyoremediasyon, atık su ve toprak mikroplastik kirliliğinin giderilmesinde biyolojik organizmaların kullanımına dayanan sürdürülebilir ve etkili bir yöntem olarak öne çıkmaktadır (Adamu ve ark., 2024). Bu yöntem, mikrobiyal aktiviteye dayandığı için, algler, bakteriler ve mantarlar gibi daha büyük biyolojik topluluklar, atık su arıtma süreçlerinde mikroplastiklerin biyoremediasyonu için önemli bir rol oynamaktadır (Hasan ve ark., 2024). Yapılan araştırmalarda, mikroorganizmaların mikroplastiklerin bozunumu üzerindeki etkileri incelenmiş ve çeşitli türlerin bu konuda potansiyel taşıdığına dair bulgular elde edilmiştir. Örneğin, Pseudomonas sp. ADL15 ve Rhodococcus sp. ADL36 bakteri türlerinin polipropilen mikroplastikler üzerindeki biyoremediasyon etkisi incelenmiş ve bu bakterilerin 40 gün süresince mikroplastiklerin ağırlığında sırasıyla %17.3 ve %7.3 oranında azalma sağladığı bildirilmiştir (Habib ve ark., 2020). Ji ve ark, (2019) tarafından yapılan bir çalışmada, atık çamuruna Pseudomonas sp. LZ-B türü bir bakteri izole edilmiştir. Çalışma sonuçları, bu bakteri türünün uygun koşullarda çoğalma kapasitesine sahip olduğunu ve biyokütlesinde anlamlı bir artış sağladığını ortaya koymuştur.

Atık su arıtma tesislerinde mikroplastik biyoremediasyonunun etkinliği, doğru mikroorganizma türlerinin seçimiyle doğrudan ilişkilidir (Tang ve Hadibarata, 2022). Özellikle, farklı biyolojik süreçlere tabi olan mikroplastik türlerini işleyebilecek mikroorganizmaların kullanımı, geniş bir plastik yelpazesinde etkin bozunma sağlayabilmesi açısından büyük önem taşımaktadır (Hadian-Ghazvini ve ark., 2022). Ayrıca, atık su arıtma tesislerinde kullanılan mikroorganizmalar, pH ve sıcaklık gibi değişken çevresel koşullara uyum sağlarken mevcut mikrobiyal popülasyonlara zarar vermemesi ve uzun süreli etkinlik göstermesi, biyoremediasyon yönteminin ekolojik güvenliğinin sağlaması açışından önem taşımaktadır (Tang, 2023).

Membran Biyoreaktörlerin Kullanımı

Atık su arıtma tesislerinde kullanılan membran biyoreaktörler, atık sulardan mikroplastiklerin verimli bir şekilde giderilmesini sağlayan yenilikçi ve ileri bir arıtma teknolojisi olarak ön plana çıkmaktadır (Acarer, 2023). Membran biyoreaktörlerin, karmaşık endüstriyel atıkların giderimindeki üstün performansı, mikroplastikler gibi dirençli kirleticilerin uzaklaştırılmasında uygulanabilirliğini ve etkinliğini kanıtlamaktadır (Gonzalez-Camejo ve ark., 2023). Membran biyoreaktör sistemleri, geleneksel arıtma yöntemlerinden farklı olarak, gelişmiş arıtma teknolojileriyle mikroplastik partiküllerin etkin şekilde ayrıştırılmasını sağlamaktadır (Poerio ve ark., 2019). Bu sistemler, hızlı kum filtrasyonu, yerçekimi filtrasyonu, disk filtreleri ve çözünmüş hava flotasyonu gibi çeşitli yenilikçi tekniklerle entegre edilerek, mikroplastiklerin atık su tesislerinden uzaklaştırılmasında yüksek verimlilik sunmaktadır (Zahmatkesh ve ark., 2023).

Membran biyoreaktör yöntemi, 0.1 mikron gibi son derece düşük, gözenek boyutlarına sahip membranlar aracılığıyla mikroplastiklerin atık suya geçişini etkili bir şekilde engellemekte ve genellikle %99'un üzerinde arıtma verimliliği sağlamaktadır (Ramos ve ark., 2023). Atık sulardan mikroplastiklerin uzaklaştırılmasını incelemek amacıyla 18 ay boyunca gerçekleştirilen bir çalışmada, membran biyoreaktör teknolojisi ve hızlı kum filtrasyonu olmak üzere iki farklı yöntem kullanılmıştır. Deneme sonuçları, izole edilen partiküllerin %76.68'inin mikroplastik olduğunu ortaya koymuştur. Mikroplastiklerin şekil açısından dağılımı lifler (1.34 ± 0.23 adet L^{-1}), filmler (0.59 ± 0.24 adet L^{-1}), parçalar (0.20 ± 0.09 adet L^{-1}) ve mikroboncuklar (0.02 ± 0.01 adet L^{-1}) olarak belirlenmiştir. Ayrıca, membran biyoreaktör yönteminin %79.01 oranında mikroplastik giderim verimliliği ile hızlı kum filtrasyonu yöntemine (%75.49) kıyasla daha yüksek bir performans sergilediği tespit edilmiştir (Bayo ve ark., 2020). Konvansiyonel ve membran biyoreaktör teknolojisine sahip atık su arıtma tesislerinin çamurlarındaki mikroplastik oluşumu üzerine yapılan bir başka çalışmada, atık su arıtma tesislerinde bulunan mikroplastiklerin atık çamurlarda biriktiğini ortaya konmuştur. Membran biyoreaktör teknolojisiyle işletilen tesisteki çamurdaki mikroplastiklerin yoğunluğunun, diğer tesislerdeki çamurlara göre ($36\text{-}46 \times 10^3$ parçacık/kg kuru çamur) neredeyse iki katı (81.1×10^3 parçacık/kg kuru çamur) kadar yüksek olduğu, tespit edilmiştir. Ayrıca, membran biyoreaktör çamurundaki mikroplastiklerin bileşimi, polietilen, polipropilen, polietilen tereftalat, poliolefinler ve polibütadien gibi çeşitlilik gösterirken; konvansiyonel atık çamurunda ise polibütadien, selüloz asetat ve polyester gibi mikroplastik türlerinin daha sınırlı bir bileşim gösterdiği bildirilmiştir (Di Bella ve ark., 2022).

Sol-jel Yöntemi

Sol-jel yöntemi, atık sulardaki mikroplastik kirleticilerin giderilmesinde kullanılan yenilikçi bir arıtma teknolojisidir (Das ve ark., 2024). Bu yöntem, pH değişiklikleriyle atık su içindeki polimerlerin agregasyonunu indükleyerek büyük agregat parçacıkları oluşturmaktadır (Mahmud ve ark., 2022). Bu şekilde oluşan mikroplastik flokülatlar, füzyon yoluyla meydana gelmekte ve bu süreç, kum tuzakları gibi ayrıştırma yöntemleriyle mikroplastiklerin atık sudan etkin bir şekilde ayrılmasını sağlamaktadır (Collivignarelli ve ark., 2018). Giderme sürecinin ilk aşaması, tüm molekülün biyomoleküler bileşenleri olarak işlev görecek bir dahil etme ünitesinin tasarlanmasından oluşmaktadır. Bu aşama, mikroplastiklerin etkin bir şekilde ayrılmasını ve arıtma sürecine dahil edilmesini sağlamayı amaçlamaktadır. Giderme sürecinin ikinci aşaması, dahil edilecek bileşiğin, kendi kısmı aracılığıyla etkin bir şekilde bağlantı kurabilecek bir edinme ünitesinin geliştirilmesi ile oluşmaktadır. İkinci aşama, mikroplastiklerin etkili bir şekilde ayrıştırılması için gerekli olan bağlantıların kurulmasına odaklanmaktadır (Kirshnan ve ark., 2023).

Sol-jel işlemi, asidik ve alkali ortamlarda uygulanabilen esnek bir yöntem olup, farklı koşullarda etkin bir şekilde kullanılabilmektedir (Bokov ev ark., 2021). Bu yöntem, mikroplastiklerin flokülasyonunu pH seviyelerine duyarlı bir şekilde destekler, böylece mikroplastikler alkoksi-silil fonksiyonel gruplara sahip moleküller kullanılarak bağlanır (Golmohammadi ve ark., 2023). Ayrıca sol-jel yöntemi, düşük üretim maliyetleri ile öne çıkmakta ve çevresel faktörler (pH, sıcaklık) ile kirleticilerin türü, boyutu ve konsantrasyonu gibi değişkenlerden etkilenmemektedir (Ahmed ve ark., 2024).Sonuç olarak, mikroplastikler agregat formuna geçerek atık sudan daha etkin bir şekilde ayrılabilir, bu da atık sularda mikroplasik azaltım verimliliğini önemli ölçüde artırabilmektedir (Tang ve Hadibarata, 2021). Herbort ve ark, (2018) tarafından yapılan bir çalışmada, polietilen ve polipropilen mikroplastiklerin bulunduğu atık sudan, iki aşamalı fizikokimyasal lokalizasyon ve sol-jel yöntemi kullanılarak mikroplastiklerin giderilmesi incelenmiştir. Araştırmacılar, triklorosilan-silikon türevlerinin eklenmesinin, su ortamının pH seviyesinden bağımsız olarak mikroplastik parçacık boyutunda önemli bir artışa yol açtığını ve Si bazlı mikroplastik agregatlarının oluşumunu sağladığını tespit etmiştir. Yöntemin, mikroplastik parçacıkların her türlü işlem koşulunda aglomerasyon ürünleri oluşturma özelliği sayesinde, atık sudan mikroplastiklerin sürdürülebilir bir şekilde uzaklaştırılmasında yüksek bir potansiyel sunduğu belirtilmiştir.

Piroliz Yöntemi

Polistiren, polietilen ve polivinil klorür gibi mikroplastikler, piroliz yöntemiyle termal geri dönüşüm süreçlerinde yakıt öncülleri veya katma değere sahip ürünlere dönüştürülmesi bakımından en kapsamlı şekilde incelenen yöntemler arasında yer almaktadır (Kumar ve ark., 2023). Piroliz işlemi sırasında plastikler, oksijensiz bir ortamda termal bozunmaya uğrayarak polimer yapılarındaki uzun alkil zincirleri, daha düşük moleküler ağırlığa sahip hidrokarbonlara veya çeşitli yan ürünlere dönüştürmektedir (Adeoye ve ark., 2024). İlk zamanlarda yapılan araştırmalarda, çoğunlukla katalitik olmayan piroliz yöntemleri incelenmiştir. Ancak son dönemde, işlem sürelerinin kısaltılması, yüksek kaliteli ürünlerin üretimi ve süreç verimliliğinin artırılması gibi önemli avantajları nedeniyle katalizörlerin kullanımı daha yaygın hale gelmiştir (Peng ve ark., 2022).

Katalitik piroliz tekniği ile mikroplastiklerin uzaklaştırılmasında, katalizör seçimi, mikroplastiklerin polimer özellikleri ve piroliz sıcaklığı, yöntemin etkinliği açısından büyük önem taşımaktadır (Zoppas ve ark., 2023). Jung ve ark, (2022), tarım arazilerinden elde edilen plastik malç filmlerinin nikel katalizörü (Ni/SiO_2) ile 550 °C sıcaklıkta piroliz edilerek hidrokarbon yağı elde edildiğini belirtmiştir. Ayrıca, Singh ve ark, (2018), bakır karbonat ($CuCO_3$) katalizörünün, 390 °C sıcaklıkta yüksek yoğunluklu polietilen mikroplastiklerden sıvı hidrokarbon yağı üretiminde etkin olduğunu rapor etmiştir. Bununla birlikte plastik atıklar, 600 °C'nin üzerinde sıcaklıklarda katalitik piroliz yöntemiyle kimyasal maddeler, karbon nanotüpler ve grafen gibi yüksek ekonomik değere sahip ürünlere dönüşebilmektedirler (Dai ve ark., 2023). Bu kapsamda, piroliz yöntemi, mikroplastik kirliliğinin azaltılması açısından, plastik atıkları kimyasal hammadde veya yakıtlara dönüştürmek için, çok yönlü bir yöntem olarak öne çıkmaktadır (Yang ve ark., 2022).

Hidroliz Yöntemi

Hidroliz yöntemi, su ile asidik veya bazik bileşiklerin reaksiyona girerek plastiklerin polimerik bağlarını parçalayarak daha basit bileşenlere ayrışmasını sağlayan bir süreci ifade etmektedir (Zaaba ve Jaafar, 2020). Hidroliz yöntemi, mikroplastik kirliliğinin etkilerini azaltarak, elde edilen daha küçük plastik polimerlerinin biyolojik olarak daha kolay ayrışmasını sağlayabilmektedir (Azizi ve ark., 2024). Bu durum, toprakta mikroplastik kirliliğinin azalmasına katkı sağlamaktadır. Ancak, hidroliz yönteminin etkinliği, kullanılan kimyasal bileşiklerin özelliklerine, plastiklerin polimer yapısına ve işlem koşullarına bağlı olarak değişkenlik gösterebilmektedir (Ivleva, 2021). Wang ve ark, (2024), atık su arıtma tesisinde, termal hidroliz ve anaerobik sindirim süreçleri ile atık çamurunda mikroplastiklerin etkilerini incelemişlerdir. Deneme sonuçlarına göre, atık su arıtma tesisindeki mikroplastik yoğunluğunun 0.75 ± 0.26 adet/L olduğu ve mikroplastiklerin yaklaşık %98'inin atık çamurda adsorbe olduğu tespit edilmiştir. Araştırmacılar, anaerobik sindirim ve termal hidroliz yöntemleriyle mikroplastiklerin yüksek oranda (%41) giderildiğini belirtmişlerdir. Arhant ve ark, (2019), ise polietilen tereftalat mikroplastiklerinin, 80 °C ve 110 °C sıcaklıklarda, 150 güne kadar su ile reaksiyona girerek yüksek bozunma derecelerine ulaştığını bildirmiştir. Ayrıca, bu süreçte polietilen tereftalat mikroplastiklerinin mol kütlesinin 17 kg/mol'ün altına düştüğü belirtilmiştir.

Ultrasonik Mekanik Bozunma Yöntemi

Ultrasonik mekanik bozunma yöntemi, yüksek sıcaklıklar ve basınçlar oluşturarak, enerji transfer mekanizmaları aracılığıyla mikroplastik polimerlerinin, özellikle C–C bağlarının kırılmasına neden olmaktadır (Xu ve ark., 2024). Bu süreç, sıvı bir ortamda yüksek frekanslı ses dalgalarının yarattığı titreşimler yoluyla gerçekleşir ve mikro kabarcıkların oluşumu ve çökmesini içermektedir (Wen ve ark., 2024). Bu titreşimler, mikroplastiklerin yüzeyinde mekanik gerilim ve basınç dalgalanmaları oluşturarak, polimer zincirlerini parçalayabilen ve plastiklerin daha küçük moleküllere ayrılmasını sağlayan bir etki yaratmaktadır (Goli ve Singh, 2023). Ultrasonik yöntemi etkisi altında yüksek frekans kullanımı, özellikle perflorlu bileşikleri parçalamak için etkili bir yöntem olarak kullanılmaktadır (Cao ve ark., 2020). Bunun nedeni, ultrasonik yöntemde, yüksek frekans bölgesinde küçük yarıçaplı ve düşük sıkıştırma oranına pek çok kabarcık oluşması ve buda bozunma sürecine katkı sağlamasıdır (Loannidi ve ark., 2023). Ancak bu yöntem uygulanırken mikroplastiklerin değişimini karakterize etmek ve izlemek amacıyla Raman spektroskopisi ve taramalı elektron mikroskobu gibi çeşitli analitik tekniklere ihtiyaç duyulmaktadır (Chen ve ark., 2020). Pu ve ark. (2024), politetrafloroetilen mikroplastiklerinin bozunması üzerine 40°C sıcaklıkta ve 580 kHz yüksek frekansla ultrasonik yöntem kullanarak bir araştırma gerçekleştirmiştir. Çalışmada, politetrafloroetilen mikroplastikler sodyum dodesil sülfat yardımıyla ayrıştırılmış ve ardından optimum koşullar altında 9 saat süresince ultrasonikasyon uygulanarak, mikroplastik kirliliğinin yaklaşık %32 oranında giderildiği bildirilmiştir. Araştırmacılar moleküler spektrum penceresinde yaptıkları incelemede, bu bozunmanın doğruluğunu tespit etmişlerdir. Ayrıca, taramalı elektron mikroskobu ile politetrafloroetilen mikroplastikleri net bir şekilde görüntülenmiş, Raman spektroskopisi ile de moleküler spektrum penceresinden ince parçacıkların varlığı rapor edilmiştir.

Sonuç ve Öneriler

Topraklardaki mikroplastik kirliliğinin tarımsal sürdürülebilirlik, insan sağlığı ve ekosistemdeki hareketi üzerindeki etkilerinin yeterince anlaşılamaması, mikroplastiklerin kaynaklarına ve çevredeki davranışlarına odaklanmayı gerektirmektedir. Özellikle, tarımsal uygulamalarda atık çamur ve atık su kullanımı, plastik malç filmleri ve plastik kaplı gübreler, toprak ekosisteminde mikroplastik birikimine önemli ölçüde katkıda bulunmaktadır. Bu durum, mikroplastiklerin kaynaklarının belirlenmesi, analiz yöntemlerinin geliştirilmesi ve ürün tasarımının çevresel etkileri minimize edecek şekilde iyileştirilmesini gerektirmektedir.

Mikroplastikler, toprak ortamına girdikten sonra toprağın fiziksel, kimyasal ve biyolojik özellikleri üzerinde olumsuz etkiler oluşturmakta ve ağır metaller gibi kirleticileri adsorbe ederek toprak kirliliğinin artmasına yol açmaktadır. Bu süreç, mikroplastik kirliliğinin etkin bir şekilde kontrol edilmesi ve yönetilmesi için kapsamlı ve bütüncül stratejilerin uygulanmasını gerektirmektedir. Toprakta mikroplastiklerin kirliliğini minimize etmek için atık çamur ve atık suyun elde edildiği atık su arıtma tesislerinde mikroplastiklerin etkin bir şekilde tutulması kritik bir öneme sahiptir. Bu amaçla, biyoremediasyon, membran biyoreaktör sistemleri ve sol-jel gibi yenilikçi arıtma teknolojilerinin uygulanması, mikroplastiklerin uzaklaştırılmasını sağlayarak çevresel kirliliğin azaltılmasına katkı sunabilir.

Son olarak karbon açısından zengin bir materyal olan biyokömürün kullanımıyla toprağın yapısının iyileştirilmesi, plastik malçların yerine doğal bitki artıklarının veya biyobozunur malçların tercih edilmesi ve plastik üretim süreçlerinde yapılacak düzenlemeler, mikroplastik kirliliğinin önlenmesinde kritik bir rol oynamaktadır. Ayrıca, toprakta mikroplastik kirliliğini azaltmak için, plastik atık yönetiminde sürdürülebilir geri dönüşüm stratejilerinin benimsenmesi, düzenleyici politikaların geliştirilmesi, ulusal ve uluslararası düzeyde düzenlemelerin hayata geçirilmesi ve eğitim ile farkındalık kampanyalarının artırılması, mikroplastik kirliliğini azaltmaya önemli ölçüde katkı sağlayabilir.

Kaynaklar

Abd Karim, S. B., Norman, S., Koting, S., Simarani, K., Loo, S. C., Mohd Rahim, F. A., ... & Nagor Mohamed, A. H. (2023). Plastic Roads in Asia: Current Implementations and Should It Be Considered?. Materials, 16(16), 5515.

Acarer, S. (2023). A review of microplastic removal from water and wastewater by membrane technologies. Water Science & Technology, 88(1), 199-219.

Adamu, H., Bello, U., IbrahimTafida, U., Garba, Z. N., Galadima, A., Lawan, M. M., ... & Qamar, M. (2024). Harnessing bio and (Photo) catalysts for microplastics degradation and remediation in soil environment. Journal of Environmental Management, 370, 122543.

Adeoye, A. O., Yelwa, J. M., Imam, N., Quadri, R. O., Lawal, O. S., Malomo, D., ... & Garba, H. A. (2024). Pyrolysis of Plastic Wastes Towards Achieving a Circular Economy: An Advanced Chemistry and Technical Approach. In Dynamics of Transportation Ecosystem, Modeling, and Control (pp. 215-259). Singapore: Springer Nature Singapore.

Ahmed, S. F., Islam, N., Tasannum, N., Mehjabin, A., Momtahin, A., Chowdhury, A. A., ... & Mofijur, M. (2024). Microplastic removal and management strategies for wastewater treatment plants. Chemosphere, 347, 140648.

Alshehrei, F. (2017). Biodegradation of synthetic and natural plastic by microorganisms. Journal of Applied & Environmental Microbiology, 5(1), 8-19.

Anonim, (2021). https://www.dogrulukpayi.com/bulten/turkiye-paris-anlasmasi-ni-onayladi?gad_source=1&gclid=CjwKCAiA0rW6BhAcEiwAQH28In0YVizH9k1JSWztgVUSVMcDTrVkfJqgWDjjFhgv0jkjW229Dhg-zRoC29gQAvD_BwE. Erişim Tarihi: 02.12.2024.

Anonim, (2022). https://www.ntv.com.tr/turkiye/plastik-kirliligi-ile-mucadelede-yeni-adim,f41uAtoJy0CTztS-ZrfAPA. Erişim Tarihi: 02.12.2024.

Arab, M., Yu, J., & Nayebi, B. (2024). Microplastics in Sludges and Soils: A Comprehensive Review on Distribution, Characteristics, and Effects. ChemEngineering, 8(5), 86.

Arhant, M., Le Gall, M., Le Gac, P. Y., & Davies, P. (2019). Impact of hydrolytic degradation on mechanical properties of PET-Towards an understanding of microplastics formation. Polymer degradation and stability, 161, 175-182.

Association of Southeast Asian Nations (WORLDBANKASEAN). (2021). https://www.worldbank.org/en/news/press-release/2021/05/28/asean-member-states-adopt-regional-action-plan-to-tackle-plastic-pollution. Erişim tarihi: 28.11.2024.

Azizi, S. M. M., Haffiez, N., Mostafa, A., Hussain, A., Abdallah, M., Al-Mamun, A., ... & Dhar, B. R. (2024). Low-and high-temperature thermal hydrolysis pretreatment for anaerobic digestion of sludge: Process evaluation and fate of emerging pollutants. Renewable and Sustainable Energy Reviews, 200, 114453.

Bayo, J., López-Castellanos, J., & Olmos, S. (2020). Membrane bioreactor and rapid sand filtration for the removal of microplastics in an urban wastewater treatment plant. Marine Pollution Bulletin, 156, 111211.

Bokov, D., Turki Jalil, A., Chupradit, S., Suksatan, W., Javed Ansari, M., Shewael, I. H., ... & Kianfar, E. (2021). Nanomaterial by sol-gel method: synthesis and application. Advances in materials science and engineering, 2021(1), 5102014.

Boots, B., Russell, C. W., & Green, D. S. (2019). Effects of microplastics in soil ecosystems: above and below ground. Environmental science & technology, 53(19), 11496-11506.

Bucknall, D. G. (2020). Plastics as a materials system in a circular economy. Philosophical Transactions of the Royal Society A, 378(2176), 20190268.
Cao, H., Zhang, W., Wang, C., & Liang, Y. (2020). Sonochemical degradation of poly-and perfluoroalkyl substances–a review. Ultrasonics Sonochemistry, 69, 105245.
Cao, Y., Zhao, M., Ma, X., Song, Y., Zuo, S., Li, H., & Deng, W. (2021). A critical review on the interactions of microplastics with heavy metals: Mechanism and their combined effect on organisms and humans. Science of the Total Environment, 788, 147620.
Chen, H., Wang, Y., Sun, X., Peng, Y., & Xiao, L. (2020). Mixing effect of polylactic acid microplastic and straw residue on soil property and ecological function. Chemosphere, 243, 125271.
Chen, G., Fu, Z., Yang, H., & Wang, J. (2020). An overview of analytical methods for detecting microplastics in the atmosphere. TrAC Trends in Analytical Chemistry, 130, 115981.
Chen, Y., Awasthi, A. K., Wei, F., Tan, Q., & Li, J. (2021). Single-use plastics: Production, usage, disposal, and adverse impacts. Science of the total environment, 752, 141772.
Chia, R. W., Lee, J. Y., Lee, M., Lee, G. S., & Jeong, C. D. (2023). Role of soil microplastic pollution in climate change. Science of the Total Environment, 887, 164112.
Chia, W. Y., Tang, D. Y. Y., Khoo, K. S., Lup, A. N. K., & Chew, K. W. (2020). Nature's fight against plastic pollution: Algae for plastic biodegradation and bioplastics production. Environmental Science and Ecotechnology, 4, 100065.
Collivignarelli, M. C., Abbà, A., Benigna, I., Sorlini, S., & Torretta, V. (2017). Overview of the main disinfection processes for wastewater and drinking water treatment plants. Sustainability, 10(1), 86.
Čolnik, M., Knez-Hrnčič, M., Škerget, M., & Knez, Ž. (2020). Biodegradable polymers, current trends of research and their applications, a review. Chemical industry and chemical engineering quarterly, 26(4), 401-418.
Cowan, E., Booth, A. M., Misund, A., Klun, K., Rotter, A., & Tiller, R. (2021). Single-use plastic bans: exploring stakeholder perspectives on best practices for reducing plastic pollution. Environments, 8(8), 81.
Çevre Yönetimi Genel Müdürlüğü. (2019). https://cygm.csb.gov.tr/plastik-posetlerin-ucretlendirilmesi-usul-esas-guncellemesi-duyuru-411670. Erişim Tarihi: 28.11.2024.
Çevre Şehircilik ve İklim Değişikliği Bakanlığı. (2018). https://iklim.gov.tr/g20-cevre-ve-iklim-bakanlari-toplantisi-bali-de-gerceklestirildi-haber-36. Erişim Tarihi: 02.12.2024.
Da Costa, J. P., Mouneyrac, C., Costa, M., Duarte, A. C., & Rocha-Santos, T. (2020). The role of legislation, regulatory initiatives and guidelines on the control of plastic pollution. Frontiers in Environmental Science, 8, 104.
Dai, L., Karakas, O., Cheng, Y., Cobb, K., Chen, P., & Ruan, R. (2023). A review on carbon materials production from plastic wastes. Chemical Engineering Journal, 453, 139725.
Das, K. P., Chauhan, P., Staudinger, U., & Satapathy, B. K. (2024). Exploring sustainable adsorbents to mitigate micro-/nano-plastic contamination: perspectives on electrospun fibrous constructs, biochar, and aerogels. Environmental Science: Advances.
Di Bella, G., Corsino, S. F., De Marines, F., Lopresti, F., La Carrubba, V., Torregrossa, M., & Viviani, G. (2022). Occurrence of microplastics in waste sludge of wastewater treatment plants: comparison between membrane bioreactor (MBR) and conventional activated sludge (CAS) technologies. Membranes, 12(4), 371.
Di Giacomo, G., & Romano, P. (2022). Evolution and prospects in managing sewage sludge resulting from municipal wastewater purification. Energies, 15(15), 5633.
do Val Siqueira, L., Arias, C. I. L. F., Maniglia, B. C., & Tadini, C. C. (2021). Starch-based biodegradable plastics: Methods of production, challenges and future perspectives. Current Opinion in Food Science, 38, 122-130.

El-Beltagi, H. S., Basit, A., Mohamed, H. I., Ali, I., Ullah, S., Kamel, E. A., ... & Ghazzawy, H. S. (2022). Mulching as a sustainable water and soil saving practice in agriculture: A review. Agronomy, 12(8), 1881.

Enfrin, M., Myszka, R., & Giustozzi, F. (2022). Paving roads with recycled plastics: Microplastic pollution or eco-friendly solution?. Journal of Hazardous Materials, 437, 129334.

European Parliament and Council. (2019). Directive (EU) 2019/904 of the European Parliament and of the Council. On the Reduction of the Impact of Certain Plastic Products on the Environment.

Fan, P., Yu, H., Xi, B., & Tan, W. (2022). A review on the occurrence and influence of biodegradable microplastics in soil ecosystems: are biodegradable plastics substitute or threat?. Environment International, 163, 107244.

Garcia, J. M., & Robertson, M. L. (2017). The future of plastics recycling. Science, 358(6365), 870-872.

Ghosh, S., Sinha, J. K., Ghosh, S., Vashisth, K., Han, S., & Bhaskar, R. (2023). Microplastics as an emerging threat to the global environment and human health. Sustainability, 15(14), 10821.

Goli, V. S. N. S., & Singh, D. N. (2023). Effect of ultrasonication conditions on polyethylene microplastics sourced from landfills: A precursor study to establish guidelines for their extraction from environmental matrices. Journal of Hazardous Materials, 459, 132230.

Golmohammadi, M., Musavi, S. F., Habibi, M., Maleki, R., Golgoli, M., Zargar, M., ... & Razmjou, A. (2023). Molecular mechanisms of microplastics degradation: A review. Separation and Purification Technology, 309, 122906.

Gonzalez-Camejo, J., Morales, A., Peña-Lamas, J., Lafita, C., Enguídanos, S., Seco, A., & Martí, N. (2023). Feasibility of rapid gravity filtration and membrane ultrafiltration for the removal of microplastics and microlitter in sewage and wastewater from plastic industry. Journal of Water Process Engineering, 51, 103452.

Habib, S., Iruthayam, A., Abd Shukor, M. Y., Alias, S. A., Smykla, J., & Yasid, N. A. (2020). Biodeterioration of untreated polypropylene microplastic particles by Antarctic bacteria. Polymers, 12(11), 2616.

Hadian-Ghazvini, S., Hooriabad Saboor, F., & Safaee Ardekani, L. (2022). Bioremediation techniques for microplastics removal. In Microplastics Pollution in Aquatic Media: Occurrence, Detection, and Removal (pp. 327-377). Singapore: Springer Singapore.

Hahladakis, J. N., Velis, C. A., Weber, R., Iacovidou, E., & Purnell, P. (2018). An overview of chemical additives present in plastics: Migration, release, fate and environmental impact during their use, disposal and recycling. Journal of hazardous materials, 344, 179-199.

Han, H., Song, P., Jiang, Y., Fan, J., Khan, A., Liu, P., ... & Li, X. (2024). Biochar immobilized hydrolase degrades PET microplastics and alleviates the disturbance of soil microbial function via modulating nitrogen and phosphorus cycles. Journal of Hazardous Materials, 134838.

HASAN, M., HASAN, M. R., & RASHID, T. U. (2024). Bioremediation of Microplastics by Microorganisms: Trends, Challenges, and Perspectives. Microbial Bioremediation and Multiomics Technologies for Sustainable Development: Recent Trends, 13, 49.

Hao, G., He, M., Lim, S. M., Ong, G. P., Zulkati, A., & Kapilan, S. (2024). Recycling of plastic waste in porous asphalt pavement: Engineering, environmental, and economic implications. Journal of Cleaner Production, 440, 140865.

Hechmi, S., Bhat, M. A., Kallel, A., Khiari, O., Louati, Z., Khelil, M. N., ... & Jedidi, N. (2024). Soil contamination with microplastics (MPs) from treated wastewater and sewage sludge: risks and sustainable mitigation strategies. Discover Environment, 2(1), 95.

Hsieh, L., He, L., Zhang, M., Lv, W., Yang, K., & Tong, M. (2022). Addition of biochar as thin preamble layer into sand filtration columns could improve the microplastics removal from water. Water Research, 221, 118783.
Herbort, A. F., Sturm, M. T., & Schuhen, K. (2018). A new approach for the agglomeration and subsequent removal of polyethylene, polypropylene, and mixtures of both from freshwater systems–a case study. Environmental Science and Pollution Research, 25, 15226-15234.
Horton, A. A., Walton, A., Spurgeon, D. J., Lahive, E., & Svendsen, C. (2017). Microplastics in freshwater and terrestrial environments: Evaluating the current understanding to identify the knowledge gaps and future research priorities. Science of the total environment, 586, 127-141.
Igalavithana, A. D., Mahagamage, M. G. Y., Gajanayake, P., Abeynayaka, A., Gamaralalage, P. J. D., Ohgaki, M., ... & Itsubo, N. (2022). Microplastics and potentially toxic elements: potential human exposure pathways through agricultural lands and policy based countermeasures. Microplastics, 1(1), 102-120.
Ivleva, N. P. (2021). Chemical analysis of microplastics and nanoplastics: challenges, advanced methods, and perspectives. Chemical reviews, 121(19), 11886-11936.
Ji, J., Kakade, A., Zhang, R., Zhao, S., Khan, A., Liu, P., & Li, X. (2019). Alcohol ethoxylate degradation of activated sludge is enhanced by bioaugmentation with Pseudomonas sp. LZ-B. Ecotoxicology and Environmental Safety, 169, 335-343.
Jung, J. M., Cho, S. H., Jung, S., Lin, K. Y. A., Chen, W. H., Tsang, Y. F., & Kwon, E. E. (2022). Disposal of plastic mulching film through CO2-assisted catalytic pyrolysis as a strategic means for microplastic mitigation. Journal of Hazardous Materials, 430, 128454.
Khalid, N., Aqeel, M., & Noman, A. (2020). Microplastics could be a threat to plants in terrestrial systems directly or indirectly. Environmental Pollution, 267, 115653.
Krishnan, R. Y., Manikandan, S., Subbaiya, R., Karmegam, N., Kim, W., & Govarthanan, M. (2023). Recent approaches and advanced wastewater treatment technologies for mitigating emerging microplastics contamination–A critical review. Science of the Total Environment, 858, 159681.
Kumar, M., Bolan, S., Padhye, L. P., Konarova, M., Foong, S. Y., Lam, S. S., ... & Bolan, N. (2023). Retrieving back plastic wastes for conversion to value added petrochemicals: opportunities, challenges and outlooks. Applied Energy, 345, 121307.
Kumar, R., Verma, A., Shome, A., Sinha, R., Sinha, S., Jha, P. K., ... & Vara Prasad, P. V. (2021). Impacts of plastic pollution on ecosystem services, sustainable development goals, and need to focus on circular economy and policy interventions. Sustainability, 13(17), 9963.
Kurek, M., & Benbettaieb, N. (2021). Bio-based Materials. Packaging Materials and Processing for Food, Pharmaceuticals and Cosmetics, 145-182.
Lamba, P., Kaur, D. P., Raj, S., & Sorout, J. (2022). Recycling/reuse of plastic waste as construction material for sustainable development: a review. Environmental Science and Pollution Research, 29(57), 86156-86179.
Lehmann, A., Leifheit, E. F., Gerdawischke, M., & Rillig, M. C. (2021). Microplastics have shape-and polymer-dependent effects on soil aggregation and organic matter loss–an experimental and meta-analytical approach. Microplastics and Nanoplastics, 1(1), 7.
Li, X., Yao, S., Wang, Z., Jiang, X., Song, Y., & Chang, S. X. (2022). Polyethylene microplastic and biochar interactively affect the global warming potential of soil greenhouse gas emissions. Environmental Pollution, 315, 120433.
Lin, D., Yang, G., Dou, P., Qian, S., Zhao, L., Yang, Y., & Fanin, N. (2020). Microplastics negatively affect soil fauna but stimulate microbial activity: insights from a field-based microplastic addition experiment. Proceedings of the Royal Society B, 287(1934), 20201268.

Liu, J., Liang, J., Ding, J., Zhang, G., Zeng, X., Yang, Q., ... & Gao, W. (2021). Microfiber pollution: an ongoing major environmental issue related to the sustainable development of textile and clothing industry. Environment, Development and Sustainability, 23, 11240-11256.

20Liu, T. K., Wang, M. W., & Chen, P. (2013). Influence of waste management policy on the characteristics of beach litter in Kaohsiung, Taiwan. Marine Pollution Bulletin, 72(1), 99-106.

Lwanga, E. H., Beriot, N., Corradini, F., Silva, V., Yang, X., Baartman, J., ... & Geissen, V. (2022). Review of microplastic sources, transport pathways and correlations with other soil stressors: a journey from agricultural sites into the environment. Chemical and Biological Technologies in Agriculture, 9(1), 20.

Lokhandwala, S., Gautam, P., Desai, Z., & Gajara, V. (2024). Waste Disposal and Its Environmental Impact. Solid Waste Treatment Technologies, 74-97.

Ma, R., Xu, Z., Sun, J., Li, D., Cheng, Z., Niu, Y., ... & Wang, T. (2023). Microplastics affect C, N, and P cycling in natural environments: Highlighting the driver of soil hydraulic properties. Journal of Hazardous Materials, 459, 132326.

MacLeod, M., Arp, H. P. H., Tekman, M. B., & Jahnke, A. (2021). The global threat from plastic pollution. Science, 373(6550), 61-65.

Mahmud, A., Wasif, M. M., Roy, H., Mehnaz, F., Ahmed, T., Pervez, M. N., ... & Islam, M. S. (2022). Aquatic microplastic pollution control strategies: sustainable degradation techniques, resource recovery, and recommendations for Bangladesh. Water, 14(23), 3968.

Masiá, P., Sol, D., Ardura, A., Laca, A., Borrell, Y. J., Dopico, E., ... & Garcia-Vazquez, E. (2020). Bioremediation as a promising strategy for microplastics removal in wastewater treatment plants. Marine pollution bulletin, 156, 111252.

Mazhandu, Z. S., Muzenda, E., Mamvura, T. A., Belaid, M., & Nhubu, T. (2020). Integrated and consolidated review of plastic waste management and bio-based biodegradable plastics: Challenges and opportunities. Sustainability, 12(20), 8360.

Mitrano, D. M., & Wohlleben, W. (2020). Microplastic regulation should be more precise to incentivize both innovation and environmental safety. Nature communications, 11(1), 5324.

Moshood, T. D., Nawanir, G., Mahmud, F., Mohamad, F., Ahmad, M. H., & AbdulGhani, A. (2022). Sustainability of biodegradable plastics: New problem or solution to solve the global plastic pollution?. Current Research in Green and Sustainable Chemistry, 5, 100273.

Munhoz, D. R., Harkes, P., Beriot, N., Larreta, J., & Basurko, O. C. (2022). Microplastics: a review of policies and responses. Microplastics, 2(1), 1-26.

Munir, M. A. M., Yousaf, B., Ali, M. U., Dan, C., Abbas, Q., Arif, M., & Yang, X. (2021). In situ synthesis of micro-plastics embedded sewage-sludge co-pyrolyzed biochar: Implications for the remediation of Cr and Pb availability and enzymatic activities from the contaminated soil. Journal of Cleaner Production, 302, 127005.

Palansooriya, K. N., Sang, M. K., Igalavithana, A. D., Zhang, M., Hou, D., Oleszczuk, P., ... & Ok, Y. S. (2022). Biochar alters chemical and microbial properties of microplastic-contaminated soil. Environmental Research, 209, 112807.

Pathan, S. I., Arfaioli, P., Bardelli, T., Ceccherini, M. T., Nannipieri, P., & Pietramellara, G. (2020). Soil pollution from micro-and nanoplastic debris: A hidden and unknown biohazard. Sustainability, 12(18), 7255.

Peng, Y., Wang, Y., Ke, L., Dai, L., Wu, Q., Cobb, K., ... & Ruan, R. (2022). A review on catalytic pyrolysis of plastic wastes to high-value products. Energy Conversion and Management, 254, 115243.

Periyasamy, A. P. (2023). Environmentally Friendly Approach to the Reduction of Microplastics during Domestic Washing: Prospects for Machine Vision in Microplastics Reduction. Toxics, 11(7), 575.

Prata, J. C., Silva, A. L. P., Da Costa, J. P., Mouneyrac, C., Walker, T. R., Duarte, A. C., & Rocha-Santos, T. (2019). Solutions and integrated strategies for the control and mitigation of plastic and microplastic pollution. International journal of environmental research and public health, 16(13), 2411.
Poerio, T., Piacentini, E., & Mazzei, R. (2019). Membrane processes for microplastic removal. Molecules, 24(22), 4148.
Pu, R., Zhao, L., Deng, S., Naidu, R., Mantzavinos, D., Lin, L., ... & Lei, Y. (2025). Effect of high-frequency ultrasonication on degradation of polytetrafluoroethylene (PTFE) microplastics/nanoplastics. Separation and Purification Technology, 357, 130229.
Ramos, R. L., dos Santos, C. R., Drumond, G. P., de Souza Santos, L. V., & Amaral, M. C. S. (2023). Critical review of microplastic in membrane treatment plant: removal efficiency, environmental risk assessment, membrane fouling, and MP release. Chemical Engineering Journal, 148052.
Ran, T., Li, J., Liao, H., Zhao, Y., Yang, G., & Long, J. (2023). Effects of biochar amendment on bacterial communities and their function predictions in a microplastic-contaminated Capsicum annuum L. soil. Environmental Technology & Innovation, 31, 103174.
Rochman, C. M., Browne, M. A., Halpern, B. S., Hentschel, B. T., Hoh, E., Karapanagioti, H. K., ... & Thompson, R. C. (2013). Classify plastic waste as hazardous. Nature, 494(7436), 169-171.
Rogovina, S. Z. (2016). Biodegradable polymer composites based on synthetic and natural polymers of various classes. Polymer Science Series C, 58, 62-73.
Rujnić-Sokele, M., & Pilipović, A. (2017). Challenges and opportunities of biodegradable plastics: A mini review. Waste Management & Research, 35(2), 132-140.
Schuhen, K., & Sturm, M. T. (2020). Microplastic pollution and reduction strategies. Handbook of Microplastics in the Environment, 1-33.
Seetasang, S., & Iwai, C. B. (2024). Enhancing Domestic Wastewater Treatment: Integrating Vermifiltration and Biochar for Heavy metal and Microplastic Reduction and By-Product Utilization. Case Studies in Chemical and Environmental Engineering, 101025.
Seewoo, B. J., Wong, E. V., Mulders, Y. R., Goodes, L. M., Eroglu, E., Brunner, M., ... & Dunlop, S. A. (2024). Impacts associated with the plastic polymers polycarbonate, polystyrene, polyvinyl chloride, and polybutadiene across their life cycle: A review. Heliyon.
2023Shen, M., Song, B., Zeng, G., Zhang, Y., Huang, W., Wen, X., & Tang, W. (2020). Are biodegradable plastics a promising solution to solve the global plastic pollution?. Environmental pollution, 263, 114469.
Singh, M. V., Kumar, S., & Sarker, M. (2018). Waste HD-PE plastic, deformation into liquid hydrocarbon fuel using pyrolysis-catalytic cracking with a CuCO 3 catalyst. Sustainable Energy & Fuels, 2(5), 1057-1068.
Sridharan, S., Kumar, M., Bolan, N. S., Singh, L., Kumar, S., Kumar, R., & You, S. (2021). Are microplastics destabilizing the global network of terrestrial and aquatic ecosystem services?. Environmental Research, 198, 111243.
Sri Shalini, S., Palanivelu, K., Ramachandran, A., & Raghavan, V. (2021). Biochar from biomass waste as a renewable carbon material for climate change mitigation in reducing greenhouse gas emissions—a review. Biomass Conversion and Biorefinery, 11(5), 2247-2267.
Sol, D., Laca, A., Laca, A., & Díaz, M. (2020). Approaching the environmental problem of microplastics: Importance of WWTP treatments. Science of the Total Environment, 740, 140016.
Sun, J., Zheng, H., Xiang, H., Fan, J., & Jiang, H. (2022). The surface degradation and release of microplastics from plastic films studied by UV radiation and mechanical abrasion. Science of the Total Environment, 838, 156369.

Surendran, U., Jayakumar, M., Raja, P., Gopinath, G., & Chellam, P. V. (2023). Microplastics in terrestrial ecosystem: Sources and migration in soil environment. Chemosphere, 318, 137946.

Qi, R., Jones, D. L., Li, Z., Liu, Q., & Yan, C. (2020). Behavior of microplastics and plastic film residues in the soil environment: A critical review. Science of the Total Environment, 703, 134722.

Qi, Y., Beriot, N., Gort, G., Lwanga, E. H., Gooren, H., Yang, X., & Geissen, V. (2020). Impact of plastic mulch film debris on soil physicochemical and hydrological properties. Environmental Pollution, 266, 115097.

Qiu, Y., Zhou, S., Zhang, C., Zhou, Y., & Qin, W. (2022). Soil microplastic characteristics and the effects on soil properties and biota: A systematic review and meta-analysis. Environmental Pollution, 313, 120183.

Tang, K. H. D. (2023). Bioaugmentation of anaerobic wastewater treatment sludge digestion: A perspective on microplastics removal. Journal of Cleaner Production, 387, 135864.

Tang, K. H. D., & Hadibarata, T. (2021). Microplastics removal through water treatment plants: Its feasibility, efficiency, future prospects and enhancement by proper waste management. Environmental Challenges, 5, 100264.

Tang, K. H. D., & Hadibarata, T. (2022). The application of bioremediation in wastewater treatment plants for microplastics removal: a practical perspective. Bioprocess and Biosystems Engineering, 45(11), 1865-1878.

Tian, L., Jinjin, C., Ji, R., Ma, Y., & Yu, X. (2022). Microplastics in agricultural soils: sources, effects, and their fate. Current Opinion in Environmental Science & Health, 25, 100311.

United Nations Environment Program (UNEP/IUCN). (2020) National Guidance for Plastic Pollution Hotspotting and Shaping Action; IUCN: Gland,Switzerland,2020;ISBN9789280737936.
https://www.unep.org/resources/report/national-guidance-plastic-pollution-hotspotting-and-shaping-action. ErişimTarihi: 28.11.2024.

Usman, S., Abdull Razis, A. F., Shaari, K., Azmai, M. N. A., Saad, M. Z., Mat Isa, N., & Nazarudin, M. F. (2022). The burden of microplastics pollution and contending policies and regulations. International journal of environmental research and public health, 19(11), 6773.

Venus, O. (2020). National Marine Microbead Policy in Developed Nations: How Microbead Bans Have Influenced Microplastic Pollution in Waterways and Begun the Trend Towards International Collaboration (Doctoral dissertation).

Walker, T. R., & Xanthos, D. (2018). A call for Canada to move toward zero plastic waste by reducing and recycling single-use plastics. Resour. Conserv. Recycl, 133, 99-100.

Wang, C., Song, J., Nunes, L. M., Zhao, H., Wang, P., Liang, Z., ... & Xing, B. (2024). Global microplastic fiber pollution from domestic laundry. Journal of Hazardous Materials, 477, 135290.

Wang, Q., Feng, X., Liu, Y., Cui, W., Sun, Y., Zhang, S., & Wang, F. (2022). Effects of microplastics and carbon nanotubes on soil geochemical properties and bacterial communities. Journal of Hazardous Materials, 433, 128826.

Wang, W., Ge, J., Yu, X., & Li, H. (2020). Environmental fate and impacts of microplastics in soil ecosystems: Progress and perspective. Science of the total environment, 708, 134841.

Wang, W., Xie, Y., Li, H., Dong, H., Li, B., Guo, Y., ... & Zhou, W. (2024). Responses of lettuce (Lactuca sativa L.) growth and soil properties to conventional non-biodegradable and new biodegradable microplastics. Environmental Pollution, 341, 122897.

Wang, Z., Sedighi, M., & Lea-Langton, A. (2020). Filtration of microplastic spheres by biochar: removal efficiency and immobilisation mechanisms. Water Research, 184, 116165.

Wen, H., Cheng, D., Chen, Y., Yue, W., & Zhang, Z. (2024). Review on ultrasonic technology enhanced biological treatment of wastewater. Science of The Total Environment, 171260.

World Health Organization (WHO). (2019). https://www.who.int/news/item/22-08-2019-who-calls-for-more-research-into-microplastics-and-a-crackdown-on-plastic-pollution. Erişim Tarihi: 28.11.2024.

Wu, C., Ma, Y., Shan, Y., Song, X., Wang, D., Ren, X., ... & Ma, Y. (2024). Exploring the potential of biochar for the remediation of microbial communities and element cycling in microplastic-contaminated soil. Chemosphere, 362, 142698.

Ya, H., Jiang, B., Xing, Y., Zhang, T., Lv, M., & Wang, X. (2021). Recent advances on ecological effects of microplastics on soil environment. Science of the total environment, 798, 149338.

Yang, L., Zhang, Y., Kang, S., Wang, Z., & Wu, C. (2021). Microplastics in soil: A review on methods, occurrence, sources, and potential risk. Science of the Total Environment, 780, 146546.

Yang, R. X., Jan, K., Chen, C. T., Chen, W. T., & Wu, K. C. W. (2022). Thermochemical conversion of plastic waste into fuels, chemicals, and value-added materials: a critical review and outlooks. ChemSusChem, 15(11), e202200171.

Yang, X., Zhang, Z., & Guo, X. (2023). Impact of soil structure and texture on occurrence of microplastics in agricultural soils of karst areas. Science of the Total Environment, 902, 166189.

Yao, Y., Lili, W., Shufen, P., Gang, L., Hongmei, L., Weiming, X., ... & Dianlin, Y. (2022). Can microplastics mediate soil properties, plant growth and carbon/nitrogen turnover in the terrestrial ecosystem?. Ecosystem Health and Sustainability, 8(1), 2133638.

Yu, H., Zhang, Y., Tan, W., & Zhang, Z. (2022). Microplastics as an emerging environmental pollutant in agricultural soils: effects on ecosystems and human health. Frontiers in Environmental Science, 10, 855292.

Yuan, H., Lu, T., Huang, H., Zhao, D., Kobayashi, N., & Chen, Y. (2015). Influence of pyrolysis temperature on physical and chemical properties of biochar made from sewage sludge. Journal of Analytical and Applied Pyrolysis, 112, 284-289.

Xu, C., Zhang, B., Gu, C., Shen, C., Yin, S., Aamir, M., & Li, F. (2020). Are we underestimating the sources of microplastic pollution in terrestrial environment?. Journal of hazardous materials, 400, 123228.

Xu, T., Wang, X., Shi, Q., Liu, H., Chen, Y., & Liu, J. (2024). Review of Soil Microplastic Degradation Pathways and Remediation Techniques. International Journal of Environmental Research, 18(5), 77.

Xu, Z., Bai, X., & Ye, Z. (2021). Removal and generation of microplastics in wastewater treatment plants: A review. Journal of Cleaner Production, 291, 125982.

Zaaba, N. F., & Jaafar, M. (2020). A review on degradation mechanisms of polylactic acid: Hydrolytic, photodegradative, microbial, and enzymatic degradation. Polymer Engineering & Science, 60(9), 2061-2075.

Zahmatkesh, S., Klemeš, J. J., Bokhari, A., Wang, C., Sillanpaa, M., Amesho, K. T. T., & Vithanage, M. (2023). Various advanced wastewater treatment methods to remove microplastics and prevent transmission of SARS-CoV-2 to airborne microplastics. International Journal of Environmental Science and Technology, 20(2), 2229-2246.

Zeb, A., Liu, W., Ali, N., Shi, R., Wang, Q., Wang, J., ... & Liu, J. (2024). Microplastic pollution in terrestrial ecosystems: Global implications and sustainable solutions. Journal of hazardous materials, 461, 132636.

Zhang, Z., & Chen, Y. (2020). Effects of microplastics on wastewater and sewage sludge treatment and their removal: a review. Chemical Engineering Journal, 382, 122955.

Zhou, J., Gui, H., Banfield, C. C., Wen, Y., Zang, H., Dippold, M. A., ... & Jones, D. L. (2021). The microplastisphere: biodegradable microplastics addition alters soil microbial community structure and function. Soil Biology and Biochemistry, 156, 108211.
Zhou, Y., Wang, J., Zou, M., Jia, Z., Zhou, S., & Li, Y. (2020). Microplastics in soils: A review of methods, occurrence, fate, transport, ecological and environmental risks. Science of the Total Environment, 748, 141368.
Zoppas, F. M., Sacco, N., Soffietti, J., Devard, A., Akhter, F., & Marchesini, F. A. (2023). Catalytic approaches for the removal of microplastics from water: Recent advances and future opportunities. Chemical Engineering Journal Advances, 100529.
Zou, X., Cao, K., Wang, Q., Kang, S., & Wang, Y. (2024). Enhanced degradation of polylactic acid microplastics in acidic soils: Does the application of biochar matter?. Journal of Hazardous Materials, 477, 135262.

THE INTERACTION BETWEEN SOIL MANAGEMENT AND CARBON FOOTPRINT

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ABSTRACT
Soil is an important component of the global carbon cycle and serves as one of the largest reservoirs of organic carbon practices that affect the carbon footprint of agricultural systems by affecting the carbon dynamics of the soil. The relationship between soil management and carbon footprint involves interactions between soil structure, organic matter content, microbial activity, and the physical and chemical processes that govern the carbon cycle in soil. Effective soil management can enrich agricultural soils with carbon in the long term by increasing carbon sequestration. Soil science recognizes that SOC levels vary greatly depending on soil texture, structure, and moisture. Soil management plays a crucial role in shaping the carbon footprint of agricultural systems; soil science offers insights into how specific practices affect SOC dynamics and carbon sequestration. Soil management is an important factor in controlling the carbon footprint of agricultural practices. Practices such as conservation tillage, cover cropping, crop rotation, organic amendments and agroforestry increase soil carbon storage by preserving organic matter, increasing soil fertility and preventing erosion. However, difficulties in monitoring soil carbon, variability in soil types, and economic barriers make it difficult to widely adopt these techniques. Soil scientists play an important role in developing carbon management models, monitoring SOC changes, and improving techniques to increase SOC storage in various ecosystems. Collaboration between researchers, farmers, and policymakers is essential to overcome technical, economic, and practical barriers to effective soil carbon management. Accurate SOC monitoring also requires advanced tools such as remote sensing and soil spectroscopy to assess changes in SOC over time.
Key Words: Soil management, carbon footprint, soil carbon dynamics

INTRODUCTION
Soil is an essential component of the global carbon cycle and serves as one of the largest reservoirs of organic carbon (Galati et al., 2016). Effective soil management can increase carbon sequestration, turning agricultural soils into long-term carbon sinks rather than carbon sources. Several studies (Aurich et al., 2006; Mendoza et al., 2006; Gan et al., 2014; Alhajj Ali et al., 2015) have investigated various forms of agricultural management in terms of

emission reduction including tillage, fertilization and crop rotation. Soil science provides insights into how different practices impact soil carbon dynamics, influencing the carbon footprint of agricultural systems. The relationship between soil management and carbon footprint involves interactions between soil structure, organic matter content, microbial activity, and the physical and chemical processes that govern carbon cycling in soils (Figure 1). This article reviews soil management practices that influence SOC storage and highlights the role of soil science in optimizing these practices for sustainable agriculture.

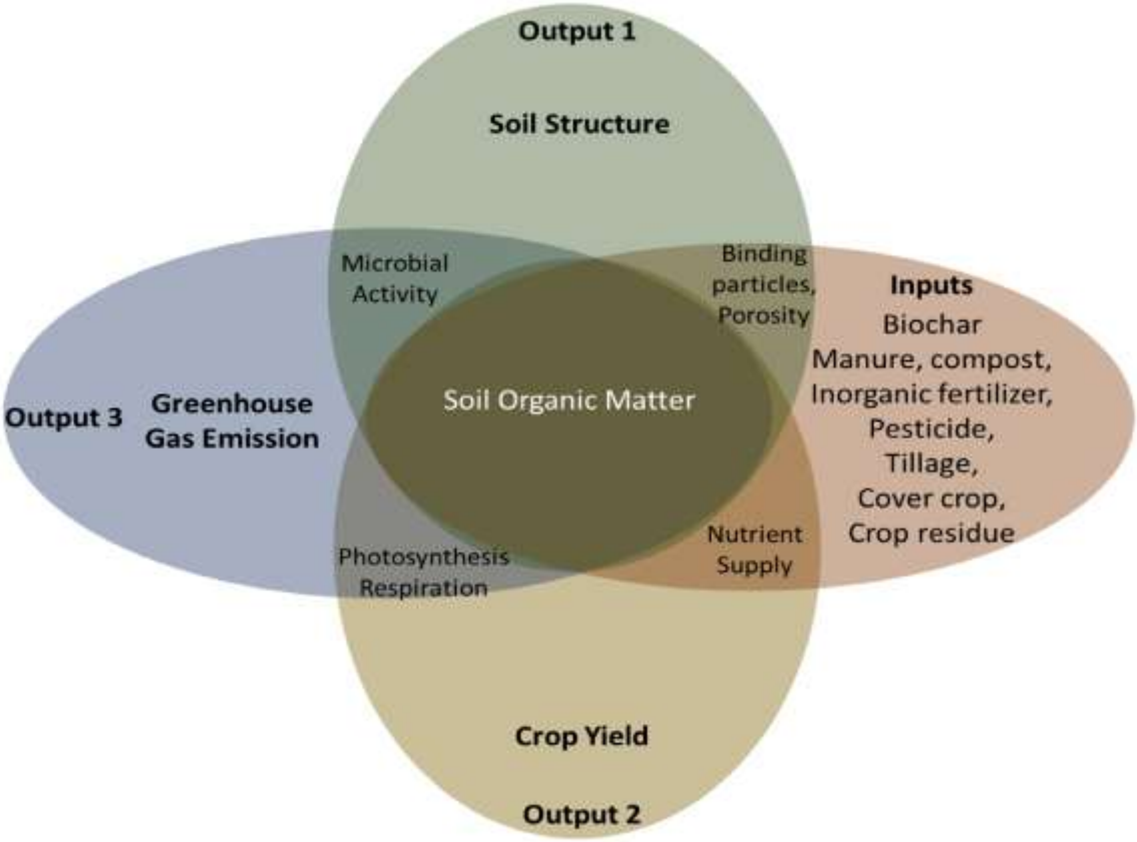

Figure 1. Carbon movement in soils and its relationship with some soil and plant properties (Ozlu et al. 2022)

Soil Organic Carbon (SOC) and the Carbon Cycle

Soil organic carbon (SOC) is a primary indicator of soil health and carbon sequestration potential. SOC originates from plant residues, root exudates, and organic amendments that decompose and are stabilized within the soil matrix. This organic carbon can remain in the soil for varying durations, depending on soil type, climate, and management practices. SOC serves as a carbon sink when carbon inputs exceed outputs, while practices that disrupt the soil, such as excessive tillage or monocropping, can lead to carbon release as CO_2, increasing the agricultural carbon footprint. Thus, maintaining or enhancing SOC levels is crucial for minimizing emissions and promoting sustainable soil management (Figure2). In the long-term experiment manure application was reported to cause a significant increase in SOC (0.10 Mg C ha^{-1} $year^{-1}$) when applied as organic fertilizer. (Buysse et al., 2013). Higher amounts of crop residue have been found to sequester more carbon when compared to fertilizer application.

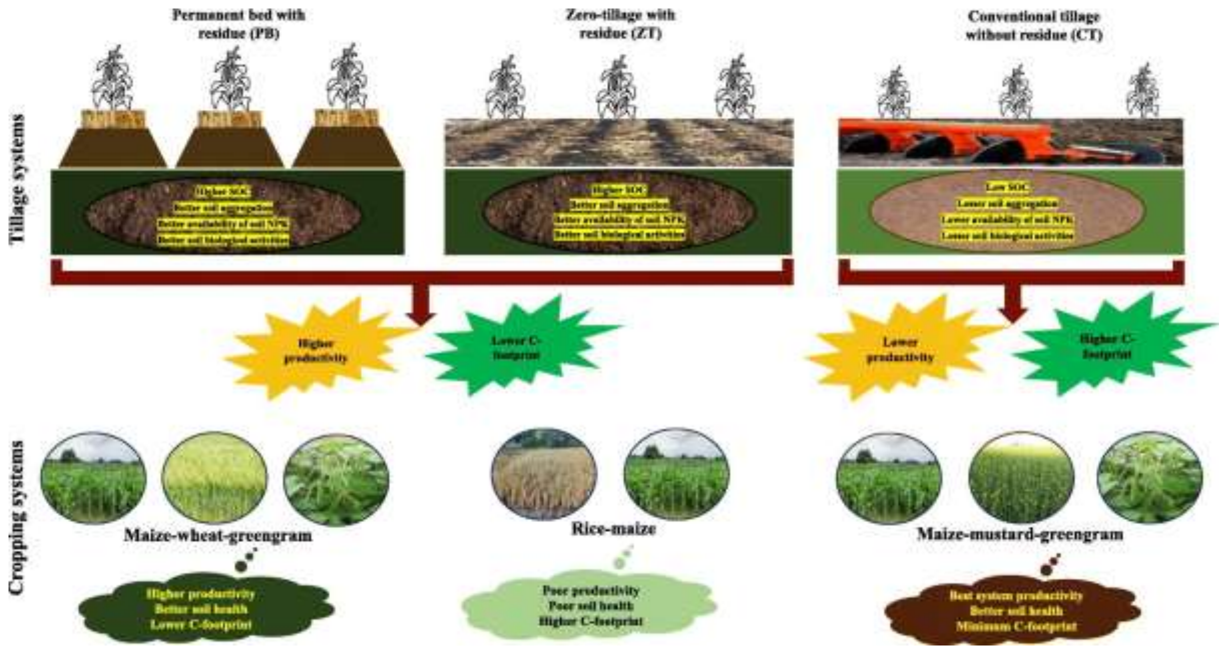

Figure 2. Soil carbon-nutrient cycling (Pramanick et al.2024))

Soil Management Practices and Their Influence on Carbon Footprint

Conservation Tillage

Tillage is used to prepare soil for planting, but excessive tillage breaks down soil structure, accelerating organic matter decomposition and CO_2 emissions. Conservation tillage practices, including reduced-till and no-till, preserve soil structure and reduce erosion, enabling soils to retain more organic matter and sequester carbon. Soil science research shows that reduced soil disturbance helps maintain stable aggregates where carbon can be stored, thus lowering the carbon footprint of tillage-intensive farming systems. Emission differences between tillage methods are mainly due to the presence and absence of tillage operations (primary and secondary tillage) with different fuel consumption (Abbas et al., 2017). Farm machinery-related green house gas emisions includig CO_2. Higher use of agricultural machinery led to greater amounts of fossil fuel-related emissions; represents 14.4% of fossil fuel-related emissions Maraseni et al. (2010).

Cover Cropping

Cover crops, grown during fallow periods, protect soil from erosion, enhance soil organic matter, and improve soil structure. Leguminous cover crops also add nitrogen to the soil, reducing the need for synthetic fertilizers. Soil science reveals that cover crops enhance SOC by increasing biomass inputs and supporting microbial communities that aid in organic matter decomposition and stabilization. As a result, cover cropping reduces soil CO_2 emissions, contributing to a lower carbon footprint. The estimated amount of crop residue produced in the world is 2962 million Mg year^{-1} (Lal and Kimble, 1997). Some of these residues may be useful for increasing SOC and consequent carbon sequestration, which is returned to the soil by CT. It has been reported that approximately 8% more SOC is retained when CT is used compared to the conventional tillage system in Eastern Nigeria (Ohiri and Ezumah, 1990). In the study conducted by Oertel et al. (2016), wetlands (2.7%) show the highest mean absolute carbon emission rates; they are higher for other different land uses (Figure 3). Forests, grasslands, croplands, and wastelands follow in decreasing order of emission rates. This depends on land management and climate zone conditions. Using a combined mean of 300 mg CO_2e m−2 h^{-1} for all land cover types, global annual soil emissions result in ≥350 Pg CO_2e, corresponding to approximately 21% of the estimated global soil C and N pools.

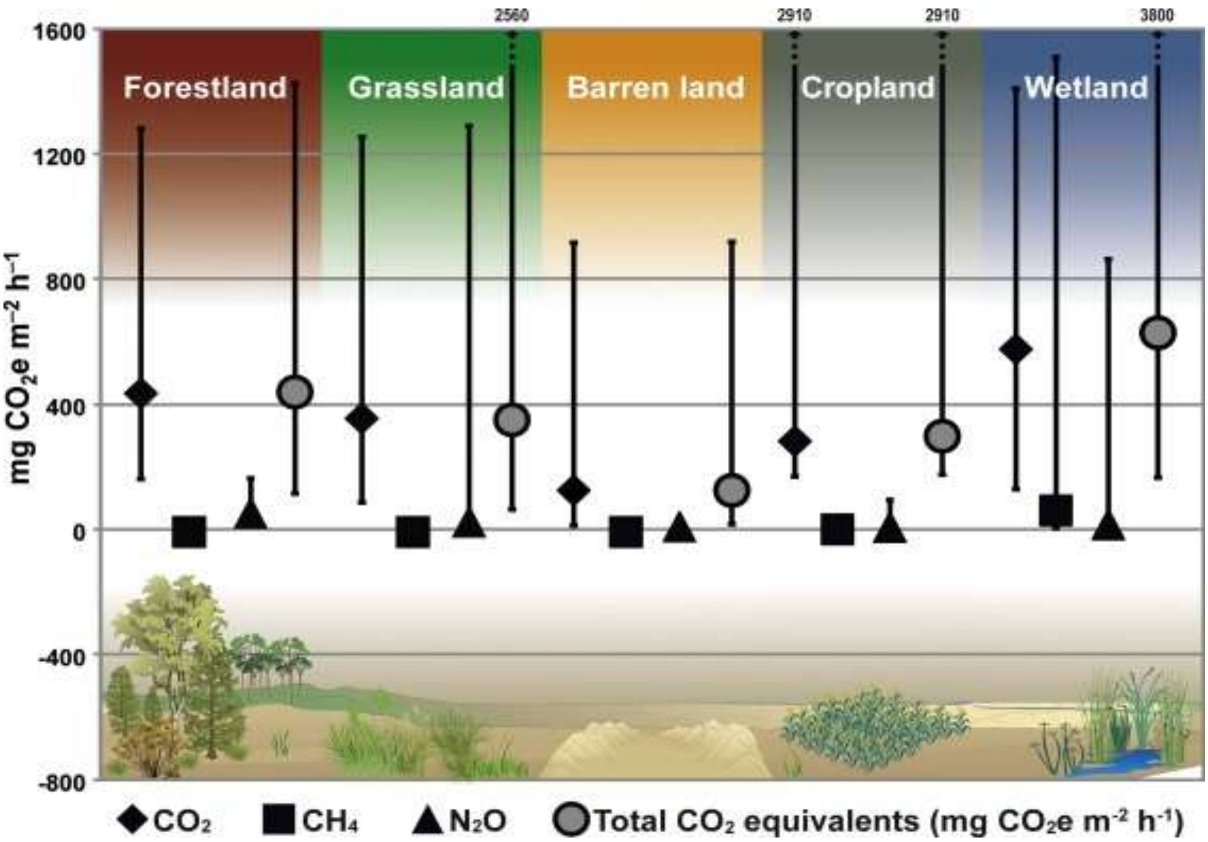

Figure. 3. GHG emissions (CO_2-eq) of CO_2, N_2O and CH_4 from soils with different land cover: grassland, forestland, barren land, cropland, and wetland (Oertel et al. 2016)

Crop Rotation and Diversification

Crop rotation, especially with deep-rooted or perennial crops, is a strategy to improve soil fertility and carbon sequestration. Soil science findings suggest that diverse rotations increase SOC by varying the types of organic matter input and supporting diverse microbial communities. This practice prevents soil degradation, enhances nutrient cycling, and stores carbon deeper within the soil, where it is less likely to be released as CO_2. By reducing dependency on synthetic inputs and enhancing soil resilience, crop diversification also reduces the GHG emissions associated with monoculture systems. Yang et al (2023) reported that winter wheat-summer maize-summer maize cropping rotation combined with irrigation was the most effective treatment to promote SOC sequestration and reduce greenhouse gas emissions with relatively high yield

Organic Amendments

Applying organic amendments, such as compost, manure, and biochar, adds stable organic carbon to soils. Biochar, for instance, is a carbon-rich material that decomposes slowly, providing long-term SOC storage. Soil science research highlights biochar's effectiveness in retaining carbon, improving soil fertility, and reducing leaching. Organic amendments enhance soil structure, promote water retention, and provide a steady carbon input, all contributing to a lower carbon footprint by reducing CO_2 emissions from soil respiration and nutrient losses. Huang et al. (2016) reported that The SOC accumulation in paddy soils is due to the high organic material input and comparatively low rate of decomposition under anaerobic conditions (Huang et al., 2016).

While the decomposition of organic matter by microorganisms in the soil causes carbon loss in the form of CO_2 in the soil, a small proportion of the carbon is retained by the formation of humus, which generally gives a dark color to soils rich in organic matter Figure 4 (Ontl and Schulte 2012)

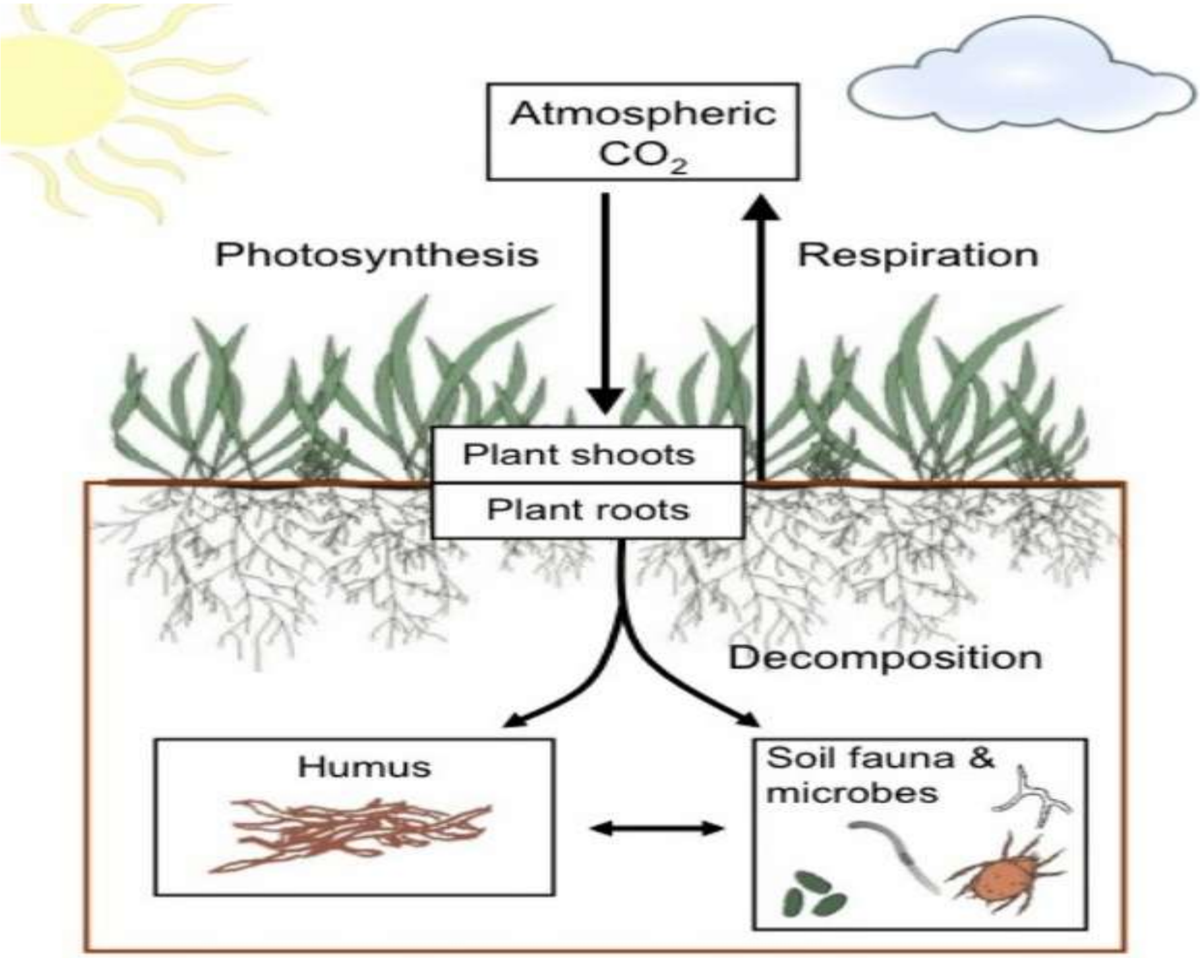

Figure 4. Carbon balance within the soil (brown box) is controlled by carbon inputs from photosynthesis and carbon losses by respiration. (Ontl and Schulte 2012)
Decomposition of roots and root products by soil fauna and microbes produces humus, a long-lived store of SOC.

Agroforestry and Perennial Cropping Systems
Agroforestry, the integration of trees with crops or livestock, is highly beneficial for carbon sequestration. Trees sequester carbon in both aboveground biomass and soils, creating a multi-layered ecosystem that supports biodiversity and SOC stability. Soil science has shown that perennial root systems improve SOC storage by transporting carbon to deeper soil layers. Perennial systems reduce erosion, improve nutrient cycling, and increase soil stability, creating conditions for long-term carbon storage and reduced emissions.

Challenges in Soil Carbon Management
While soil management practices hold great potential for carbon sequestration, challenges remain in standardizing and measuring these impacts across different soil types, climates, and land-use systems. Soil science recognizes that SOC levels vary widely depending on soil texture, structure, and moisture. Accurate SOC monitoring requires advanced tools, such as remote sensing and soil spectroscopy, to assess changes in SOC over time. Economic challenges, including upfront costs for adopting conservation practices, also limit their widespread implementation. To make soil carbon sequestration feasible on a larger scale, it is essential to invest in improved SOC monitoring technologies, region-specific guidelines, and incentive programs for farmers.

The Role of Soil Science in Policy and Practice

Soil science can guide policy by providing evidence-based best practices for SOC management and quantifying the impact of soil practices on carbon emissions. Policymakers can support soil carbon sequestration by creating financial incentives, like carbon credits, and promoting sustainable land-use policies. Soil scientists play a crucial role in developing carbon management models, monitoring SOC changes, and refining techniques to increase SOC storage across diverse ecosystems. Collaboration among researchers, farmers, and policymakers is essential to address the technical, economic, and practical barriers to effective soil carbon management.

CONCLUSION

Soil management plays a pivotal role in shaping the carbon footprint of agricultural systems, with soil science offering insights into how specific practices affect SOC dynamics and carbon sequestration. By adopting conservation tillage, cover cropping, crop rotation, organic amendments, and agroforestry, soil can act as a carbon sink rather than a source of emissions. Overcoming the challenges of SOC monitoring, soil heterogeneity, and economic barriers will require a concerted effort from researchers, policymakers, and agricultural practitioners. With advancements in soil science, improved management practices, and supportive policies, sustainable soil management can significantly contribute to reducing the carbon footprint of agriculture, ultimately supporting global climate mitigation efforts. This article outlines the scientific foundation and practical considerations for leveraging soil management to reduce carbon footprints in agriculture, highlighting the essential contributions of soil science to sustainable environmental solutions.

REFERENCES

Abbas, F., Hammad, H.M., Fahad, S., Cerda, A., Rizwan, M., Farhad, W., Ehsan, S., Bakhat, H.F., 2017. Agroforestry: a sustainable environmental practice for carbon sequestration under the climate change scenarios – a review. Environ. Sci. Pollut. Res. 24, 11177–11191. https://doi.org/10.1007/s11356-017-8687-0.

Alhajj Ali, S., Tedone, L., De Mastro, G., 2015. Optimization of the environmental performance of rainfed durum wheat by adjusting the management practices. J. Clean. Prod. 87, 105e118 .

Aurich, A.M., Weersink, A., Janovicek, K., Deen, B., 2006. Cost efficient rotation and tillage options to sequester carbon and mitigate GHG emissions from agriculture in Eastern Canada. Agric. Ecosyst. Environ. 117, 119e127.

Buysse, P., Roisin, C., Aubinet, M., 2013. Fifty years of contrasted residue management of an agricultural crop: impacts on the soil carbon budget and on soil heterotrophic respiration. Agric. Ecosyst. Environ. 167, 52–59. https://doi.org/10.1016/j. agee.2013.01.006.

Galati, A., Crescimanno, M., Gristina, L., Keesstra, S., Novara, A., 2016. Actual provision as an alternative criterion to improve the efficiency of payments for ecosystem services for C sequestration in semiarid vineyards. Agric. Syst. 144, 58–64.

Gan, Y., Liang, C., Chai, Q., Lemke, R.L., Campbell, C.A., Zentner, R.P., 2014. Improving farming practices reduces the carbon footprint of spring wheat production. Nat. Commun. 5.

Huang, S., Sun, Y., Yu, X., Zhang, W., 2016. Interactive effects of temperature and moisture on CO_2 and CH4 production in a paddy soil under long-term different fertilization regimes. Biol. Fertil. Soils 52, 285–294. https://doi.org/10.1007/s00374-015-1075-3.

Lal, R., Kimble, J.M., 1997. Conservation tillage for carbon sequestration. Nutrient Cycl. Agroecosyst. 49, 243–253. https://doi.org/10.1023/A:1009794514742.

Maraseni, T.N., Cockfield, G., Maroulis, J., 2010. An assessment of greenhouse gas emissions from the Australian vegetables industry. J. Environ. Sci. Health 45, 578e588.

Mendoza, A.P., Boeckxb, P.F., Miceli, F.G., Cleemput, O.V., Dendooven, L., 2006. Influence of water regime and N availability on the emission of nitrous oxide and carbon dioxide from tropical, semi-arid soils of Chiapas, Mexico. J. Arid. Environ.64, 137e151.

Oertel C., Matschullat J., Zurba K., Zimmermann F. & Erasm S., (2016). Greenhouse gas emissions from soils—A review, Geochemistry, Volume 76, Issue 3, Pages 327-352,ISSN 0009-2819,https://doi.org/10.1016/j.chemer.2016.04.002.

Ohiri, A.C., Ezumah, H.C., 1990. Tillage effects on cassava (Manihot esculenta) production and some soil properties. Soil Tillage Res. 17, 221–229. https://doi.org/10.1016/0167-1987(90)90037-E.

Ontl, T. A. & Schulte, L. A. (2012) Soil Carbon Storage. Nature Education Knowledge 3(10):35

Ozlu, E., Arriaga, F. J., Bilen, S., Gozukara, G., & Babur, E. (2022). Carbon Footprint Management by Agricultural Practices. Biology, 11(10), 1453. https://doi.org/10.3390/biology11101453

Pramanick B., Kumar M., Naik B.M., Kumar Singh S.M., Kumar M.& Shiv Vendra Singh S.V., (2024). Soil carbon-nutrient cycling, energetics, and carbon footprint in calcareous soils with adoption of long-term conservation tillage practices and cropping systems diversification, Science of The Total Environment, Volume 912, 169421, ISSN 0048-9697, https://doi.org/10.1016/j.scitotenv.2023.169421.

Yang, X., Sui, P., Zhang, M., Chen, Y., Gao, W., 2014. Reducing agricultural carbon footprint through diversified crop rotation systems in the North China Plain. J. Clean. Prod. 76, 131e139.

BIOCHAR USE AS A SEED COATING MATERIAL

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Abstract
Biochar, a carbon-rich material produced through the pyrolysis of biomass, has emerged as a promising tool in sustainable agriculture, particularly as a seed coating material. Its unique properties, including high porosity, cation exchange capacity, and microbial interaction, make it an effective medium for enhancing seed germination, seedling establishment, and overall plant performance. This study explores the potential of biochar-coated seeds to improve agricultural outcomes, particularly under challenging environmental conditions such as drought, nutrient deficiencies, and salinity. The application of biochar in seed coatings offers numerous benefits. It enhances germination rates, promotes uniform seedling growth, and improves nutrient retention while reducing nutrient leaching. Biochar's porous structure allows for gradual nutrient release, ensuring sustained plant development. Additionally, its ability to absorb and immobilize harmful substances reduces phytotoxic effects, contributing to healthier crop growth. By fostering beneficial microbial activity in the soil, biochar further enhances plant nutrition and disease resistance. Two primary methods of biochar application, dry and wet seed coating, are examined for their efficiency and scalability. While dry coating offers simplicity and cost-effectiveness, wet coating ensures better adherence and uniformity. Both methods demonstrate potential for large-scale agricultural applications, though optimization is needed to address seed-specific requirements and reduce production costs. Despite its promising applications, challenges remain. Further research is required to refine biochar formulations, understand its long-term impacts on soil health, and evaluate its scalability across diverse agricultural systems. Moreover, regulatory frameworks and farmer education programs are essential for the successful integration of biochar in modern agricultural practices. This study highlights biochar-coated seeds as an innovative approach to improving crop yields and soil health while addressing global food security and sustainability challenges. The findings underline the need for collaborative efforts to maximize the benefits of this versatile material in agriculture.
Keywords:
Biochar, Seed Coating, Sustainable Agriculture, Germination Enhancement, Nutrient Retention, Soil Health, Microbial Interactions, Crop Productivity, Drought Resilience, Environmental Sustainability

Introduction to Seed Coating and Biochar

In agriculture, seed coating is a technology that is being adopted by farmers and seed companies alike. The technique is based on covering the outside area of seeds with substances that fulfill different roles, such as nutrient and pesticide carriers, and covering materials with synergy among them. These roles aim to improve seed performance and establishment, technically known as increasing vigor (Afzal et al., 2020). This fact led some researchers worldwide to investigate this technique as an alternative to increase crop yields, especially under severe environmental field conditions. Since ancient times, people have recognized the beneficial properties of adding a layer of materials to seeds to improve germination and seedling growth. Possibly, coatings constructed of carbon-rich biochar materials might represent the next frontier in global seed coatings biomimicry efforts (Bolan et al.2022).

Biochar is a carbon-rich material that is produced by pyrolysis of biomass. It presents unique properties such as porosity and cation and anion exchange sites, which give physical and chemical protection against biodegradation, secondary metabolism of microorganisms, and otherwise from phytotoxic elements as high-value properties that can be used in seed pretreatment practices or with fertilizers in soil enhancement strategies (Alfattani et al., 2021). In the field of agricultural applications, because of these characteristics, biochar has caught the attention of those looking for more sustainable agricultural approaches. It is considered a nanomaterial due to its carbon-rich structure and control of variables. The consistency of the data regarding its size distribution is quite variable, which opposes the classifications of international organizations (Nidheesh et al.2021).

Importance of Seed Coating in Agriculture

It is critical for modern agriculture to focus on crop establishment methodologies. Seed coating, which is widely acknowledged as a farm-level industry and regular practice, has been a part of agriculture for thousands of years. Its primary role is to alleviate the adverse effects of seeds from the germinating phase to establishment in the field (Mawar et al., 2021). Seed coating protects the seed from several attacking organisms such as seed, root, and soil-borne pathogens, pests, and environmental constraints such as salinity, sodicity, inadequate soil moisture content, and extreme temperatures. In addition to this, coating materials often carry essential plant nutrients required during the initial growth period. In contrast to traditional fertilizers, substances present in the seed coatings are most likely immediately available for the emerging young roots and shoots (Javed et al.2022).

Another major role of seed coatings is its propensity to optimize planting conditions. A gradual sprout of seeds due to seed coatings provides a uniform and dense crop stand without giving any open space for the unwanted growth of weeds. Several high-value and low-seeded crops can benefit from this technology (Afzal et al., 2020). The need for efficient use of resources and reducing environmental impact will continue to be the drivers for innovation in the field of seed coating. The changing climate and the evolving concerns about resource scarcity elevate the importance of these fields. At the global level, if only a small percentage of grain farmers invest in seed priming and the biological potential is increased by only a small percentage, then this has a major economic impact, a net return of about $150 per billion and a significant amount of seeds produced (Afzal et al., 2020). The greatest impact of seed priming and biochar as a seed coating agent undoubtedly falls on the farmers. In the developing countries where subsistence-level farmers still cultivate, seed-priming technologies and biochar are more suitable. In all of these cases, the need is to attain food security and provide employment opportunities through fresh assignments (Waqas et al.2022).

Definition and Characteristics of Biochar

Biochar is a type of soil amendment that can be produced from the pyrolysis of various types of organic materials. With high carbon content, biochar is a highly stable form of carbon that can persist in soil for centuries or even millennia under certain circumstances. In terms of morphology, biochar is a solid material with a black color that results from incomplete pyrolysis processes. The biochar surface contains a number of pores, with sizes that vary from nanometer to micrometer (Wang et al.2020). These pores might be able to provide a suitable environment for microbial life or directly absorb gases, such as those responsible for bad odors. In particular, many hydroxyl and acid groups are located on the biochar surface, which provide the opportunity to form ester or covalent bonds with other molecules such as enzymes, hormones, lignin, pectin, and hemicelluloses, resulting in biochar's excellent properties for adsorbing and immobilizing organic materials from soils (Tan et al.2021).

Several advantages of biochar as a soil amendment have been reported. Notably, due to its porous structure, biochar can improve both soil aeration and water retention. Biochar's cation exchange capacity can, either directly through ion adsorption or indirectly by influencing the availability of oxygen, phosphorus, potassium, and micronutrients, improve soil fertility. When interacting with abiotic and biotic factors in soil, such as microorganisms, rising temperature, or changes to the pH of the growth medium, biochar has been reported to enhance nutrient availability (Razzaghi et al., 2020). In addition, due to the conversion of liability with soil organic carbon transport, biochar in fields was considered an efficient tool to mitigate greenhouse gas emissions by reducing emissions and enhancing carbon sequestration. Because the production of a large amount of biochar will remove plant debris and its benefits from burning for the environment in return for the reduction in greenhouse gas emissions, biochar is also considered an environmentally friendly tool in crop yield. The soil pH and nutrient content of biochar are controlled by the production conditions and the raw materials used to make biochar (Sri et al.2021). The pyrolysis temperature influences both the cation exchange capacity of biochar and nutrient loss. The developed structure and order can affect some characteristics of biochar, such as the specific surface area and pore volume. These properties can be influenced by the biochar production method and purpose. Many studies have reported that biochar is safe and non-toxic in terms of use for agriculture and the environment. Biochar has antibacterial and antifungal activities as well. Thus, the material could be tested for animal and human uses with further direction (Silva et al.2021). Since biochar is environmentally friendly, can store moisture well, improve soil pH, and absorb excess metal ions, it can be used in field trials or as a commercial component for seed treatment. It should be a good seed coating material. However, much of the literature and previous studies have concentrated mostly on the potential of biochar in improving soil health and cropping systems, or biological applications for water filtration. There has still been little information available on the capacity of biochar to adsorb and retain nutrients as a seed coating material. This paper introduces the current knowledge about production methods, properties, and surface characteristics of biochar related to the potential for use as a seed coating material in agriculture (Afzal et al., 2020).

Benefits of Using Biochar as a Seed Coating Material

There are many benefits of using biochar as a seed coating material. Firstly, enhanced seedling establishment, which encompasses rapid and uniform seed germination and robust and quick seedling growth, not only decreases the growing period of crops but also improves yields. This is especially desirable under drought-prone environments (Jahan et al., 2020). Biochar can promote seed germination, uniformity, and seedling growth. In addition to these direct benefits, researchers are also studying the interactions of biochar with soil microbes. Initial results suggest that biochar can promote an environment where beneficial microbes flourish and give rise to significant beneficial outcomes such as disease suppression and improved crop nutrition (Zhang et al.2023).

Biochar properties can facilitate the retention of essential nutrients and bring about more significant nutrient uptake by plants. Such properties, coupled with an ability to enhance soil water retention, have a strong effect on yield. One recent review has noted that biochar can, in certain instances, reduce the harmful effects of soil contaminants on plants and beneficially alter the soil structure and water-holding capacity (Razzaghi et al., 2020). Some growers are now suggesting that for every 1% soil moisture increase achieved through biochar addition, yield improvements can reach major thresholds. In terms of investment, biochar does not always seem to facilitate reduced fertilizer usage, but several experiments have reported the ability of plants to produce as well using lower input levels as control treatments (Joseph et al.2021). Finally, some researchers argue that through these improvements, biochar can reduce the chances of unseasonal weather disrupting the timing of operations in the field. If planting can be sufficiently staggered across the sowing season, it would help reduce risk further. There is a good deal of current research on this subject with encouraging results. Several studies have quantified the improved yields and reductions in synthetic inputs achievable with the use of biochar seed coatings and soil amendments. Some research has found no improvement in desired outcomes, and the reasons for this are not always clear. However, the benefits described above are such that the potential for biochar use in crop production is seen to be very much worth further exploration (Zhang et al.2020).

Enhanced Seed Germination and Growth

Biochar in the form of seed coating contributes to the enhancement of the germination and growth potential of crops in comparison to untreated seeds. However, plant species and biochar types also need consideration for positive effects on seed performance. Based on findings, seeds coated with selected woody and manure biochar mixes had significantly improved basic germination performance as compared to the control. Potential mechanisms of seed enhancement include the efficacy of biochar to create favorable microenvironments for seed development, germination, and seedling establishment (Uslu et al., 2020). With the application of biochar in seed coatings, seed performance was less sensitive to a lowering of soil moisture content, indicating an improvement in seed moisture availability for germination, which in turn is of potential benefit for germination success under variable field conditions. Furthermore, root development can be enhanced by biochar application in seed development, supporting above-ground plant growth and, in turn, health. The root growth development may further support seed germination, either from improved early water and nutrient uptake or later through a potentially quickening establishment rate for more rapid early root development. It has been suggested that one potential mechanism by which biochar can enhance seed germination and growth is by having a positive impact on seedling establishment. Resulting from improved nutrient availability, seedling growth, and tillering, coated pea seeds with biochar and salicylic acid produced earlier increased performance in growth compared to control seeds (Li et al.2020). To further elucidate the mechanisms of potential biochar application on seed performance, the application of micronutrients in coatings with biochar was investigated. In Araucaria araucana seeds, no effect was observed on germination rate, but the dominant effects on growth parameters show a possible nutritional effect. Nutrient release of biochar is generally slow, which can be expected to sustain the vigorous growth of seedlings (An et al.2021). Biochar coatings that contained different quantities of boron were produced to coat sugar beet seeds. The results of a conventional germination test indicated a positive effect on mean germination time following planting. Seeds coated with biochar sustained 94–97% germination, and seedlings had a 100% vigor after the treatment period. These studies present some evidence of a nutrient and growth improvement effect. Based on the generally established literature, we may surmise that biochar has potential as a seed coating in order to improve seed performance from improved germination and growth (Javed et al.2022).

Improved Nutrient Retention and Availability

Nutrient availability and leaching are also important factors with respect to plant growth and productivity. Due to its porous and hydrophilic nature, biochar can trap nutrients from the soil solution and prevent them from leaching out of the system. Biochar's alkaline surface can bind with plant nutrients such as phosphate to form stable compounds, potentially reducing phosphorus leaching away from the seed (Wang et al.2022). The CEC of biochar ranges between 100 and 600 cmol/kg, depending on feedstock, temperature, and the method of production. Ample CEC can facilitate better retention of essential plant nutrients such as nitrogen (N), phosphorus (P), potassium (K), and micronutrients. Biochar can also adsorb potentially toxic heavy metals and can mitigate their phytotoxic effects. The addition of biochar can produce soil that maintains a stable pH over time. Biochar may have no pH-buffering function if the pH is already higher than the buffer capacity of the biochar (Rasuli et al.2022).

Nitrogen availability in soil is also influenced by biochar, as biochar has been documented to keep the nitrogen within its structure and microsites away from leaching. Over time, nitrifiers and other nitrogen-transforming microorganisms transform ammonium to nitrate in different biochar/compost mixtures. This is beneficial for the plant as nitrate is available for plant uptake and growth (Haider et al.2020). Other research studies also highlighted the potential of biochar to enhance and support beneficial microbial activities performing functions such as nitrogen fixation, nutrient mineralization, and organic matter decomposition. Improved organic matter, macro and micronutrients, and greenhouse gas emissions are a result of biochar use. In addition, biochar conducts a significant amount of nutrients and humus, which increase soil productivity and can remain stable over a long period of time. The benefits of using biochar include large advantages, both to the crop and the soil, as a result of the biophysical effects in the cropping systems (Gou et al.2023).

Methods of Applying Biochar as a Seed Coating

A number of methods have been proposed for putting biochar onto seed coatings, and they can generally be broken down into dry and wet seed coating processes. The dry seed coating process is usually simpler than the wet one, which involves a suspension process to allow the biochar to adhere to the seed surface better (Suhag et al.2020). The dry process usually involves mixing biochar either with dry or flowable fine powders or liquids or with an adhesive that helps the biochar stick to the seeds. The mixing process should ensure that the biochar is well distributed on the seed surface. The advantages of dry methods are that their application can be scalable, they are relatively cheap, and tend to be easier than wet methods because they can use accessible equipment suitable for mass production. Disadvantages, however, include the potential for dust pollution, but also that some suitable adhesives might be too expensive for large-scale usage, reducing the cost competitiveness of the coated seed (Troyano et al.2020).

Depending on the kind of seed used, particularly on their size and texture, the time and mixing conditions needed to ensure a uniform application of biochar on seeds can vary. In the case of a system using polymers as binders, the use of a dry formulation involving first dissolving the polymer and then mixing this with the aggregate mixture may result in better adherence of the biochar than formulations using only water (Chrysargyris et al., 2020). The wet seed coating process involves the use of a liquid suspension of the biochar, often with other ingredients applied usually through an atomizer so that the product becomes evenly distributed over the seed. The wet seed formulations tend to involve some time to dry before use. In general, the biggest factor affecting the adhesion of biochar and seed in wet formulations is the time the coating is allowed to dry. The thickness of the seed coating affects seed germination rate and elongation of the growing radicle, which could affect field germination and emergence. To get good results, it is always best to adjust the adherence methods according to the seed type (Guo et al., 2020).

Dry Seed Coating Techniques

Techniques Biochar can simply be mixed with the seed using either a dry or a liquid method. In the dry seed coating, the biochar powder and the seeds are mixed with adhesive or filler in order to attain proper adhesion of the coating on the seed. Using this technique, the biochar load can be increased and reduced from the seed. It is relatively easy to implement, and as long as the shelf life of the product is mainly defined by the stability of the adhesive and by humidity, the shelf life of the seeds will not be affected. However, there is a risk of damage to the seeds during biochar production (Xu et al.2023). The main challenge in achieving a uniform deposition of a coating in a dry coating is the creation of a good bond between the seed and the coating layer. This technique requires that it is possible to cover a relatively large solid surface with a layer of particles. The attachment is determined by the van der Waals forces and the ability of the biochar to wet the seeds well. When wetting is not sufficient, this can be improved using appropriate adjuvants. However, coating uniformity, once deposited, should not be affected by variations in seed size and seed loading in the bed. The thermal treatment of seeds in large volumes has been demonstrated to be feasible. Independently of the mode of heating used, the necessity to maintain the natural moisture of the seeds during the process could be limiting, particularly for small seeds that have a high surface-to-volume ratio (Ivanova et al.2023). Absorption of the dilute highly soluble nanoparticles could lead to disruption and agglomeration of the nanoparticles in the coating. The thermal activation and the related water absorption of biochar depend on the kind of biochar that has to be investigated. Biochar incorporated in the seed coating should not be sold commercially. Only for research can, in some cases, such a preparation be excluded (Panwar & Pawar, 2020).

Wet Seed Coating Techniques

Wet bulk-seed coating of biochar has become a particularly common method of application due to lower levels of dust and simple, upscaled methods of application. Wet seed coating generally employs a slurry of biochar mixed with water and glue that is made into a thick liquid which curtains over and sticks to the seed. Pre-drying granular biochar does not solve problems of dust as the process increases biochar brittleness and dust production when seeds are coated. Dust reduction is important during handling and planters' health and safety concerns. Wet coating has become popular as it is simple and upscalable for commercial application. The process of coating can be manual, but for large quantities of seeds, specialized coating machines are required, which are expensive (Bayer, 2020).

Wet-seed coating is simple as the slurry easily spreads out to provide good coverage, but the slurry must remain viscous long enough for the seed to leave the coating chamber and not run off. Wet coating of biochar and treatment addition may offer further advantages. Wet coating of seed has two coat systems for seeds. In the first method, the biochar feedstocks can be artificially mixed with glue producing a biochar-only coating, or mixed in a second phase to glue to add further fertilizer and treatments as appropriate (Wang et al.2022). The wet coating equipment exerts no air pressure and sits atop a soft plugging material and has proven to be delicate enough to sit atop many seeds of differing shape, size, and mass. If applied with gravity alone, it has grown over time from its original design, working a 4-tined type gadget which swept through a drum acting as a blinding barrel wherein the seeds and slurry mixture were married. The system is not universally adaptable, and some tender seeds are squashed or abraded, and cooling time is essential. The possibility of seed damage is the biggest downside of this option, and factors such as seed hardness, adhesive viscosity, and drying time of the biochar will all affect the consequences of coating. Other factors such as drying/hardening time of the adhesive, seed size and shape, and viscosity of the adhesive will also affect coating effectiveness (ME Trenkel, 2021).

Seed size and shape will dictate the setting through which the coated seeds pass; therefore, it is not commonly used for golf courses. The advantages are that it is inexpensive, liquid-adhesive formulations are straightforward, do not contain any dust requirements or concerns, are highly effective due to the wet adhesion of the biochar to the seed, lend themselves easily to mixing with micronutrients/herbicide applications due to this physical characteristic, and maintain bioefficacy by facilitating germination wherever the nutrients are in the soil solution (Zhang et al.2022). Water absorbance capacity and water holding are minimal, and it could otherwise be subjected to increased application rates. The method has some good statistical significance in all categories for biochar + seeds as well as directly sown crops. This is a simple but low-volume method, but for the high stakes approach of premium-grade seeds.

When included in coatings, the biochar should be at an application rate of 25-30%, particularly if multiple pre-inoculates are used (An et al.2021).

Future Directions and Conclusion

Future Directions Although this article provides encouraging evidence of biochar's potential as a seed coating in specific agricultural settings, large gaps remain in our understanding and applicability. More research is needed to better understand the role of modified biochars as seed coatings in additional agricultural settings. Additional research is needed to develop an optimum mixture of biochar and coating material for application to a wide variety of seed types. Systematic data-based evidence from in-the-field trials will be essential for gaining a better understanding of how biochar as a seed coating contributes to local yield increase potential, while also leading to gains in soil health and plant growth (Zhang et al.2022). Cultivation practice evaluations are limited to the use of mineral fertilizers, and results may differ with the use of organic farming systems. In addition, experiments to elucidate if and to what extent biochar seed coatings interact with microbiome composition are limited, but besides seed coat content quantification, such experiments should be performed. Furthermore, analysis of persistence in the soil of biochar coatings and the influence on carbon sequestration potential and soil properties is needed (Zhang et al.2022).

Understanding the scalability and limitations of biochar seed coatings with regard to different settings is critical for improving and adapting the technology to meet the demand of different stakeholders. As with any new agricultural system, farmer education activities will be necessary for disseminating knowledge about biochar seed coatings, providing verification of product quality or effectiveness and fostering interaction with key stakeholders to ensure co-learning and continuous improvement (Sohail et al., 2022). Regulatory considerations regarding the use of biochar in seed coatings will need to be addressed. Conclusion: Despite the promising properties of biochar, this sustainable land management tool will not be a "silver bullet" solution for the sequestration of carbon and soil amendment, in general. However, based on the promising results reported in our analysis, we recommend that biochar-coated seeds continue to be explored as a potentially stable biochar storage and application tool. Collaborative approaches among researchers, policymakers, and farmers would be crucial for advancing the development of biochar-coated seeds, providing concrete and optimized results for multiple agricultural settings, as well as advocating for systemic and sustainable agricultural practices (Joseph et al.2021).

References:

Afzal, I., Javed, T., Amirkhani, M., & Taylor, A. G. (2020). Modern seed technology: Seed coating delivery systems for enhancing seed and crop performance. Agriculture. mdpi.com

Bolan, N., Hoang, S. A., Beiyuan, J., Gupta, S., Hou, D., Karakoti, A., ... & Van Zwieten, L. (2022). Multifunctional applications of biochar beyond carbon storage. International Materials Reviews, 67(2), 150-200. [HTML]

Alfattani, R., Shah, M. A., Siddiqui, M. I. H., Ali, M. A., & Alnaser, I. A. (2021). Bio-char characterization produced from walnut shell biomass through slow pyrolysis: sustainable for soil amendment and an alternate bio-fuel. Energies. mdpi.com

Nidheesh, P. V., Gopinath, A., Ranjith, N., Akre, A. P., Sreedharan, V., & Kumar, M. S. (2021). Potential role of biochar in advanced oxidation processes: a sustainable approach. Chemical Engineering Journal, 405, 126582. [HTML]

Mawar, R., Manjunatha, B. L., & Kumar, S. (2021). Commercialization, diffusion and adoption of bioformulations for sustainable disease management in Indian arid agriculture: prospects and challenges. Circular Economy and Sustainability. springer.com

Javed, T., Afzal, I., Shabbir, R., Ikram, K., Zaheer, M. S., Faheem, M., ... & Iqbal, J. (2022). Seed coating technology: An innovative and sustainable approach for improving seed quality and crop performance. Journal of the Saudi Society of Agricultural Sciences, 21(8), 536-545. sciencedirect.com

Waqas Mazhar, M., Ishtiaq, M., Maqbool, M., Akram, R., Shahid, A., Shokralla, S., ... & Elansary, H. O. (2022). Seed priming with iron oxide nanoparticles raises biomass production and agronomic profile of water-stressed flax plants. Agronomy, 12(5), 982. mdpi.com

Wang, L., Ok, Y. S., Tsang, D. C., Alessi, D. S., Rinklebe, J., Wang, H., ... & Hou, D. (2020). New trends in biochar pyrolysis and modification strategies: feedstock, pyrolysis conditions, sustainability concerns and implications for soil amendment. Soil Use and Management, 36(3), 358-386. wiley.com

Tan, X. F., Zhu, S. S., Wang, R. P., Chen, Y. D., Show, P. L., Zhang, F. F., & Ho, S. H. (2021). Role of biochar surface characteristics in the adsorption of aromatic compounds: Pore structure and functional groups. Chinese Chemical Letters, 32(10), 2939-2946. [HTML]

Razzaghi, F., Obour, P. B., & Arthur, E. (2020). Does biochar improve soil water retention? A systematic review and meta-analysis. Geoderma. [HTML]

Sri Shalini, S., Palanivelu, K., Ramachandran, A., & Raghavan, V. (2021). Biochar from biomass waste as a renewable carbon material for climate change mitigation in reducing greenhouse gas emissions—a review. Biomass Conversion and Biorefinery, 11(5), 2247-2267. greeninstitute.ng

Silva, R. V., Gonçalves, A. D., Vinhal, J. O., Cassella, R. J., Santos, R. C., Dal Sasso, M. A., ... & Romeiro, G. A. (2021). Bioproducts from the pyrolysis of castor seed cake: basic dye adsorption capacity of biochar and antifungal activity of the aqueous phase. Journal of Environmental Chemical Engineering, 9(1), 104825. [HTML]

Jahan, S., Iqbal, S., Rasul, F., & Jabeen, K. (2020). Efficacy of biochar as soil amendments for soybean (Glycine max L.) morphology, physiology, and yield regulation under drought. Arabian Journal of Geosciences. academia.edu

Zhang, K., Han, X., Fu, Y., Zhou, Y., Khan, Z., Bi, J., ... & Luo, L. (2023). Biochar Coating as a cost-effective Delivery Approach to promoting seed quality, Rice Germination, and Seedling Establishment. Plants, 12(22), 3896. mdpi.com

Joseph, S., Cowie, A. L., Van Zwieten, L., Bolan, N., Budai, A., Buss, W., ... & Lehmann, J. (2021). How biochar works, and when it doesn't: A review of mechanisms controlling soil and plant responses to biochar. Gcb Bioenergy, 13(11), 1731-1764. wiley.com

Zhang, X., Fang, Q., Zhang, T., Ma, W., Velthof, G. L., Hou, Y., ... & Zhang, F. (2020). Benefits and trade-offs of replacing synthetic fertilizers by animal manures in crop production in China: A meta-analysis. Global change biology, 26(2), 888-900. researchgate.net

Uslu, O. S., Babur, E., Alma, M. H., & Solaiman, Z. M. (2020). Walnut shell biochar increases seed germination and early growth of seedlings of fodder crops. Agriculture. mdpi.com

Li, Q., Wang, M., Fu, Q., Li, T., Liu, D., Hou, R., ... & Ji, Y. (2020). Short-term influence of biochar on soil temperature, liquid moisture content and soybean growth in a seasonal frozen soil area. Journal of Environmental Management, 266, 110609. [HTML]

An, X., Wu, Z., Qin, H., Liu, X., He, Y., Xu, X., ... & Yu, B. (2021). Integrated co-pyrolysis and coating for the synthesis of a new coated biochar-based fertilizer with enhanced slow-release performance. Journal of Cleaner Production, 283, 124642. [HTML]

Wang, C., Luo, D., Zhang, X., Huang, R., Cao, Y., Liu, G., ... & Wang, H. (2022). Biochar-based slow-release of fertilizers for sustainable agriculture: A mini review. Environmental Science and Ecotechnology, 10, 100167. sciencedirect.com

Rasuli, F., Owliaie, H., Najafi-Ghiri, M., & Adhami, E. (2022). Effect of biochar on potassium fractions and plant-available P, Fe, Zn, Mn and Cu concentrations of calcareous soils. Arid Land Research and Management, 36(1), 1-26. [HTML]

Haider, G., Joseph, S., Steffens, D., Müller, C., Taherymoosavi, S., Mitchell, D., & Kammann, C. I. (2020). Mineral nitrogen captured in field-aged biochar is plant-available. Scientific reports, 10(1), 13816. nature.com

Gou, Z., Zheng, H., He, Z., Su, Y., Chen, S., Chen, H., ... & Sun, Y. (2023). The combined action of biochar and nitrogen-fixing bacteria on microbial and enzymatic activities of soil N cycling. Environmental Pollution, 317, 120790. [HTML]

Suhag, R., Kumar, N., Petkoska, A. T., & Upadhyay, A. (2020). Film formation and deposition methods of edible coating on food products: A review. Food Research International, 136, 109582. academia.edu

Troyano, J., Çamur, C., Garzón-Tovar, L., Carné-Sánchez, A., Imaz, I., & Maspoch, D. (2020). Spray-drying synthesis of MOFs, COFs, and related composites. Accounts of chemical research, 53(6), 1206-1217. csic.es

Chrysargyris, A., Prasad, M., Kavanagh, A., & Tzortzakis, N. (2020). Biochar type, ratio, and nutrient levels in growing media affects seedling production and plant performance. Agronomy. mdpi.com

Guo, C., Shen, Y., & Shi, F. (2020). Effect of Temperature, Light, and Storage Time on the Seed Germination of Pinus bungeana Zucc. ex Endl.: The Role of Seed-Covering Layers and Abscisic Acid …. Forests. mdpi.com

Xu, Z., Zhang, B., Wang, T., Liu, J., Mei, M., Chen, S., & Li, J. (2023). Environmentally friendly crab shell waste preparation of magnetic biochar for selective phosphate adsorption: Mechanisms and characterization. Journal of Molecular Liquids, 385, 122436. [HTML]

Ivanova, N., Obaeed, G. L. O., Sulkarnaev, F., Buchkina, N., Gubin, A., & Yurtaev, A. (2023). Effect of biochar aging in agricultural soil on its wetting properties and surface structure. Biochar, 5(1), 75. springer.com

Panwar, N. L. & Pawar, A. (2020). Influence of activation conditions on the physicochemical properties of activated biochar: A review. Biomass Conversion and Biorefinery. [HTML]

Bayer, I. S. (2020). Superhydrophobic coatings from ecofriendly materials and processes: a review. Advanced Materials Interfaces. wiley.com

ME Trenkel, T. (2021). Slow-and controlled-release and Stabilized Fertilizers: an option for enhancing nutrient use effiiency in agriculture. upertis.ac.id

Zhang, K., Khan, Z., Yu, Q., Qu, Z., Liu, J., Luo, T., ... & Luo, L. (2022). Biochar coating is a sustainable and economical approach to promote seed coating technology, seed germination, plant performance, and soil health. Plants, 11(21), 2864. mdpi.com

Sohail, M., Pirzada, T., Opperman, C. H., & Khan, S. A. (2022). Recent advances in seed coating technologies: transitioning toward sustainable agriculture. Green Chemistry. [HTML]

TRANSGENİK BİTKİ BAZLI YENİLEBİLİR AŞILAR ÜZERİNE: BİBLİYOMETRİK BİR ANALİZ
A BIBLIOMETRIC ANALYSIS ON TRANSGENIC PLANT-BASED EDIBLE VACCINES

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ÖZET

Yenilebilir aşılar, transgenik bitkiler kullanılarak üretilen antijenler aracılığıyla bağışıklık oluşturmayı amaçlayan yenilikçi bir teknoloji olarak karşımıza çıkmaktadır. Bu yaklaşım, özellikle düşük gelirli ve gelişmekte olan ülkelerde sağlık hizmetlerine erişimi kolaylaştırmakta, lojistik ve maliyet sorunlarına alternatif bir çözüm sunmaktadır. Geleneksel aşı yöntemlerinin yerini alabilecek bu teknoloji, çevre dostu üretim süreçleri ve yüksek verimlilik avantajlarıyla dikkat çekmektedir. Bununla birlikte, üretim süreçlerindeki kalite kontrol zorlukları ve düzenleyici engeller, teknolojinin benimsenmesi önündeki temel engeller arasında yer almaktadır. Bu çalışmada, transgenik bitki bazlı yenilebilir aşılara yönelik bilimsel literatür, bibliyometrik analiz yöntemleriyle incelenmiştir. Çalışmanın amacı, bu alandaki araştırma eğilimlerini, kilit katkıda bulunanları ve uluslararası iş birliği ağlarını ortaya koyarak bilimsel ilerlemeye ışık tutmaktır. 1996-2024 yıllarını kapsayan analizde, Scopus veri tabanından elde edilen 289 doküman, VOSviewer ve R programı kullanılarak değerlendirilmiştir. Analiz sonuçları, "transgenic plant" ve "edible vaccine" gibi anahtar kelimelerin araştırma odağında yer aldığını ve ABD, Çin, Hindistan gibi ülkelerin bu alanda lider olduğunu göstermektedir. Türkiye'nin ise uluslararası iş birliklerinde giderek artan bir rol oynadığı tespit edilmiştir. Elde edilen bulgular, yenilebilir aşıların düşük maliyetli üretim potansiyelinin yanı sıra, lojistik ve çevresel avantajlarını ortaya koyarken, bu alandaki bilimsel boşlukları da tespit etmektedir. Çalışma, transgenik bitkilerden elde edilen yenilebilir aşıların gelecekteki aşı teknolojileri ve sağlık çözümleri için sunduğu olanakları anlamaya yönelik değerli bir rehber sunmaktadır. Ayrıca, uluslararası iş birliklerinin güçlendirilmesi ve

bu yenilikçi teknolojinin küresel ölçekte benimsenmesine yönelik stratejilerin geliştirilmesi için önemli çıkarımlar sağlamaktadır.
Anahtar kelimeler: Transgenik bitki,Yenilebilir aşı,Bibliyometrik analiz, Antijen üretimi

ABSTRACT
Edible vaccines are an innovative technology that aims to create immunity through antigens produced using transgenic plants. This approach facilitates access to healthcare services, especially in low-income and developing countries, and offers an alternative solution to logistical and cost problems. This technology, which could replace traditional vaccination methods, stands out with its environmentally friendly production processes and high efficiency advantages. However, quality control challenges in production processes and regulatory hurdles are among the main barriers to adoption. In this study, the scientific literature on transgenic plant-based edible vaccines was reviewed using bibliometric analysis methods. The aim of the study is to shed light on scientific progress by revealing research trends, key contributors and international collaboration networks in this field. In the analysis covering the years 1996-2024, 289 documents obtained from the Scopus database were evaluated using VOSviewer and R program. The results of the analysis show that keywords such as "transgenic plant" and "edible vaccine" are in the research focus and countries such as the USA, China and India are the leaders in this field. Turkey was found to play an increasing role in international collaborations. The findings reveal the potential for low-cost production of edible vaccines, as well as their logistical and environmental advantages, while identifying scientific gaps in the field. The study provides a valuable guide to understanding the possibilities that edible vaccines from transgenic plants offer for future vaccine technologies and healthcare solutions. It also provides important implications for strengthening international collaborations and developing strategies for the global adoption of this innovative technology.
Keywords: Transgenic plant, Edible vaccine, Bibliometric analysis, Antigen production

GİRİŞ

Yenilebilir aşılar, biyoteknoloji ve tarım bilimlerinde umut verici bir sınırı temsil eden, yenilikçi bir aşı teknolojisidir. Geleneksel aşı üretim yöntemleri, yüksek maliyetler, lojistik zorluklar ve soğuk zincir gereksinimleri gibi önemli sınırlamalara sahiptir. Bunun yerine, transgenik bitkiler kullanılarak üretilen antijenler, düşük maliyetli, çevre dostu ve yüksek verimlilikte bir alternatif sunar (Malabadi, 2008). Yenilebilir aşılar, özellikle düşük gelirli ve gelişmekte olan ülkelerde, tıbbi kaynaklara erişimi sınırlı olan bölgelerde önemli bir çözüm olarak ortaya çıkmaktadır (Kim and Yang, 2010).

Bitki bazlı aşılar, geleneksel iğne ile yapılan aşıların yerine geçebilecek bir çözüm sunar. Bu aşılar, doğrudan tüketim yoluyla bağışıklık oluşturma kapasitesine sahiptir ve bu da iğne kullanımına olan ihtiyacı ortadan kaldırır (Singh et al. 2023). Bitkilerde üretilen antijenlerin uzun raf ömrü ve düşük sıcaklıkta depolama gereksinimleri, bu aşıların daha geniş çapta ve düşük maliyetle dağıtılmasını mümkün kılar. Ayrıca, bitkilerde üretilen antijenlerin stabilitesi ve etkinliği, geleneksel aşılara göre bazı avantajlar sunmaktadır (Jain et al. 2013).

Örneğin, domates bazlı "TOMAVAC" adlı COVID-19 aşısı hem sistemik hem de mukozal bağışıklık tepkilerini artırarak virüse karşı güçlü bir koruma sağlamaktadır. Bu aşı, sadece bitki bazlı bir yöntemle üretilmiş olmasına rağmen, geleneksel aşılara göre daha ucuz ve lojistik olarak daha verimli bir çözüm sunmaktadır (Buriev et al. 2024). Ayrıca; Mısır, patates ve muz gibi transgenik bitkiler, hepatit B ve kolera gibi hastalıklara karşı bağışıklık kazandırmaya yönelik antijenleri ifade edecek şekilde tasarlanmaktadır (Saxena and Rawat, 2014). Bitki biyoteknolojisi ve immünolojinin entegrasyonu sadece aşı geliştirme kapsamını

genişletmekle kalmamış, aynı zamanda seri üretim ve basitleştirilmiş dağıtım potansiyelini de ortaya çıkarmıştır.
Ancak, bitki bazlı aşıların üretimi ve kullanımı, bazı zorluklarla karşı karşıyadır. Çevresel faktörlerin antijen üretimi üzerindeki etkileri, kalite kontrolünün zorluğu ve düzenleyici engeller, bu teknolojilerin geniş çapta kullanılabilirliğini engelleyen başlıca unsurlardır (Aryamvally et al. 2017). Düzenleyici onay süreçlerinin yavaşlığı ve ürünlerin güvenliği gibi faktörler, bu teknolojinin dünya çapında geniş bir şekilde benimsenmesini zorlaştırmaktadır. Bununla birlikte, ilerleyen yıllarda yapılan klinik çalışmalar ve bu alanda yapılan araştırmalar, yenilebilir aşıların büyük bir sağlık çözümü olarak kabul edilmesini sağlayabilir (Tripurani et al. 2003).
Hızla gelişen bu alanı keşfederken bibliyometrik analiz, bilimsel manzarayı değerlendirmek için nicel bir mercek sağlayarak araştırma çıktılarındaki eğilimleri, kilit katkıda bulunanları ve iş birliği ağlarını ortaya çıkarır (Donthu et al. 2021). Bu çalışma, bibliyometrik verilerin görselleştirilmesini ve istatistiksel analizini sağlayan VOSviewer ve R gibi araçlar aracılığıyla transgenik bitki bazlı yenilebilir aşılara yönelik akademik odağı değerlendirmeyi amaçlamaktadır.
"Transgenik bitki", 'yenilebilir aşı' ve 'bibliyometri' gibi anahtar kelimeler, ilgili literatürün sistematik olarak çıkarılmasını kolaylaştırarak bu analizin bel kemiğini oluşturmaktadır. VOSviewer ve R gibi araçlar, anahtar kelime eş-oluşumlarının ve tematik gelişimin net bir şekilde görselleştirilmesini sağlayan bibliyometrik haritaların oluşturulmasında kritik bir rol oynamaktadır.
Sonuç olarak, bu çalışma yenilebilir aşı araştırmalarındaki entelektüel ilerlemenin ve işbirlikçi çabaların haritasını çıkaracaktır. Atıf ağlarını ve tematik kümeleri analiz ederek, bu bibliyometrik araştırma etkili yayınları vurgulayacak, bilgi boşluklarını belirleyecek ve gelecekteki araştırma yönlerini önerecektir. Bulgular, politika yapıcılara, bilim insanlarına ve endüstri liderlerine iş birliğini teşvik etmede ve bitki bazlı aşıların benimsenmesini hızlandırmada yardımcı olacaktır.

MATERYAL ve YÖNTEM

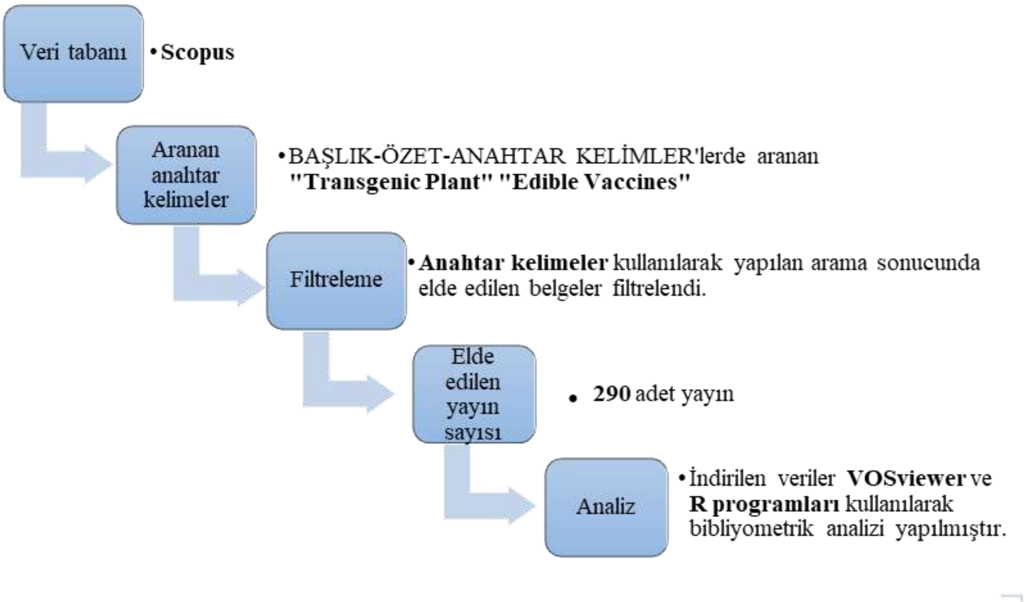
Bu çalışma, transgenik bitki bazlı yenilebilir aşılar konusundaki bilimsel literatürü incelemek ve bu alandaki araştırma trendlerini belirlemek amacıyla yapılmıştır. Bibliyometrik analiz için, Scopus veri tabanı kullanılarak "Transgenic Plant" ve "Edible Vaccines" anahtar kelimeleriyle 1996-2024 yıllarını kapsayan bir arama gerçekleştirilmiştir. Yalnızca İngilizce dilindeki makaleler, derlemeler, konferans bildirileri ve kitap bölümleri analize dahil edilmiştir. Bu seçim, uluslararası iş birliği ve bilimsel etkinliklerin daha iyi değerlendirilmesini sağlamıştır.

Yöntem

Elde edilen 290 yayın, atıf analizleri, anahtar kelime eş-oluşumları ve uluslararası iş birliklerini değerlendirmek için analiz edilmiştir. Analiz sürecinde kullanılan araçlar ve yöntemler şu şekildedir:

VOSviewer: Atıf ağlarının, anahtar kelime eş-oluşumlarının ve tematik kümelerin görselleştirilmesi için tercih edilmiştir. Bu araç, bibliyometrik verilerin grafiksel sunumunda geniş çapta kabul görmektedir.

R Programı ve Bibliometrix Paketi: Yayınların yıllara göre dağılımı, ülkeler arası iş birlikleri ve anahtar kelime trendlerinin analizinde kullanılmıştır. Bibliometrix'in web tabanlı arayüzü olan "Biblioshiny", interaktif görselleştirme ve istatistiksel analizler için kullanılmıştır.



Şekil 1. Bibliyometrik analiz için veri indirme şeması

Veri toplama ve analiz süreçleri, Şekil 1'de görselleştirilmiştir. Çalışmada kullanılan analiz türleri ve bu türlerin sağladığı çıktılar ise Çizelge 1'de detaylandırılmıştır.

Çizelge 1. Çalışmada kullanılan R ve Vosviwer analiz çeşitleri

VOSviewer	R
	Yayınlar hakkında ana bilgiler
En çok atıf alan ülkelerin analizi	Yayınların yıllara göre dağılımı
En çok atıf alan dergiler analizi	Ülkelerin iş birliği
Anahtar kelime analizleri	En fazla çalışma yapan yazarlar
	Yazarların üretkenlik zamanları
	Anahtar kelimelerin tekrar durumları

BULGULAR

Genel Veriler

Bu çalışmada, 1996-2024 yılları arasında transgenik bitki bazlı yenilebilir aşılar konusundaki literatür analiz edilmiştir. 178 farklı kaynaktan 289 doküman incelenmiş ve dokümanların ortalama yaşı 14,4 yıl olarak hesaplanmıştır. Doküman başına düşen ortalama atıf sayısı 40,24'tür. Araştırmalarda 991 farklı yazarın katkıda bulunduğu ve toplamda 2532 anahtar kelimenin kullanıldığı belirlenmiştir. Doküman başına ortalama yazar sayısı 4,75 iken, uluslararası ortak yazarlık oranı %13,49 olarak tespit edilmiştir.

Doküman türleri incelendiğinde, 180 araştırma makalesi (%62,28) en yaygın doküman türü olarak öne çıkarken, derleme makaleler (%26,30), kitap bölümleri (%5,53) ve kongre bildirileri (%3,80) de önemli katkılar sağlamaktadır (Çizelge 2).

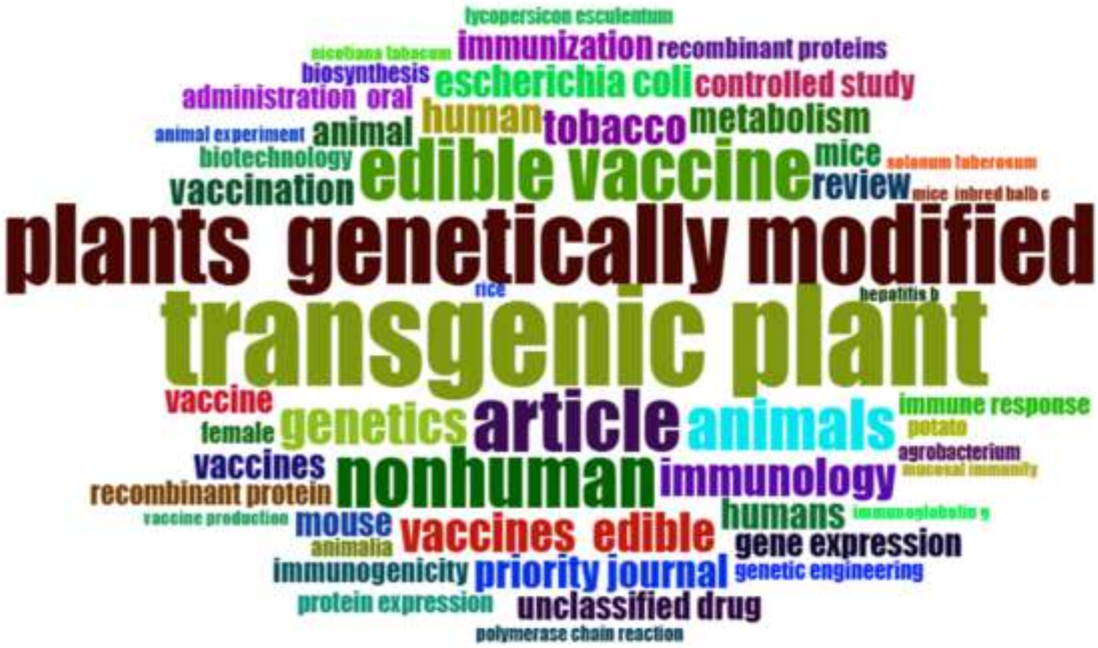
Çizelge 2. Transgenik bitki tabanlı yenilebilir aşı çalışmaları ile ilgili genel veriler

Veriler Hakkında Ana Bilgiler	Sonuçlar
Zaman aralığı	1996:2024
Kaynaklar (Dergiler, Kitaplar, vb.)	178
Belge	289
Yıllık büyüme oranı %	0
Belge ortalama yaşı	14,4
Doküman başına ortalama atıf	40,24

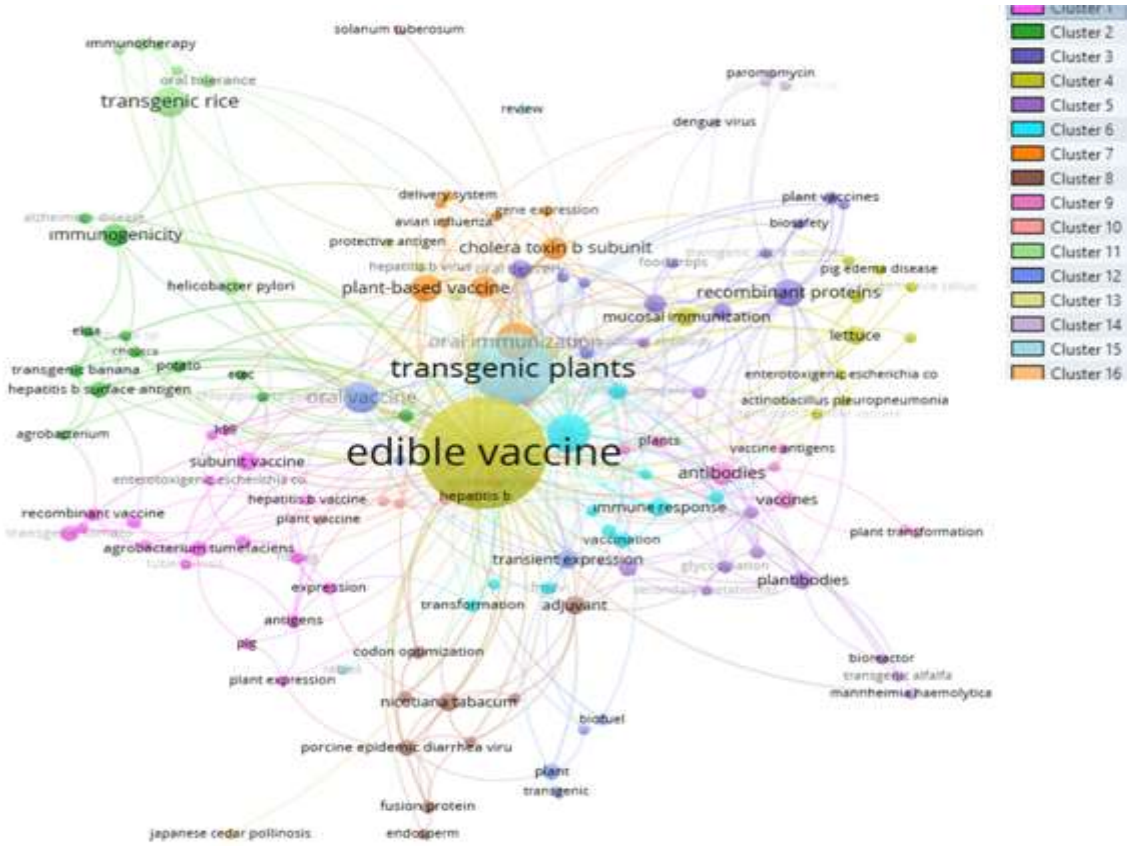
Anahtar Kelimeleri	2532
Yazarlar	991
Tek yazarlı dokümanlar	25
Doküman başına ortak yazarlar	4,75
Uluslararası ortak yazarlıklar %	13,49
Yayın Türleri	
Makale	180
Kitap	1
Kitap Bölümü	16
Kongre bildirisi	11
Derleme makale	76

Anahtar Kelime Analizleri ve Tematik Kümeler
Araştırmada, toplamda 2532 anahtar kelimenin kullanıldığı belirlenmiştir. En sık kullanılan anahtar kelimeler şunlardır:

- **"Transgenic Plant" (227 kez)**: Bu anahtar kelime, yenilebilir aşıların üretiminde kullanılan teknolojik yaklaşımları temsil etmektedir.
- **"Genetically Modified Plants" (178 kez)** ve **"Edible Vaccines" (140 kez)**: Bu kelimeler, araştırma odaklarını ve bilimsel eğilimleri ortaya koymaktadır.
- Diğer öne çıkan anahtar kelimeler: **"Genetics" (97 kez), "Immunology" (86 kez) ve "Tütün" (80 kez)**.



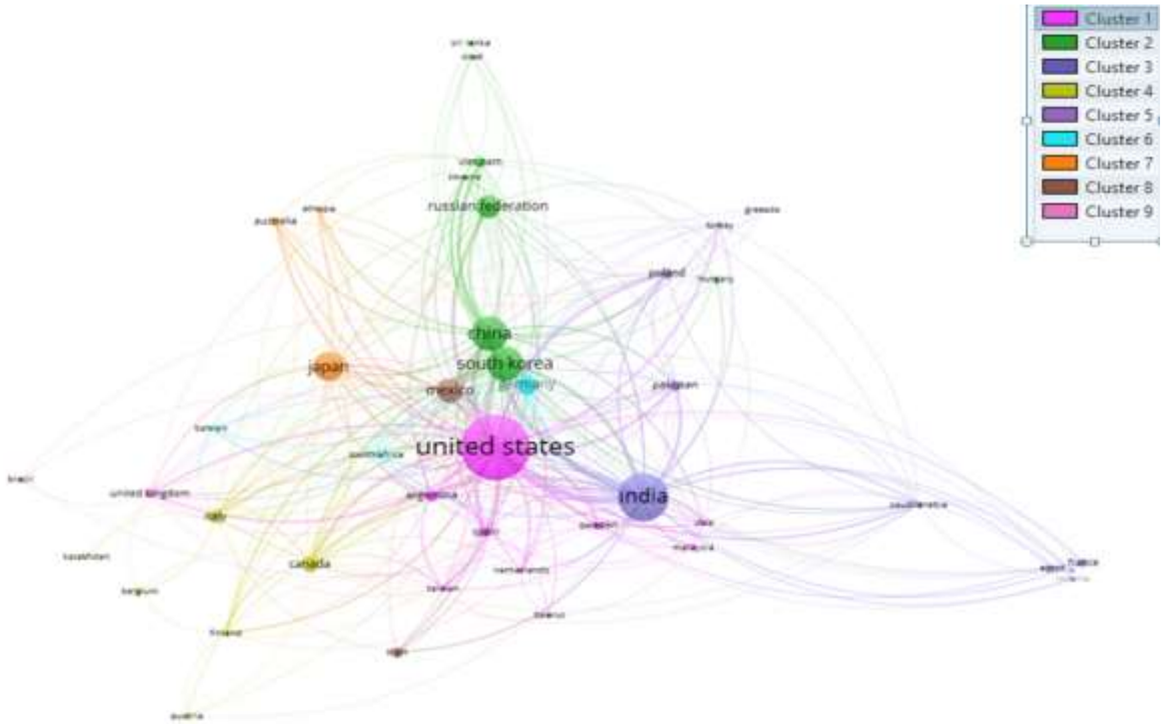
Şekil 2. En fazla kullanılan anahtar kelimeler
Anahtar kelime eş-oluşum analizine göre, 16 tematik küme oluşturulmuştur. Bu kümelerde **"transgenic plant"** ve **"edible vaccines"** anahtar kelimelerinin ağın merkezinde yer aldığı görülmektedir. Ayrıca, **"recombinant proteins" 'plant-based vaccines'** ve **"oral vaccine"** gibi kavramların tematik çeşitlilik sağladığı ve disiplinler arası bir yapıyı yansıttığı tespit edilmiştir (Şekil 2 ve Şekil 3).



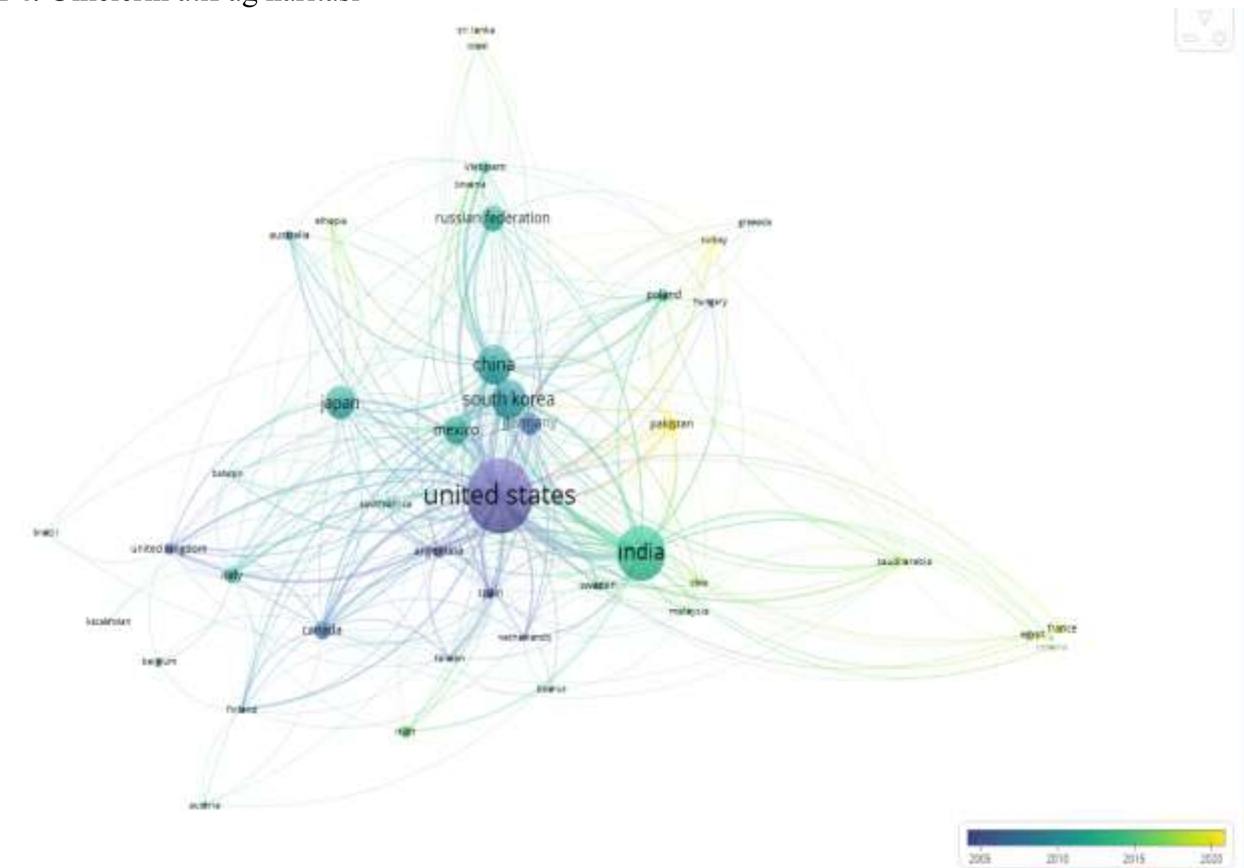
Şekil 3. Anahtar kelime eş-oluşum analizi

Ülkeler Arası İş birliği ve Atıf Haritası

Ülkeler arasında dokuz ana küme belirlenmiştir. Atıf ağı haritasında, ABD'nin ağın merkezinde yer aldığı ve Çin, Hindistan, Japonya, Almanya ve Kanada gibi ülkelerle güçlü iş birlikleri yaptığı tespit edilmiştir. Türkiye'nin Hindistan liderliğindeki bir kümede yer alması, uluslararası iş birliklerinin geliştirilmesi için fırsatlar sunduğunu göstermektedir. Türkiye'nin özellikle Fransa ve Pakistan gibi ülkelerle yakın çalışmalarda bulunduğu ve bu ilişkilerin bilimsel katkıları artırabileceği öngörülmüştür (Şekil 4 ve Şekil 5).



Şekil 4. Ülkelerin atıf ağ haritası



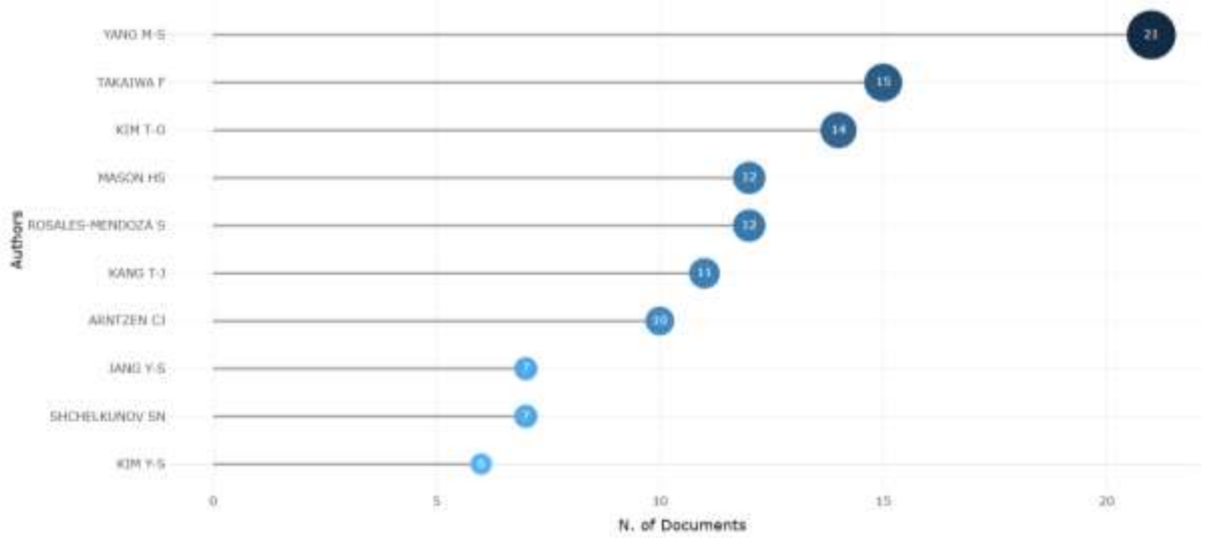
Şekil 5. Ülkelerin Zaman Haritası

Yazar Analizleri ve Üretkenlik

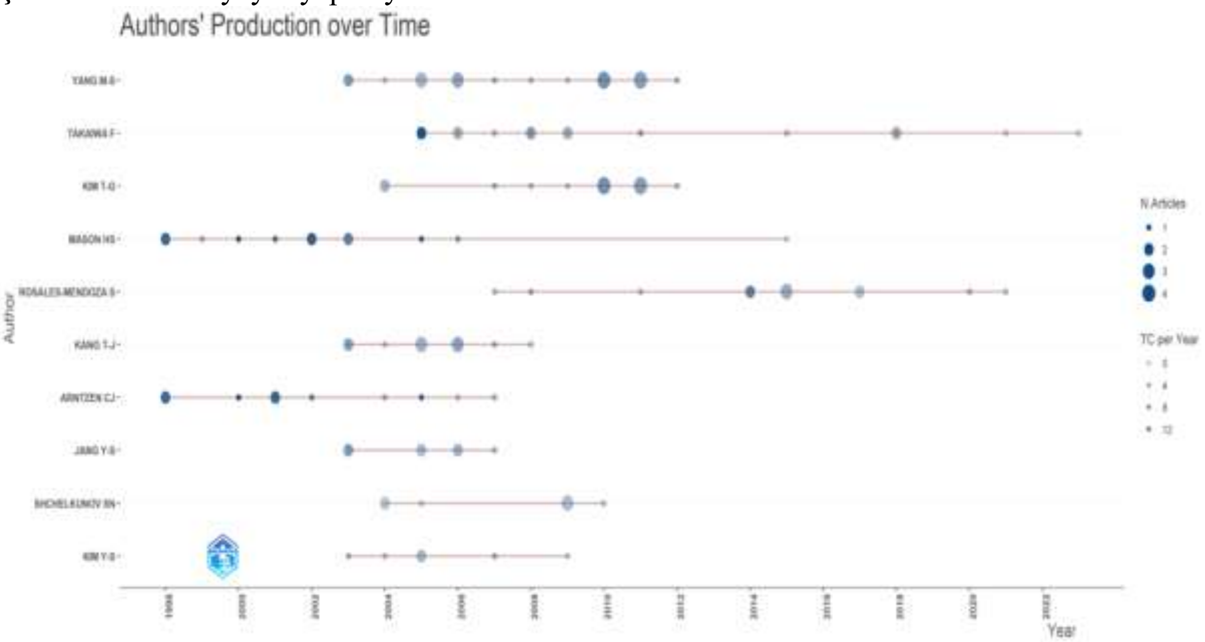
Araştırmada, en fazla yayın yapan yazarlar şunlardır:

- **Yang MS (21 yayın)**, **Takaiwa F (15 yayın)** ve **Kim TG (12 yayın)**: Bu yazarlar, bitki tabanlı aşıların üretimi ve etkinliği üzerine odaklanmıştır.
- **Mason HS** ve **Rosales-Mendoza S**: Bu yazarların geniş bir kapsama sahip yenilikçi çalışmaları, alanın ilerlemesine katkı sağlamıştır.

Yazarların üretkenlik zamanlarına bakıldığında, Takaıwa F'nin 2005-2023 yılları arasında, Mason HS'nin 1998-2015 yılları arasında aktif olduğu tespit edilmiştir. Bu durum, bu yazarların alandaki uzun vadeli katkılarını göstermektedir (Şekil 6 ve Şekil 7).



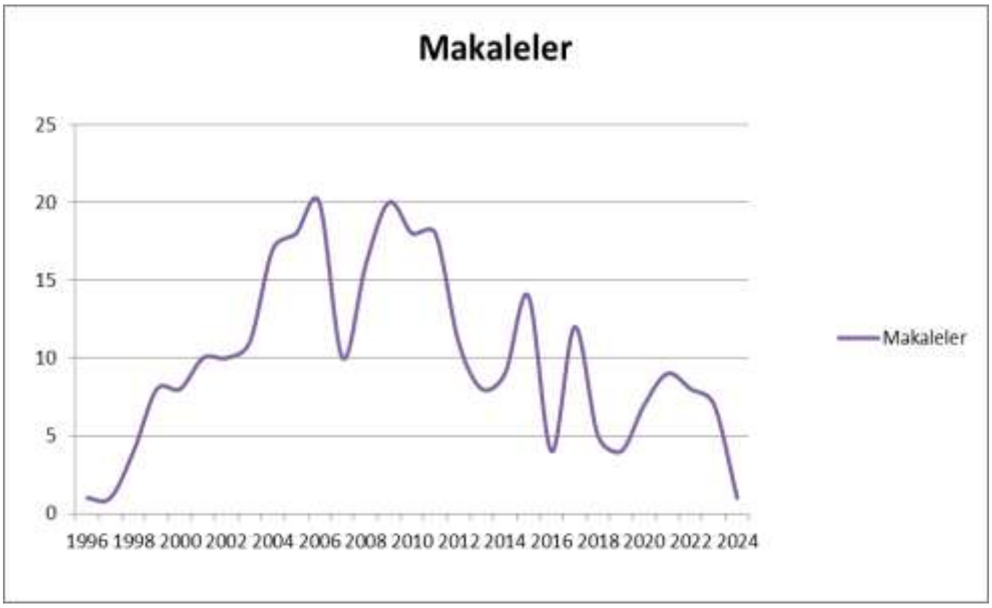
Şekil 6. En fazla yayın yapan yazarlar



Şekil 7. Yazarların üretkenlik zamanları

Yıllara Göre Yayın Dağılımı

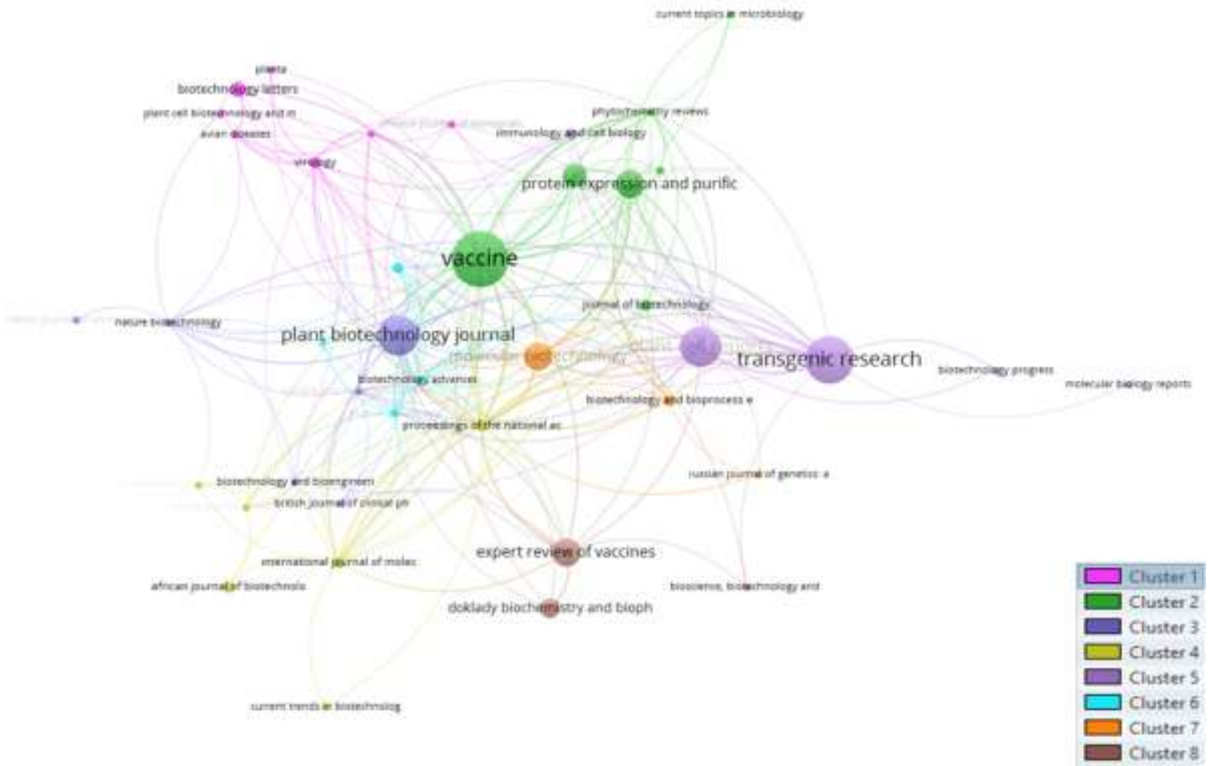
1996-2024 yılları arasında yapılan çalışmalar incelendiğinde, yayın sayılarında dalgalanmalar olduğu görülmüştür. En yüksek yayın sayısına 2006 ve 2009 yıllarında ulaşılmıştır (20 yayın). Ancak, son yıllarda yayın sayılarında azalma olduğu ve bu durumun bilimsel ilginin yeniden canlandırılmasını gerektirdiği belirlenmiştir. Bu dalgalanmalar, biyoteknolojik gelişmeler ve küresel sağlık sorunları ile ilişkilendirilebilir (Şekil 8).



Şekil 8. Transgenik Bitki Tabanlı Yenilebilir Aşılar ile ilgili yayınların yıllara göre sayısı

Dergi Analizleri

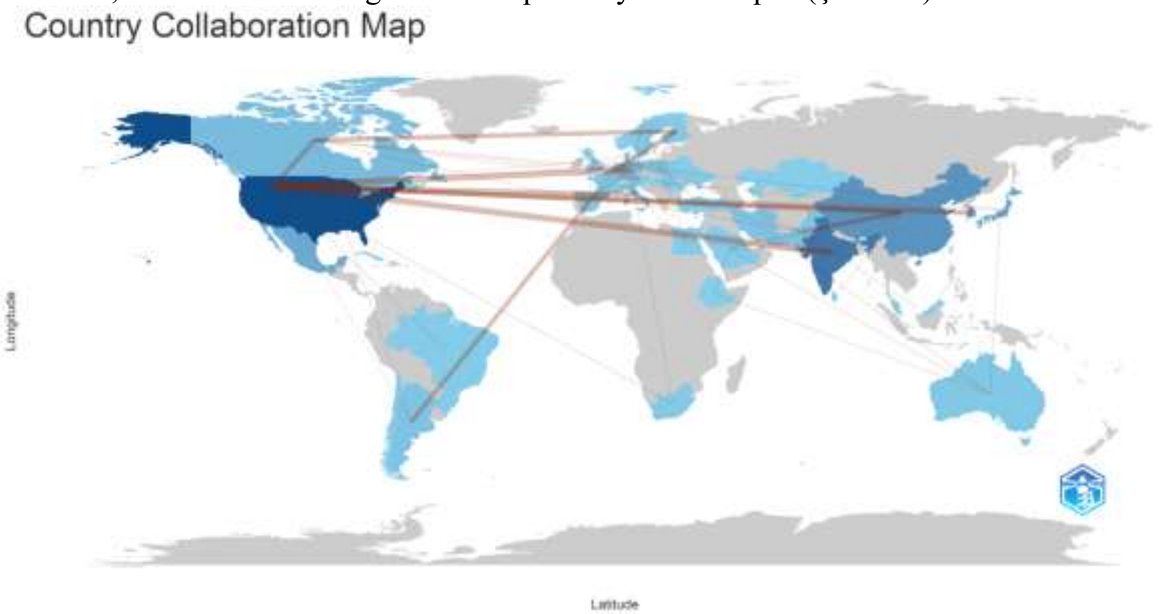
En fazla atıf alan dergiler arasında Vaccine, Plant Biotechnology Journal ve Transgenic Research öne çıkmaktadır. Bunun yanı sıra, Molecular Biotechnology ve Plant Cell, Tissue and Organ Culture gibi dergiler de alandaki önemli yayın platformlarıdır. Ancak, bazı dergilerin (örneğin, Current Topics in Microbiology and Immunology) atıf ağlarında daha uzak konumlarda yer aldığı tespit edilmiştir (Şekil 9).



Şekil 9. Dergilerin atıf ağ haritası

Uluslararası Ortak Yayınlar

Araştırmada, ABD, Almanya, Çin, Hindistan ve Kanada gibi ülkelerin çift taraflı ortak yayınlar yaptığı tespit edilmiştir. Örneğin, ABD'nin Almanya ve Hindistan ile 3'er ortak yayını bulunmaktadır. Türkiye'nin, Hindistan kümesi içindeki konumu ve diğer ülkelerle iş birlikleri, bu alandaki etkinliğini artırma potansiyeline sahiptir (Şekil 10).



Şekil 10. Ülkelerin ortak yayın haritası

SONUÇ

Sonuç olarak, transgenik bitki bazlı yenilebilir aşılar, özellikle düşük maliyet, lojistik avantajlar ve çevre dostu üretim süreçleri sayesinde geleneksel aşılara güçlü bir alternatif sunmaktadır. Bu çalışmada, 1996-2024 yılları arasındaki bilimsel yayınlar bibliyometrik analiz yöntemleriyle incelenmiş ve toplamda 289 doküman, 991 yazar ve 2532 anahtar kelimenin yer aldığı kapsamlı bir değerlendirme yapılmıştır. Analizler, "transgenik bitki" ve "yenilebilir aşı" gibi anahtar kelimelerin ağ merkezinde yer aldığını, bu alandaki araştırmaların belirgin bir şekilde tematik kümelere ayrıldığını göstermiştir.

Araştırma bulguları, ABD, Çin ve Hindistan gibi ülkelerin bu alandaki liderliğini ortaya koyarken, Türkiye'nin de Hindistan liderliğindeki bir kümede önemli bir yere sahip olduğunu göstermiştir. Özellikle ABD'nin atıf ağının merkezi olması, bu ülkede gerçekleştirilen öncü çalışmaların etkisini vurgulamaktadır. Bununla birlikte, yenilebilir aşı araştırmalarında son yıllarda bir azalma olduğu ve bu alandaki bilimsel ilginin yeniden canlandırılması gerektiği tespit edilmiştir.

Gelecekteki çalışmaların, yenilebilir aşıların klinik etkinliğini artırmaya, transgenik bitkilerde antijen üretim süreçlerini iyileştirmeye ve düzenleyici çerçeveleri geliştirmeye odaklanması önemlidir. Bu bibliyometrik analiz, yenilebilir aşı teknolojilerinin bilimsel ve uygulamalı yönlerini değerlendirmek için kapsamlı bir temel sunmuş ve gelecekteki araştırma ve politikalar için rehberlik sağlayacağı düşünülmektedir.

KAYNAKÇA

Aryamvally, A., Gunasekaran, V., Narenthiran, K. R., & Pasupathi, R. (2017). New strategies toward edible vaccines: An overview. Journal of Dietary Supplements, 14(1), 101-116.

Buriev, Z. T., Shermatov, S. E., Usmanov, D. E., Mirzakhmedov, M. K., Ubaydullaeva, K. A., Kamburova, V. S., ... & Abdurakhmonov, I. Y. (2024). Tomato-made edible COVID-19 vaccine TOMAVAC induces neutralizing IgGs in the blood sera of mice and humans. Frontiers in Nutrition, 10, 1275307.

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. Journal of business research, 133, 285-296.

Jain, A., Saini, V., & Veer Kohli, D. (2013). Edible transgenic plant vaccines for different diseases. Current pharmaceutical biotechnology, 14(6), 594-614.
Kim, T. G., & Yang, M. S. (2010). Current trends in edible vaccine development using transgenic plants. Biotechnology and Bioprocess Engineering, 15, 61-65.
Malabadi, R. B. (2008). Production of edible vaccines for oral immunization in transgenic plants, current and future prospectives.
Singh, S., Singh, P. K., Sachan, K., Garg, S., & Sharma, A. N. (2023). Recent Progress and Challenges in the Development of Edible Vaccines Produced by Genetically Modified Plants. Current Protein and Peptide Science, 24(9), 711-720.
Saxena, J., & Rawat, S. (2014). Edible vaccines. Advances in biotechnology, 207-226.
Tripurani, S. K., Reddy, N. S., & Rao, K. S. (2003). Green revolution vaccines, edible vaccines. African Journal of Biotechnology, 2(12), 679-683.

OPPORTUNITIES AND THREATS IN HAZELNUT FARMING IN TURKEY

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ABSTRACT

Hazelnut is a type of hard-shelled fruit and can be stored and kept in stock for a certain period of time. In our country most of it is produced in the Eartern Black Sea Region, and a small amount is producrd in Sakarya, Adapazarı and Düzce provinces.The rainy and humid climate of the Eastern Black Sea Region is very suitable for hazelnut cultivation. Hazelnut cultivatıon has been carried out in our country for about a century. While very little of the hazelnuts produced are consumed in the domestic market, most of them are exported to foreign markets.Hazelnuts are among the top agricultural products exported by our country. With this feature, it bring significant foreing currency to our country. Türkiye accounns for approximately %70 of world's hazelnut production. Accorting to the data World Food Organization, the total production amount of other hazelnut producing countries is only half of Turkey's production. The majority of hazelnuts, %80 of which are chocolate,are used in the confectionary, biscuit, ice cream, pastry and oil industries. Although our country has many adventages. Since we cannot turn these advantages into opportunities, we face many threats. That's why we haven't been able to avoid being the suplier of chocolate companies in European countries for nearly a hundred years. The saddest part is that these countries buy hazelnuts from us, make chocolate and sell it back to us. Despite this, we have always sold shelled hazelnuts for three generations. The grandfather sold shelled hazelnuts, his son sold shelled hazelnuts and the grandson sells shelled hazelnuts. We could not take this one step further and make and sell chocolate from hazelnuts. Hawever, hazelnuts are a products with high added value. An İtalian company buys hazelnuts from Turkey , cocoa from Ghana or Ivory, palm oil from Malaysia and Indonesia and sugar from Brazil and makes a billion- dolar turnover by producing choocolate or a product with high added value that is spread on bread. This company in question, with its three thousand emloyees more than our five million Eastern Black Sea families. In this study the opportinuties and threads in hazelnut production are revealed and how we can turn threads into opportunities is diccussed .

Key Word: Hazelnut Production, Chocolate Making, Creating added Value.

GİRİŞ

Fındık sert kabuklu meyve türlerinden olup belirli bir süre depolanabilen ve stoklarda bekletilebilen bir üründür. Ülkemizde çoğunlukla Doğu Karadeniz Bölgesi'nin sahil şeridinde olmak üzere bir miktar da Sakarya, Adapazarı, Zonguldak ve Düzce illerinde üretilmektedir. Doğu Karadeniz Bölgesi'nin nemli ve yağışlı iklimi fındık yetiştirmek için oldukça uygundur.

Fındık, ceviz ve badem gibi sert kabuklu meyveler enerji değeri yüksek, aynı zamanda vitamin ve mineral yönüyle zengin olduğu için sporcular, işçiler ve zayıf bireyler için önerilen bir besin kaynağıdır. Ayrıca fındığın insanın beslenmesi ve sağlığında mikro element içeriği açısından önemli bir kaynak olduğu bildirilmektedir(Köksal, 2018: 107-110). İçerdiği besin değeri ile sağlıklı beslenmede büyük önem taşımaktadır. Bileşimindeki bitkisel yağda bulunan % 83 oranındaki oleik asidin özelliğinden dolayı fındık yağı donmayan yağlardandır. Bu özelliği ile kalp ve damarlara zarar vermemekte, aksine kanda kolesterolün yükselmesini önleyerek kalp- damar hastalıklarına karşı koruyucu etkisi vardır (Göreci, 2004:31).

Fındık konusunda yapılan bilimsel çalışmalarda görülmüştür ki günümüze kadar sadece gıda sektöründe tüketilen fındık, artık yakın gelecekte sağlık sektöründe de tüketilmeye adaydır. Bilimsel çalışmalardan ortaya çıkan sonuçlarda; kalp, damar, kanser, diyabet, hiper tansiyon, anemi, hafıza kaybı, kemik erimesi, cinsel isteksizlik, siroz, parkinson, depresyon, kronik yorgunluk, uykusuzluk, dikkat eksikliği gibi insanların önemli hastalıkların tedavisinde iyileştirici etki gösterdiği ifade edilmektedir(Erdem, Yamak, Memiş;2004:I).
Ülkemizin fındık üretiminde önemli avantajları olmasına rağmen bir o kadar da dezavantajları vardır. Bu avantajları fırsata çeviremediğimiz için de bir çok tehditlerle karşılaşıyoruz. Bu yüzden de yaklaşık bir asırdır AB ülkelerindeki çikolata şirketlerinin hammadde tedarikçisi olmaktan kurtulamadık. İşin en acı tarafı ise bu ülkelerin bizden aldığı kabuklu ya da iç fındığı çikolata yapıp üç kat belki daha da yüksek bir fiyata tekrar bize satmalarıdır. Bu duruma rağmen biz ise üç nesildir hep kabuklu fındık satıyoruz. Son çeyrek asırdan beri de bir miktar iç fındık satıyoruz. Bunu daha ileri aşamaya getirip fındıktan çikolata yapıp satmayı bir türlü beceremedik. Oysa çikolata yapmak çok zor bir iş olmasa gerek. Fındık çikolata ya da fındık ezmesi yapılarak satılırsa katma değeri yüksek bir ürün haline getirilir.
Bu işi başaran bir İtalyan şirketi; fındığı Türkiye'den, kakaoyu Gana ve Fildişi'nden, palm yağını Malezya ve Endonezya'dan, şekeri Brezilya'dan alıyor ve sonuçta çikolata ya da ekmeğin üzerine sürülen katma değeri yüksek bir ürün üreterek milyar dolarlık ciro yapıyor. Söz konusu bu şirket üç bin personeliyle bizim 5 milyon Doğu Karadeniz Bölgesi'ndeki insanlarımızın toplamından daha çok kazanıyor. Bu durum atalarımızın meşhur sözünü hatırlatıyor: **"İş bilenin kılıç kuşananındır**."
Bu durum karşısında bir girişimcinin, muhasebe, finansman, pazarlama, üretim gibi işletme fonksiyonlarını bilmesinden daha ziyade yönetim ve organizasyon bilgi ve yeteneğine sahip olması gerektiği gerçeği de ortaya çıkıyor. Bir girişimcinin muhasebeyi, finansmanı, üretimi, pazarı bilirse iyi olur. Ama şayet bilmiyorsa bu konuları bilen müdürler çalıştırarak onlara yaptırır. Fakat kendisi yönetim ve organizasyon bilgisine sahip olmalı ve işi yönetmelidir.
Bu çalışmada ülkemizdeki fındık tarımındaki fırsatlar ve tehditler ortaya konarak tehditleri nasıl fırsata çevirebileceğimizin tartışması yapılmaktadır. Çalışmamız bölgede yaşayan, kendisi de üç nesildir fındık üreticisi biri olarak konuyu az çok bilen bir birey olarak gözleme, bilgiye ve tecrübeye dayanan amprik ve nitel bir araştırmadır.

TÜRKİYE'DE VE DÜNYADA FINDIK TARIMI

Ülkemizde fındık üretim alanları birinci bölge Ordu ilinden başlayarak Gürcistan sınırına kadar uzanan Doğu Karadeniz Bölgesi ve ikinci bölge ise Samsun ilinden başlayarak İstanbul'a kadar uzanan Orta ve Batı Karadeniz Bölgesi olarak gruplandırılmaktadır. 01.01.2015 tarihinden itibaren geçerli olmak üzere fındık alanlarının tespitine dair bakanlar kurulu karına göre 16 il (Artvin, Bartın, Düzce, Giresun, Gümüşhane, Kastamonu, Kocaeli, Ordu, Rize, Sakarya, Samsun, Sinop, Trabzon, Zonguldak, Bolu, Tokat) ve bunlara bağlı 132 ilçe yasal fındık alanı olarak ilan edilmiştir (Balık,2016: 9).
Bölgede fındığın geçmişi çok eskilere dayanmasına rağmen bir asrı aşkın bir süredir fındık tarımı yoğun olarak yapılmaktadır. Üretilen fındığın çok azı iç pazarlarda tüketilirken çoğu dış pazarlara ihraç edilmektedir. Fındık ülkemizin ürettiği tarım ürünleri arasında ilk sıralarda yer alır. Bu özelliği nedeniyle de ülkemize önemli ölçüde döviz kazandırır. Yıllara göre değişmekle birlikte Dünya'daki fındık üretiminin yaklaşık % 75'ini Türkiye üretmektedir. Dünya Gıda ve Tarım Örgütü'nün (FAO) verilerine göre fındık üreticisi diğer ülkelerinin üretim miktarlarının toplamı Türkiye'nin üretiminin ancak yarısı kadardır. Bu durumun bir başka boyutu da diğer ülkelerin ürettikleri fındık miktarının kendi ihtiyaçlarını karşılamayıp bizden fındık ithal etmeleridir. Türkiye'den başka Dünya'da fındık az bir miktar ABD, İtalya, İspanya, Gürcistan ve Çin' de yetiştirilmektedir.

Doğu Karadeniz Bölgesi'nde çiftçiler toprak özellikleri ve üretim dönemi faaliyetlerindeki etkenlere bakmaksızın buldukları her yere fındık ağaçları dikmişlerdir. Üretim miktarını artırmak amacıyla bilinçsiz kimyasal gübre ve ilaçlama yapmaktadırlar. Ayrıca miras uygulama yöntemleriyle yaşanan aile içi kavgalar, bölgede fındık bahçelerinin dağınık bir halde olmasına ve her geçen gün küçülmesine neden olmakta ve bu durumdaki bahçelerde modern tarım yöntemlerini uygulamak zorlaşmaktadır (Korkmaz ve Kaya,2022: 22).
Fındık, bütün Dünya'da çok geniş bir tüketim alanına sahiptir. Bu durum ülkemiz için çok önemli bir fırsattır. Çerez olarak tüketildiği gibi, fındık ezmesi, fındık püresi v. b. gibi mamul hale getirilip bu şekilde de tüketilebilir. Çeşitli sanayi dallarında; çikolata, bisküvi, pasta, şekerleme, dondurma gibi yaygın olarak kullanılmaktadır.
Yıllara göre değişmekle birlikte ürettiği fındığın yaklaşık % 82' isini ihraç eden Türkiye'nin dünya fındık ihracatındaki payı % 82 dir. Bu rakamsal üstünlüklere rağmen bu değerli üründen yeteri kadar faydalanabildiği söylenemez.
Türkiye dünyanın en düşük verimlilikle fındık üretimi yapan ülkesidir. Ülkemizle mukayese edildiğinde ABD bizden üç kat daha fazla verimliliğe sahiptir. Fındık üretiminde dünyada bizden sonra ikinci sırada olan İtalya'da üretim verimliliği Türkiye'den 1,5 – 2 kat daha yüksektir. Gürcistan' da dahi fındık üretim verimliliği Türkiye'den yüksektir. Ekonomik açıdan düşük verimlilik, yüksek maliyet sonucu karlılık düşmekte ve sonuçta üretici gelirleri azalmaktadır.
Türkiye'de fındık bahçelerimiz önemli ölçüde yaşlanmıştır. Ocak şeklinde yapılan yetiştiricilikte verim diğer ülkelere göre oldukça düşüktür. Son yıllarda Doğu ve Batı Karadeniz Bölgeleri'nde fındık bahçelerindeki ocaklara uygulanan bir dönüşüm ile dal sayısı duruma göre 1-4 arasına indirilmekte ve verim mevcut verimin 3-4 katına çıkabilmektedir. Ülkemizde fındık bahçelerinde yeni başlayan bu dönüşümün yaygınlaştırılması durumunda verimliliğin ve toplam üretimin önemli bir miktarda artacağı bilinmelidir(Köksal,2018:24).
AB ülkeleri pazarına aşırı bağımlılık söz konusudur bu durum Türkiye'nin fındık ihracatını olumsuz etkilemektedir. Dünya toplam tüketiminin % 85'i AB ülkeleri ve ABD' e yapılmaktadır. Bu nedenle ülkemizin yeni pazarlara yönelmesi ve Çin, Hindistan, Rusya, Avustralya, Japonya ve Orta Doğu Ülkelerine ve özellikle de Afrika ülkelerine (çok sayıdaki Afrika ülkesinde çok bakir bir pazar var) ihracat yapabilmesi rekabet gücü açısından önemlidir.
Türkiye AB ülkeleri arasında demiryolu ağı yeterince gelişmemiştir. Hava yolu taşımacılığı ise oldukça yüksek maliyetlidir. Bu nedenle ihracatta taşımacılık kara yolu ile yapılmaktadır. Ayrıca lojistik işletmeleri esneklik ve yük tipine uygun olması nedeniyle kara yolu taşımacılığını tercih etmektedirler. Dolayısıyla nakliyat karayoluyla yapılmaktadır. Bu da fiyatları yükseltmektedir (Gültekin,2022:170).

FINDIK TARIMINDA FIRSATLAR VE TEHDİTLER
Doğu Karadeniz Bölgesi'nde üreticilerin (müstahsilin) fındık bahçelerinin ortalaması 5,5 dekar kadardır. Bölgede arazi kıttır ve olanı da dağlık ve meyillidir. Düz arazi bulmak oldukça zordur. Samsun, Adapazarı ve Düzce'de belki vardır ama Doğu Karadeniz Bölgesi'ndeki üreticilerin çoğunun bahçelerinin toplamı on dönümün altındadır. Dolayısıyla optimum işletme büyüklüğünün oldukça altındadır. Bu durum maliyetleri yükseltmektedir. Üstelik bu arazinin hepsi toplu halde bir yerde değil parçalıdır. İki dönüm bir yerde, üç dönüm bir yerde, bir dönüm başka bir yerdedir. Bu yüzden bakım, ilaçlama, gübreleme, bahçe altı temizleme, taşıma ve hasat etme masrafları oldukça yüksektir. Böyle olmasının önemli bir sebebi ise bahçelerin her geçen yıl kardeşler arasında paylaşılması nedeniyle gittikçe küçülmesidir.
Don, kuraklık ve yıllık yağış rejimi gibi iklimsel olayların etkisiyle dünyada yıllık üretim miktarında yıllara göre önemli dalgalanmalar olmaktadır. Fındıkta üretim miktarındaki bu

artış ve azalışlar iç ve dış pazarlarda daha fazla dalgalanmalara sebep olmaktadır. Fındık arzındaki % 1' lik bir artış fiyatlarda %1,62 bir düşmeye sebep olmaktadır (Gültekin,2022: 167).

Fındık üretiminde destekler yetersizdir. Fındık destekleri toprak analizi (TL/da) toprak analizi 0,8 TL., gübre desteği 8TL. mazot desteği 17 TL. alan bazlı gelir desteği 170 TL. dir. 2019 yılında sadece gübre desteği 4 TL'den 8 TL'ye çıkarılmış diğerleri ise aynı kalmıştır. Özellikle alan bazlı gelir desteği 2014 yılında 170 TL. olarak belirlenmiş o tarihten sonra ise artırılmamıştır. Oysa aynı dönemde üretim girdilerinde mazot ve gübre fiyatlarında yüksek oranlı artışlar meydana gelmiş destekleme rakamları girdi fiyatlarındaki artış oranında yükseltilmemiştir. Bu nedenle destekler yüksek enflasyon karşısında satın alma gücünü ve destekleme özelliğini yitirmiştir. Bu durum fındık üreticisinin üretim ve gelir kaybına yol açmaktadır (Gültekin, 2022:167).

"Alan Bazlı Gelir desteği", tarım alanlarının tarım dışı bırakılmasına sebep olmakta yani üretmek değil üretmemek desteklenmektedir. Bu yanlış bir uygulamadır. Bunun yerine üreticiler çiftçi avans sistemi ve çeşitli sübvansiyonlarla desteklenmelidir (Baş, 2004:227).

"Alan bazlı gelir desteği" uygulamasının yanlış taraflarından biri de üretimi yapana değil, bahçelerin sahibine yani tapu kime ait ise ona verilmesidir. Bunun manası üretimi yapanın değil tapu sahibinin desteklenmesi demektir. Tapu sahibi ise bahçelerini yarıya vermiştir. Üretimi bizzat o yapmamaktadır.

Fındık bahçelerinde budama, gübreleme, ilaçlama, hastalık ve zararlılarla mücadele gibi uygulamaların zamanında ve usulüne uygun bir şekilde yapılması fındıkta verimin artmasına yol açar. Yaşlı ve verimden düşmüş bahçelerin sökülerek verimli ve kaliteli çeşitlerle ve yeni yöntemlerle dikilmesi gerekmektedir. Bunun için uygulamaya konulan "**Fındıkta Verim ve Kaliteyi Artırma"** projesi verimi artırmaya yönelik çalışmaların daha geniş alanlarda uygulanması, üreticilerde farkındalık oluşturması ve örnek alınarak çok sayıda benzer projelere ışık tutması bakımından oldukça önemlidir (Balık,2016:3).

Fındık hasat zamanı bölgeye Doğu ve Güney Doğu Anadolu Bölgesi illerinden başta Adıyaman ve Urfa illerinden olmak üzere, ayrıca Suriye, Gürcistan, ve Afganistan gibi ülkelerden de geçici mevsimlik işçiler gelerek çalışmaktadırlar. Bölgeye dışardan gelen bu işçilerin ücretleri bölge işçilerine göre daha düşük olmasına rağmen bu işçilerin verimlilik ve motivasyonları da o derece düşüktür (Gültekin,2022:169).

Önemli avantajlardan biri belki bölgede iş gücü ücretlerinin düşük olmasıdır. Ama buna karşılık işgücünün verimliliği de Almanya, İtalya, ABD gibi rakip ülkelere göre düşüktür. Bu sebeple iş gücü ücretlerinin düşük olmasının avantajı verimliliğinin de o derece düşük olmasını sebebiyle ortadan kalkmaktadır. Bu nedenle fındık kırma ve işleme sanayiinde iş gücü verimliliğinin yükseltilmesi için tedbirler alınmalıdır.

Fındık alımı konusunda özel sektör kadar ve hatta daha da fazla kamu sektörü faaliyette bulunmaktadır. Bunlar Toprak Mahsulleri Ofisi (TMO) ve Fiskobirlik' tir. Fiskobirlik, bizzat devlet eliyle/desteğiyle kurulmuş ve bu özelliği nedeniyle siyasal hükümetlerin değişmelerinden doğrudan etkilenen bir kooperatiftir. Devletçi ekonomik politikaların uygulandığı ve sosyal devlet anlayışının kısmen hayata geçirildiği dönemde kooperatifler devlet desteği ile kurulmuştur. Ancak özellikle neoliberal ekonomi politikalarının özelleştirmeci yani devletin küçülmesine ve piyasadan elini çekmesi yönündeki vaazlarına uygun olarak kooperatiflerden desteğini azaltmasına yol açtı (Kara,2022:116).

İyi ki bu iki kamu kuruluşları var. Aksi halde onlar olmasaydı üretici sadece tüccarın eline kalsaydı tüccar vatandaşın fındığını bu günkü piyasa fiyatlarının yarısına bile almazdı. Bu nedenle söz konusu bu kamu kuruluşları piyasa fiyatlarını dengeleyici bir rol oynuyor.

Ülkemizde fındık tarımıyla ilgili diğer tarım ürünlerinde olmayan iki usul vardır. Bunlardan biri hasat zamanından önce **"yarıya verme**" diğeri ise hasattan sonra "**emanete verme"** usulüdür. Bu kavramların kısaca açıklaması şöyledir:

Yarıya verme; Bahçe sahibi fındığın toplanması, patosa verilip ayıklanması, kurutulması ve çuvallanması gibi emek yoğun kısmını bir başkasına verip yaptırır ve sonra çıkan ürünü pay ederler buna yarıya verme denir. Birde **emanete verme** usulü vardır ki o da hasattan sonra toplanmış, kurutulmuş ve çuvallanmış fındığı üretici stok maliyetlerine katlanmamak için tüccara verir ama parasını almaz. Daha sonra fiyatlar yükseldiği zaman yüksek fiyattan parasını alır. Bu uygulamalardan yarıya verme usulü verimin düşmesine, emanete verme usulü ise daha çok satış fiyatların düşmesine neden olmakta ve sonuçta çiftçiler zarar görmektedirler.
Türkiye'den fındık ithalatı yapan yabancı firmalar, bizim piyasalarımızdaki gelişmeleri, desteklemeleri ve devletin alım fiyatlarını, iç piyasada tüccarların alım fiyatlarını, vergi fon ve yükümlülükleri, üretim miktarlarını çok yakından takip etmektedirler (Ulusoy, 2004:212).
Bu gün AB ülkelerinin konsey kararıyla aldıkları alfatoksin olayının altında yatan temel sebep de Türk fındığının ihracatını olabildiğince baltalayarak fiyatları düşürmektir (Baş,2004:227).
Dünya fındık üretiminin %75'ini üreten Türkiye dünyada rakipsizdir. Bu sebepten küresel güçler rekabet gücümüzü kırmak için bize ekim alanlarının daraltılmasını telkin etmektedirler. Telkinden de öte baskı yapmaktadırlar. İddiaları şudur: Dünyada talep fazlası fındık vardır. Peki madem talep fazlası fındık var. Niçin Amerika, İspanya, İtalya gibi diğer ülkeler fındık ekim alanlarını genişletiyorlar?(Baş,2004:226)
Fındık tarımında birde son birkaç yıldır fındığın olgunlaşma zamanında **"kahverengi kokarca**" denilen zararlı bir böcek ortaya çıkıyor ve fındığın olgunlaşmasını engelleyip büyük zarar veriyor. Geçmiş yıllarda böyle zararlı bir böcek yoktu. Bu durum son 3-5 yıldır söz konusu. Bunun rakip ülkeler tarafından türetilerek bize karşı kullandıkları biyolojik bir savaş olduğu kanaatini taşıyoruz.
Türkiye'de fındık çerez olarak tüketildiği gibi fındık sanayi ürünlerinde de kullanılmaktadır. Fındık sanayi ürünleri üç gruba ayrılarak incelenebilir:
1.iç Fındık (natürel fındık)
2.İşlenmiş fındık (kavrulmuş ve beyazlatılmış fındık)
3.İleri derecede işlenmiş fındık ürünleri (kıyılmış, dilinmiş fındık, fındık unu, fındık ezmesi, fındık püresi)
Toprak Mahsulleri Ofisi (TMO) verilerine göre 2017 yılında ülkemizin fındık ihracatının % 59'unu iç fındık (natürel), %17'sini işlenmiş fındık, %24'ünü ise ileri işlenmiş fındıktır. Bu nedenle Türkiye'nin gerçekleştirdiği fındık ihracatının önemli bir bölümünün düşük katma değerli ürünlerden oluştuğu söylenebilir. Katma değer oluşturmak açısında fındığın işlenerek piyasaya sürülmesi ve ihraç edilmesi hem milli gelir, hem ülkemizin ödemeler dengesi ve hem de istihdam açısından önem arz etmektedir. Hammadde olarak talebi yüksek olan ve dünya pazarlarında önemli bir gücümüzün olduğu fındığın çok yüksek ekonomik fayda potansiyeli bulunmaktadır (Orman, Yaşar, 2022:154).
Türkiye'de fındık işleme sanayine dayalı işletmeler çoğunlukla fındık üretiminin yapıldığı Doğu ve Batı Karadeniz bölgelerinde kurulmuştur. Fındık sanayi, bölgedeki işsizliğin azaltılmasında da önemli bir etkiye sahiptir. Fındık işleme ürünleri denildiğinde iç fındık, kavrulmuş fındık, beyazlatılmış fındık, kıyılmış fındık, dilinmiş fındık, fındık unu, fındık ezmesi ve fındık püresi akla gelmektedir (Köksal,2018:125).
Önemli bir ihracat ürünümüz olan fındık konusunda rasyonel, tutarlı, planlı ve uzun dönemli bir politikamızın olmayışı sebebiyle, ihracatı artırmak bir yana mevcut pazarlarımızı da kaybetmekteyiz. İstikrarlı bir ihracat politikası oluşturamamanın yanında yeni pazar araştırmaları yapma, ürünü dünyaya tanıtma yönünden yetersiz kaldığımızı belirtmeliyiz. ABD'nin fındığa alternatif olarak dünyaya sunduğu badem üretimini son yirmi yılda % 800 artırdığını ve dünyaya sattığını belirterek bunu bizim de fındık için yapabileceğimizi bilinç altına yerleştirmemiz gerekir (Ulusoy, 2004:214).

Eski devlet ve siyaset adamlarımızdan N. Erbakan sağlığında şöyle demişti: "**Bizim fındığımız Yahudilerin elinde olsa onu dünyaya eczanede ilaç satar gibi tane tane satarlar.**" Ama biz bu gün tane tane değil bin/ ton olarak satıyoruz.

Fındık ve mamullerinin ihracatında "**hedef pazar**" olarak AB ülkelerinin seçilmesi önemli bir pazar riski oluşturmaktadır. Özellikle üretimin fazla olduğu yıllarda büyük stoklarla karşı karşıya kalınmakta, Avrupa ülkeleri Türk fındığını istedikleri şartlardan satın alabilmektedirler. Bu durum karşısında üretici ve ihracatçı işletmeler zor durumda kalmaktadırlar. Ayrıca dünyada ülkemizden sonra gelen fındık üreticisi İtalya, İspanya gibi AB üyesi ülkeler üyelik avantajlarını da kullanarak gümrüksüz satış yapabilmektedirler. Bu ise ülkemizin pazar riskini artırmaktadır. Bu yüzden bizim AB'nin dışında kalan pazarlara yönelik pazar bulma çalışmalarını artırmamız gerekir. Hazır ürünü hazır pazara satmak yerine yeni pazarlar ve yeni mamuller geliştirmek için çaba sarf etmeliyiz. Çağdaş pazarlama anlayışı çerçevesinde tüketicilerin zevk ve beğenilerini araştırarak, pazardaki değişiklikler yakından takip eden, toplumsal çıkarları da dikkate alan bir pazarlama anlayışına sahip olmamız gerekir (Cındık, 2004,289).

Yeni mamul geliştirme çabaları yapan işletmeler genellikle büyük finansal imkanlara ve yeniliğe açık yöneticilere sahip olan işletmelerdir. Ülkemizde yeni mamul geliştirme çabaları oldukça riskli ve pahalıdır. İşletmelerin yeni mamul geliştirme çabaları birbirini izleyen, uzun zaman alan ve para harcamayı gerektiren yedi aşamaya ayrılabilir. Bunlar;

1.Yeni Mamul Fikirlerinin Toplanması
2.Ön Eleme
3.Kavram Geliştirme ve Test Etme
4.Ticari Analiz
5.Mamulün Geliştirilmesi
6.Pazar testleri
7.Pazara sunuş

Bu aşamaları geçerek pazara sunulan mamullerin sayısı toplanan çok sayıdaki yeni mamul fikirleri arasında oldukça küçük bir oranı oluşturur. Ayrıca yedinci aşamada pazara sunulan mamullerin de sadece bazıları ticari başarı sağlayabilir(Mucuk,2001:125-126).

SONUÇ VE DEĞERLENDİRME

Bütün dezavantajlara rağmen fındık, gerek çerez olarak ve gerekse çikolata ve şekerleme sanayiinde bütün dünyada yoğun olarak kullanılmaktadır. Önümüzdeki yıllarda ise sağlık alanında da kullanılmaya adaydır. Çünkü yapılan bilimsel çalışmalarda fındığın başta kalp, damar sertliği, kanser, diyabet, yüksek tansiyon, anemi, hafıza kaybı, kemik erimesi, v. b bir çok hastalığa karşı iyileştirici etkiler gösterdiği ifade edilmektedir.

Dünya ülkelerinin kullandığı fındığın çok büyük bir bölümünü de biz üretiyoruz. Bu durum ülkemiz için büyük bir avantajdır. Bu nedenle bir asırdır fındığı dışarıya geçmişte sadece kabuklu olarak şimdilerde ise hem kabuklu ve hem de iç fındık olarak da satıp sonra üç kat daha fazla fiyattan çikolata olarak geri almaktan yani AB ülkelerinin ham madde tedarikçisi olmaktan attık kurtulmalıyız. Bunun için de fındığın yetiştirildiği bölgemizde çikolata yaparak dışarıya satmalıyız. Böylece bölgedeki işsizliği biraz azaltmış da oluruz. Fındıktan çikolata yapmak zor bir iş olmasa gerektir. Aksi halde Dubai çikolatası yemek ayıbından kurulamayız.

Tarımsal ürünler ihracatımızın içerisinde fındık birinci sırada yer almaktadır. Yaklaşık 950 milyon dolar olan fındık ihracatımız toplam ihracatımız ve toplam tarım ürünleri ihracatımızın içerisinde küçümsenmeyecek bir yer tutmaktadır. Bu nedenle fındığın önemi diğer ihraç ettiğimiz tarım ürünlerine oranla daha fazladır.

Kısaca fındık tarımında biz işin sadece emek yoğun kısmını yapıyoruz. Diğer bir ifadeyle işin hamallığını yapıyoruz. Ama sermaye yoğun kısmını yapmıyoruz ya da yapamıyoruz. Daha doğrusu yapmak için bir gayret göstermiyoruz. Yıllardır bu iş böyle gelmiş böyle gidiyor.

Şayet fındık dünyada yeterince tanıtılırsa fındık talebi daha da artacaktır. Özellikle Çin, Hindistan, Japonya gibi dünyanın nüfusa sahip ülkeleri fındık ürününü iyi tanımadıklarından az tüketiyorlar. Bunun yanı sıra bütün bir Afrika kıtasında çok bakir bir pazar vardır. Yeni ürünler ve yeni mamuller geliştirerek bu pazarlara açılmamız bizi AB ülkeleri pazarına aşırı bağımlılığın risklerinden kurtaracaktır.

Dünyada tekel durumda olduğumuz bu önemli bir ürünü gerektiği gibi değerlendirmede bu güne kadar devlet ve millet olarak yetersiz kaldık. Bu yüzden dünya milletlerinin üçte ikisi fındığın çerez olarak adından, tadından ondan geliştirilen mamullerden, sağlıkla ilgili faydalı özelliklerinden habersizdir. Bu yüzden sektörün yılların ciddi olarak el atılmayan kangrenleşmiş sorunlarını çözmek için acilen üretici-tüccar- devlet iş birliği ve uzlaşma içinde devrim niteliğinde kararlar alarak uygulamaya koyulmalıdır.

KAYNAKLAR

Balık, Hüseyin İrfan, (2016), Fındık Çeşitleri, Hazelnut Cultıvars, Klasmat Matbaacılık.

Baş, Haydar (2004), Turan Karadeniz (Editör), Milli Ekonomi Modeli ve Fındık Politikası, 3.Milli Fındık Şurası Tebliğler Kitabı,(içinde bölüm), Giresun.

Cındık, Hicabi (2004), Turan Karadeniz(Editör), Dünya Fındık Pazarında Türkiye'nin İhracat Potansiyeli, 3. Milli Fındık Şurası Tebliğler Kitabı (içinde bölüm).

Erdem, A. Salih, Yamak, İbrahim, Memiş, Mehmet,(2004), 3. Milli Fındık Şurası Tebliğler Kitabı (içinde Takdim yazısı).

Göreci, Ali, (2004), Fındık Kültürü, Önder Matbaacılık Ltd. Şti, Ankara.

Gültekin, Sadettin,(2022), Giresun Fındığının Porter'in Diamond (Elmas) Modeline Göre Uluslararası Rekabet Gücünün Analizi, Giresun Ekonomisi (içinde bölüm),Ekin Yay., Bursa.

Kara, Mehmet Akif (2022), Fındık Ekonomisinde Kooperatiflerin Yeri, Fındık Ekonomisi (içinde bölüm), Ekin Basım Yayın Dağıtım, Ankara.

Korkmaz, Kaya, (2022), Giresun Fındık Ekonomisi, Arı sanat Yayınevi, İstanbul.

Köksal, A. İlhami, (2018), Türk Fındık Çeşitleri, Ankara.

Mucuk, İsmet, (2001), Pazarlama İlkeleri, Türkmen Kitabevi, 13.Baskı, İstanbul.

Orman, H. Levent, Yaşar, M. Malkoç (2022),Giresun Fındığının İktisadi Bir Değerlendirilmesi, Giresun Ekonomisi (içinde bölüm), Ekin Basım Yayın, Bursa.

Ulusoy, Ahmet, (2004), Turan Karadeniz,(Editör),Türkiye'de Fındık İhracatının Değerlendirilmesi, 3. Milli Fındık Şurası Tebliğler Kitabı, (içinde bölüm).

DEVELOPMENT OF APRICOT PRODUCTION IN TÜRKİYE: THE CASE OF IĞDIR PROVINCE

TÜRKİYE'DE KAYISI ÜRETİMİNİN GELİŞİMİ: IĞDIR İLİ ÖRNEĞİ

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Özet
Sert çekirdekli meyvelerden olan kayısı, Türkiye'nin uygun iklim koşullarına sahip olması sebebiyle yaygın olarak yetiştirilen bir meyvedir. Taze ve kuru gıda olarak tüketilmesinin yanı sıra kayısı çekirdekleri ilaç ve kozmetik sanayisinde de kullanılmaktadır. Bu araştırma Türkiye'de kayısı yetiştiriciliğinin durumunu yıllar itibariyle ortaya koymayı amaçlamıştır. Çalışmada TÜİK'in 2004-2023 yıllarını kapsayan verileri kullanılmıştır. Türkiye'de 2004 yılında toplam 900.000 dekar kayısı dikim alanı var iken 2023 yılı itibariyle 1.449.405 dekar kayısı dikim alanı bulunmaktadır. 2023 yılı toplam üretim miktarı 750.000 ton olup birim alana (dekar) kayısı verimi 517.45 kg'dır. Kurutmalık ve sofralık çeşitleri bulunan birçok kayısı türü Türkiye'nin farklı illerinde yetiştirilmektedir. Türkiye'de önemli kayısı üretim merkezleri arasında Malatya, Kahramanmaraş, Elâzığ, Mersin, Iğdır ve Hatay illeri bulunmaktadır. Sofralık üretimi için önemli bir çeşit olan Şalak Iğdır ilinde yetiştirilmektedir. Ağaç başına verimi yüksek olan Iğdır ilinde , kayısı üretimi bakımında oldukça avantajlıdır. Iğdır ili 2023 yılında toplam kayısı dikim alanı 40.618 dekardır. Iğdır ili 2004 yılında 2.520 ton kayısı üretimi ile Türkiye'deki payı %0.79 iken 2023 yılı itibariyle 38.441 ton kayısı üretimi ile Türkiye'deki payı %5.13'e yükselmiştir. Iğdır ili içerisinde dikim alanı bakımından %54.16 pay ile en fazla Merkez ilçesinde kayısı bulunmaktadır. %32.01 pay ile Tuzluca, %8.17 ile Karakoyunlu ve %5.66 ile Aralık ilçesi takip etmektedir. Yıllar içerisinde dikim alanı ve verimi artan kayısı, Iğdır ilinde meyvelik tarımında önemli bir yer tutmaktadır. Ancak gübreleme ve ilaçlama sayısının daha kontrollü yapılması, hasat sırasında meyvelerin ezilmemesi için özenli toplanması gerekmektedir. Bölgede üretici örgütlenmesi eksikliği pazarlama ve dağıtım sırasında karşılaşılan en önemli sorunlarındandır. Iğdır ili iklim ve toprak şartları bakımından Doğu Anadolu bölgesinde meyve yetiştirilen önemli bir il olması sebebiyle karşılaşılan bu sorunların giderilmesi bölge ekonomisine büyük katkı sağlayacaktır.
Anahtar Kelimeler: Kayısı, Üretim, Verim, Iğdır, Türkiye

Abstract
Apricot, one of the stone fruits, is a widely cultivated fruit due to Türkiye's favorable climatic conditions. Apricot kernel is consumed as fresh and dried food as well as used in the pharmaceutical and cosmetic industries. This study aimed to reveal the status of apricot cultivation in Türkiye over the years. TurkStat data covering the years 2004-2023 were used in the study. While there were 900,000 decares of apricot planting area in Türkiye in 2004, there are 1,449,405 decares of apricot planting area as of 2023. In 2023, the total production amount is 750,000 tons and apricot yield per unit area (decare) is 517,45 kg. Many types of apricots, including dried and table varieties, are grown in different provinces of Türkiye. Important apricot production centers in Türkiye include Malatya, Kahramanmaraş, Elâzığ, Mersin, Iğdır and Hatay. Şalak, an important variety for table production, is grown in Iğdır province. Iğdır province, which has a high yield per tree, is very advantageous in terms of apricot production. The total apricot planting area in Iğdır province in 2023 is 40,618 decares. While the share of Iğdır province in Türkiye was 0.79% with 2,520 tons of apricot production in 2004, its share in Türkiye increased to 5.13% with 38,441 tons of apricot production as of 2023. In terms of planting area in Iğdır province, apricot is mostly found in the Central district with a share of 54.16%, followed by Tuzluca with 32.01%, Karakoyunlu with 8.17% and December with 5.66%. Apricot, whose planting area and yield have increased over the years, has an important place in fruit farming in Iğdır province. However, the number of fertilizers and pesticides should be more controlled, and fruits should be collected carefully so that they are not crushed during harvest. Lack of producer organization in the region is one of the most important problems encountered during marketing and distribution. Since Igdir province is an important province where fruit is grown in the Eastern Anatolia region in terms of climate and soil conditions, eliminating these problems will make a great contribution to the regional economy.
Keywords: Apricot, Production, Yield, Iğdır, Türkiye

Giriş
Meyve yetiştiriciliği uzun yılları kapsayan bir tarımsal uğraştır (Poyraz ve Gül, 2023). Botanik sınıflandırmasında Rosales takımı, Rosaceae familyası, Prunoidae alt familyası, Prunus cinsinden olan kayısı, sert çekirdekli meyve türlerinden birisidir (Kargı vd. 2015). Türkiye uygun iklim ve ekolojik koşullara sahip olması sebebiyle kayısı yetiştiriciliği yoğun olarak yapılmaktadır (Anonim, 2004). Kayısının birçok kullanım alanı mevcuttur. Taze ve kuru gıda olarak tüketilmesinin yanı sıra kayısı çekirdekleri ilaç ve kozmetik sanayisinde de kullanılmaktadır (Sarıbaş, 2012). Türkiye'de kayısı yetiştiriciliği bakımından önemli üretim merkezleri Malatya, Kahramanmaraş, Elâzığ, Mersin, Iğdır ve Hatay illeridir.
Iğdır, Doğu Anadolu Bölgesi'nde "kurak-yarı kurak" iklim sınıflandırması ile mikro iklim bölgesi içerisinde yer alan ve meyvecilik tarımı bakımından uygun coğrafi şartlara sahip bir ildir (Alım ve Kaya, 2005; MGM, 2023). Iğdır ili, Türkiye kayısı üretimi bakımından %5'lik, sofralık kayısı üretimi bakımından ise %20'lik bir paya sahiptir (TÜİK, 2024). Sofralık üretimi için önemli bir çeşit olan Şalak Iğdır ilinde yetiştirilmektedir. Ağaç başına verimi yüksek olan Iğdır ilinde, kayısı üretimi bakımında oldukça avantajlıdır.
Bunun yanı sıra, Iğdır ovasının kendine özgü ekolojisinden dolayı Iğdır kayısısının lezzeti, aroması, kalitesi ve kuru madde oranı diğer bölgelerde üretilen kayısılara göre yüksektir (Ertürk vd. 2016).
Bu çalışmada, Türkiye'de ve Iğdır ilinde kayısı yetiştiriciliğinin gelişiminin ortaya konulması amaçlanmıştır. Türkiye'de kayısı yetiştiriciliğinin gelişimi illere göre, Türkiye'de ise ilçelere göre incelenmiştir.

Materyal ve Metot

Çalışmanın ana materyalini Türkiye ve Iğdır ili kayısı üretim verileri ve konu ile ilgili yapılmış çalışmalardan elde edilen ikincil veriler oluşturmaktadır. Bu veriler; Türkiye İstatistik Kurumu (TÜİK), ulusal ve uluslararası literatürdeki kayısı yetiştiriciliği ile ilgili bilimsel yayınlardan elde edilmiştir.

Araştırma Bulguları ve Tartışma

Türkiye'de kayısı dikim alanı 2004-2023 yılları arasında incelenmiştir. 2004 yılında 900.000 dekar olan Türkiye kayısı dikim alanı 2023 yılında 1.449.405 dekara yükselmiştir. Türkiye'de kayısı dikim alanı bakımından önemli iller incelendiğinde, ilk beş il sırasıyla Malatya, Kahramanmaraş, Elâzığ, Mersin, Iğdır ve Hatay'dır. 2004 yılında Malatya'da kayısı dikim alanı 636.980 dekardan, 2023 yılında 892.022 dekara yükselmiştir. Aynı yıllar itibariyle Kahramanmaraş'ta kayısı dikim alanı 64.320 dekardan, 109.100 dekara yükselmiş, Elazığ'da kayısı dikim alanı 35.350 dekardan, 107.806 dekara yükselmiş, Mersin'de kayısı dikim alanı 39.130 dekardan, 101.523 dekara yükselmiş, Iğdır'da kayısı dikim alanı 15.510 dekardan, 40.618 dekara yükselmiş, Hatay'da ise kayısı dikim alanı 5.620 dekardan, 30.627 dekara yükselmiştir (Çizelge 1).

Çizelge 1. Türkiye'de illere göre kayısı dikim alanı (dekar)

Yıllar	Malatya	Kahramanmaraş	Elâzığ	Mersin	Iğdır	Hatay	Diğer iller	Türkiye
2004	636.980	64.320	35.350	39.130	15.510	5.620	103.090	900.000
2005	645.320	62.660	35.430	54.630	15.250	6.200	107.510	927.000
2006	675.920	62.690	35.298	58.520	15.150	7.035	106.337	960.950
2007	679.990	61.409	35.410	63.779	15.170	7.571	104.329	967.658
2008	688.290	64.309	78.350	63.552	9.418	7.711	108.662	1.020.292
2009	700.150	71.780	77.385	63.661	9.518	7.982	110.085	1.040.561
2010	709.880	86.780	81.360	62.313	15.955	8.511	115.735	1.080.534
2011	729.100	91.780	83.095	70.506	16.652	9.693	119.967	1.120.793
2012	742.800	91.730	83.148	72.140	18.572	10.446	121.680	1.140.516
2013	754.320	92.468	83.787	68.433	18.822	11.322	126.980	1.156.132
2014	768.000	91.560	85.864	67.684	19.786	7.070	129.217	1.169.181
2015	801.100	88.880	96.341	67.943	27.126	7.523	132.685	1.221.598
2016	810.970	89.470	97.809	68.694	27.276	6.708	137.125	1.238.052
2017	808.197	88.111	97.524	67.278	32.300	19.706	137.371	1.250.487
2018	798.366	89.328	98.192	71.905	34.070	20.761	144.937	1.257.559
2019	841.883	89.218	99.354	81.316	35.600	19.637	144.772	1.311.780
2020	849.871	89.145	99.626	82.678	35.300	19.959	150.899	1.327.478
2021	856.422	88.822	102.112	86.426	38.540	24.517	151.955	1.348.794
2022	877.908	104.632	105.897	100.349	40.550	30.095	159.082	1.418.513
2023	892.022	109.100	107.806	101.523	40.618	30.627	167.709	1.449.405

Kaynak: TÜİK, 2024

Türkiye'de 2004 yılında 320.000 ton olan kayısı üretim miktarı 2023 yılında 750.000 tona yükselmiştir. Türkiye'de illere göre kayısı üretim miktarı incelendiğinde, ilk sırada yer alan Malatya 2004 yılında 84.706 tondan, 2023 yılında 328.767 tona yükselmiştir. Kayısı dikim alanı bakımından dördüncü sırada yer alan Mersin ili, kayısı üretim miktarı bakımından Türkiye'de ikinci sırada yer almakta ve aynı yıllar itibariyle 54.219 tondan, 156.590 tona yükselmiştir. Üçüncü sırada yer alan Kahramanmaraş 71.122 tondan, 39.243 tona gerilemiştir. Dördüncü sırada yer alan Iğdır 2.520 ton üretimden 38.441 tona yükselmiştir. Beşinci sırada yer alan Hatay 4.102 tondan, 37.034 tona yükselmiştir. Altıncı sırada yer alan Elâzığ ise 15.531 tondan 27.160 tona yükselmiştir (Çizelge 2).

Çizelge 2. Türkiye'de illere göre kayısı üretim miktarı (ton)

Yıllar	Malatya	Mersin	Kahramanmaraş	Iğdır	Hatay	Elâzığ	Diğer iller	Türkiye
2004	84.706	54.219	71.122	2.520	4.102	15.531	87.800	320.000
2005	500.269	55.737	147.621	15.030	4.517	23.387	113.439	860.000
2006	242.871	64.557	11.616	15.723	5.263	25.323	94.829	460.182
2007	267.733	60.217	69.432	9.426	5.919	34.436	110.409	557.572
2008	362.873	77.333	67.486	14.085	7.435	72.936	114.267	716.415
2009	340.085	48.846	59.550	17.782	7.531	67.651	119.449	660.894
2010	220.927	56.430	14.685	9.222	7.186	30.179	111.371	450.000
2011	409.646	52.486	14.678	12.063	7.615	33.991	119.521	650.000
2012	510.000	46.865	12.521	17.755	8.239	38.578	126.042	760.000
2013	411.825	94.055	78.620	20.342	8.535	39.514	127.109	780.000
2014	38.654	111.738	994	0	6.546	11.390	100.678	270.000
2015	336.000	107.922	80.444	37.544	6.707	18.417	92.966	680.000
2016	380.551	104.310	33.169	31.329	5.962	58.876	115.803	730.000
2017	672.670	86.918	25.689	31.416	7.612	53.157	107.538	985.000
2018	401.363	89.300	29.778	36.194	32.766	51.775	108.824	750.000
2019	391.801	140.301	65.454	39.658	31.593	56.184	121.615	846.606
2020	352.050	170.468	65.477	40.207	35.941	50.786	118.469	833.398
2021	389.396	162.060	18.626	42.989	21.080	31.179	134.670	800.000
2022	303.756	164.391	53.992	40.844	56.797	29.186	154.034	803.000
2023	328.767	156.590	39.243	38.441	37.034	27.160	122.765	750.000

Kaynak: TÜİK, 2024

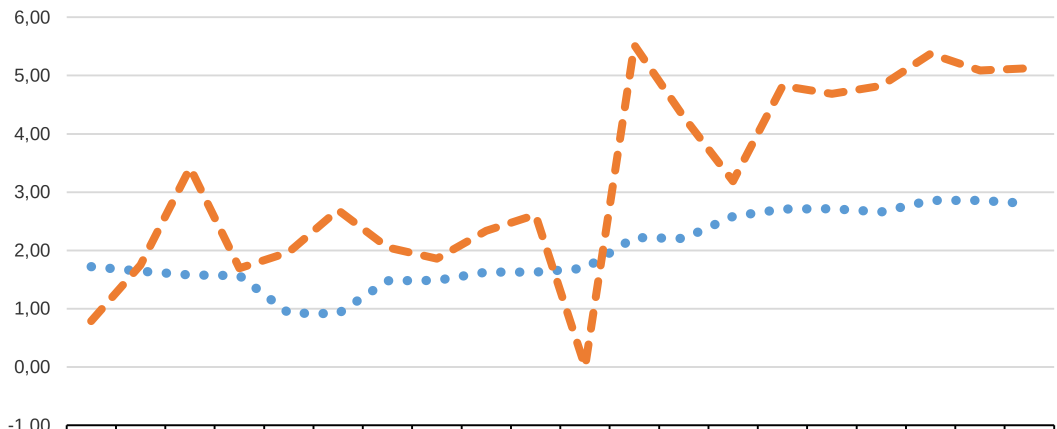
Türkiye'de 2004 yılında ortalama 355,56 kg/da olan kayısı verimi 2023 yılında 517,45 kg/da'a yükselmiştir. Türkiye kayısı verimi bakımından incelendiğinde, ilk sırada yer alan Mersin ilinin 2004 yılında kayısı verimi 1.385,62 kg/da'dan 2023 yılında 1.542,42 kg/da'a yükselmiştir. Sırasıyla Hatay 729,89 kg/da'dan, 1.209,19 kg/da'a, Iğdır 162,48 kg/da'dan, 946,40 kg/da'a, Malatya 132,98 kg/da'dan, 368,56 kg/da'a yükselmiştir. Kahramanmaraş 1.105,75 kg/da'dan, 359,70'a, Elâzığ 439,35 kg/da'dan, 251,93 kg/da'a gerilemiştir. 2023 yılı itibariyle Malatya, Hatay ve Iğdır illerinin kayısı verimi Türkiye ortalamasının üzerindedir (Çizelge 3).

Çizelge 3. Türkiye'de illere göre kayısı verimi (kg/da)

Yıllar	Mersin	Hatay	Iğdır	Malatya	Kahramanmaraş	Elâzığ	Diğer iller	Türkiye
2004	1.385,61	729,89	162,48	132,98	1.105,75	439,35	851,68	355,56
2005	1.020,26	728,55	985,57	775,23	2.355,90	660,09	1.055,15	927,72
2006	1.103,16	748,12	1.037,82	359,32	185,29	717,41	891,78	478,88
2007	944,15	781,80	621,36	393,73	1.130,65	972,49	1.058,28	576,21
2008	1.216,85	964,21	1.495,54	527,21	1.049,40	930,90	1.051,58	702,17
2009	767,28	943,50	1.868,25	485,73	829,62	874,21	1.085,06	635,13
2010	905,59	844,32	578,00	311,22	169,22	370,93	962,29	416,46
2011	744,42	785,62	724,42	561,85	159,93	409,06	996,28	579,95
2012	649,64	788,72	956,01	686,59	136,50	463,97	1.035,85	666,37
2013	1.374,41	753,84	1.080,76	545,96	850,24	471,60	1.001,02	674,66
2014	1.650,88	925,88	0,00	50,33	10,86	132,65	779,14	230,93
2015	1.588,42	891,53	1.384,06	419,42	905,09	191,16	700,65	556,65
2016	1.518,47	888,79	1.148,59	469,25	370,73	601,95	844,51	589,64
2017	1.291,92	386,28	972,63	832,31	291,55	545,07	782,83	787,69
2018	1.241,92	1.578,25	1.062,34	502,73	333,36	527,28	750,84	596,39
2019	1.725,38	1.608,85	1.113,99	465,39	733,64	565,49	840,05	645,39
2020	2.061,83	1.800,74	1.139,01	414,24	734,50	509,77	785,09	627,81
2021	1.875,13	859,81	1.115,44	454,68	209,70	305,34	886,25	593,12
2022	1.638,19	1.887,26	1.007,25	346,00	516,02	275,61	968,27	566,09
2023	1.542,41	1.209,19	946,40	368,56	359,70	251,93	732,01	517,45

Kaynak: TÜİK, 2024

Türkiye'de kayısı dikim alanı içerisinde Iğdır ilinin payları 2004-2023 yılları itibariyle incelendiğinde, 2004 yılında Iğdır ilinin payı %1,72 olup, 2015 yılında %2,22'ye, 2018 yılında %2,71'e, 2021 yılında %2,86'ya ve 2023 yılında %2,80'e yükselmiştir. Türkiye'de kayısı üretim miktarı içerisinde Iğdır ilinin payları aynı tarihler itibariyle incelendiğinde, 2004 yılında Iğdır ilinin payı %0,79 olup, 2015 yılında %5,52'ye yükselmiş, 2018 yılında %4,83'e gerilemiş, 2021 yılında %5,37'ye yükselmiş ve 2023 yılında %5,13'e gerilemiştir (Şekil 1).



	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Alan (%)	1,72	1,65	1,58	1,57	0,92	0,91	1,48	1,49	1,63	1,63	1,69	2,22	2,20	2,58	2,71	2,71	2,66	2,86	2,86	2,80
Miktar (%)	0,79	1,75	3,42	1,69	1,97	2,69	2,05	1,86	2,34	2,61	0,00	5,52	4,29	3,19	4,83	4,68	4,82	5,37	5,09	5,13

Şekil 1. Kayısı dikim alanı ve üretim miktarı bakımından Iğdır ilinin Türkiye içerisindeki payları (TÜİK, 2024)

Iğdır ili kayısı dikim alanının, ilçelere dağılımı 2004-2023 yılları arasında incelenmiştir. Iğdır ili 2004 yılında toplam 15.510 dekar kayısı dikim alanına sahiptir. Aynı yıl itibariyle kayısı dikim alanı Merkez ilçede 8.270 dekar , Tuzluca'da 6.000 dekar, Aralık'ta 1.000 dekar ve Karakoyunlu'da 240 dekardır. Iğdır ilinde 2023 yılı itibariyle kayısı dikim alanı 40.618 dekara yükselmiştir. İlçelere dağılımı incelendiğinde, Merkez ilçe 2023 yılında 22.000 dekara, Tuzluca 13.000 dekara, Karakoyunlu 3.318 dekara ve Aralık ilçesi 2.300 dekara sahiptir (Çizelge 4).

Çizelge 4. Iğdır ili kayısı dikim alanının ilçelere dağılımı (dekar)

Yıllar	Merkez	Tuzluca	Karakoyunlu	Aralık	Iğdır
2004	8.270	6.000	240	1.000	15.510
2005	8.070	6.000	180	1.000	15.250
2006	8.070	6.000	180	900	15.150
2007	8.090	6.000	180	900	15.170
2008	8.200	600	18	600	9.418
2009	8.300	600	18	600	9.518
2010	8.400	6.100	860	595	15.955
2011	8.700	6.500	1.000	452	16.652
2012	9.000	6.500	2.620	452	18.572
2013	9.173	6.552	2.641	456	18.822
2014	10.000	6.700	2.630	456	19.786
2015	13.000	12.000	1.670	456	27.126
2016	13.000	12.000	1.820	456	27.276
2017	16.167	12.520	1.839	1.774	32.300
2018	17.400	13.000	1.870	1.800	34.070
2019	17.900	14.000	1.900	1.800	35.600
2020	18.500	13.000	2.000	1.800	35.300
2021	20.500	13.000	3.100	1.940	38.540
2022	22.000	13.000	3.250	2.300	40.550
2023	22.000	13.000	3.318	2.300	40.618

Kaynak: TÜİK, 2024

Iğdır ili kayısı üretim alanının, ilçelere dağılımı 2004-2023 yılları arasında incelenmiştir. Iğdır ilinde 2004 yılında 2.520 ton olan kayısı üretim miktarı 2023 yılında 38.441 tona yükselmiştir. Iğdır ilinde, 2014 yılında yaşanan ilkbahar geç donları nedeniyle hava sıcaklıklarının mevsim normallerinin üzerinde seyretmesinden kaynaklı kayısı üretimi gerçekleşmemiştir (Anonim, 2014). Iğdır ilinde 2023 yılında Merkez ilçede kayısı üretim miktarı 19.642 ton, Tuzluca'da 14.808 ton, Karakoyunlu'da 2.941 ton ve Aralık'ta 1.050 ton'dur. (Çizelge 5).

Çizelge 5. Iğdır ili kayısı üretim miktarının ilçelere dağılımı (ton)

Yıllar	Merkez	Tuzluca	Karakoyunlu	Aralık	Iğdır
2004	0	2.520	0	0	2.520
2005	10.542	3.600	448	440	15.030
2006	10.075	4.800	448	400	15.723
2007	4.456	4.224	394	352	9.426
2008	8.845	4.300	540	400	14.085
2009	11.516	5.226	640	400	17.782
2010	3.298	5.524	100	300	9.222
2011	7.328	4.005	384	346	12.063
2012	9.863	5.563	1.944	385	17.755
2013	11.496	6.418	2.062	366	20.342
2014	0	0	0	0	0
2015	15.080	20.000	2.000	464	37.544
2016	8.977	20.036	1.880	436	31.329
2017	11.481	17.865	1.702	368	31.416
2018	13.225	20.673	1.888	408	36.194
2019	15.004	22.276	1.904	474	39.658
2020	17.130	20.619	1.974	484	40.207
2021	21.360	18.000	2.364	1.265	42.989
2022	20.926	16.235	2.447	1.236	40.844
2023	19.642	14.808	2.941	1.050	38.441

Kaynak: TÜİK, 2024

Iğdır ilinde 2004 yılında ortalama 162,48 kg/da olan kayısı verimi 2023 yılında 946,40 kg/da'a yükselmiştir. Kayısı dikim alanı bakımından 2023 yılında ikinci sırada yer alan Tuzluca ilçesi, kayısı verimi bakımından 1.139,08 kg/da verim ile ilk sırada yer almaktadır.

Aynı yıl itibariyle Merkez ilçede 892,82 kg/da, Karakoyunlu'da 886,38 kg/da ve Aralık'ta 456,52 kg/da kayısı verimi vardır (Çizelge 6).

Çizelge 6. Iğdır ili kayısı veriminin ilçelere dağılımı (kg/da)

Yıllar	Tuzluca	Merkez	Karakoyunlu	Aralık	Iğdır
2004	420,00	0,00	0,00	0,00	162,48
2005	600,00	1.306,32	2.488,89	440,00	985,57
2006	800,00	1.248,45	2.488,89	444,44	1.037,82
2007	704,00	550,80	2.188,89	391,11	621,36
2008	7.166,67	1.078,66	30.000,00	666,67	1.495,54
2009	8.710,00	1.387,47	35.555,56	666,67	1.868,25
2010	905,57	392,62	116,28	504,20	578,00
2011	616,15	842,30	384,00	765,49	724,42
2012	855,85	1.095,89	741,98	851,77	956,01
2013	979,55	1.253,24	780,76	802,63	1.080,76
2014	0,00	0,00	0,00	0,00	0,00
2015	1.666,67	1.160,00	1.197,60	1.017,54	1.384,06
2016	1.669,67	690,54	1.032,97	956,14	1.148,59
2017	1.426,92	710,15	925,50	207,44	972,63
2018	1.590,23	760,06	1.009,63	226,67	1.062,34
2019	1.591,14	838,21	1.002,11	263,33	1.113,99
2020	1.586,08	925,95	987,00	268,89	1.139,01
2021	1.384,62	1.041,95	762,58	652,06	1.115,44
2022	1.248,85	951,18	752,92	537,39	1.007,25
2023	1.139,08	892,82	886,38	456,52	946,40

Kaynak: TÜİK, 2024

Iğdır ili ve ilçelerinde kayısı yetiştiriciliği, incelenen yıllar itibariyle üretim ve verim bakımından artış göstermektedir. Yüksek oranda sofralık olarak üretilen kayısı, taze olarak piyasaya sunulmaktadır. Iğdır ili diğer üretim merkezlerine göre daha erken hasat edildiği için avantajlıdır. Ancak hasat süresinin kısa olması bölgenin dezavantajlarındandır. Çalışmanın sonuçlarına göre Iğdır ilinde kayısı yetiştiriciliği her geçen gün artmakta ve Iğdır ili için önemli istihdam ve gelir kaynağı olmaktadır.

Sonuç ve Öneriler

Bu çalışmada, Türkiye ve Iğdır ilinin kayısı üretimi gelişiminin ortaya konulması amaçlanmıştır. Iğdır ili iklim ve toprak şartları bakımından Doğu Anadolu bölgesinde meyve yetiştirilen önemli bir ildir. Bölgeye sağlayacağı istihdam ve gelir sebebiyle kayısı yetiştiriciliği önemlidir. Yıllar içerisinde dikim alanı ve verimi artan kayısı, Iğdır ilinde meyvelik tarımında önemli bir yer tutmaktadır.

- Kayısı yetiştiriciliğinde en önemli sorunlardan olan ilkbahar geç donlarının kontrol altına alınması için bahçe kurulacak yerlerin uzmanlar eşliğinde tespit edilmesi,
- Gübreleme ve ilaçlama sayısının daha kontrollü yapılması,
- Hasat sırasında meyvelerin ezilmemesi için özenli toplanması,
- Iğdır ilinde üretici örgütlenmesi eksikliği giderilerek pazarlama ve dağıtım sırasında karşılaşılan sorunların çözülmesi önemlidir.

Kayısı yetiştiriciliğinde karşılaşılan sorunlara yönelik politika yapıcı olan devletin; kayısı üretim standartları ile ilgili uygulamalı eğitim çalışmalarına ağırlık vermesi gerektiği düşünülmektedir.

Kaynaklar

Alım, M. & Kaya, G. (2005). Iğdır'da kayısı tarımı ve başlıca sorunları. Doğu Coğrafya Dergisi. 10(14), 47-65.

Anonim, (2004). Türkiye Ziraat Odaları Birliği Kayısı Raporu.

Anonim, (2014). T.C. Tarım ve Orman Bakanlığı. Erzincan Bahçe Kültürleri Araştırma Enstitüsü Müdürlüğü. Erişim adresi (28.11.2024): https://arastirma.tarimorman.gov.tr/erzincanbk/Sayfalar/Detay.aspx?OgeId=3&Liste=Haber.

Ertürk, Y. E., Geçer, M. K. & Karadaş, K. (2016). Iğdır ilinde kayısı üretimi ve pazarlaması. Meyve Bilimi, 1(Özel), 44-49.

Meteoroloji Genel Müdürlüğü (MGM), (2023). T.C. Çevre, Şehircilik ve İklim Değişikliği Bakanlığı. Iğdır, Ağrı ve Kars İllerimizin İklim ve Meteorolojik Analizi.

Paydaş Kargı, S., Kafkas, E. & Rehber Dikkaya, Y. (2015). Kayısı Yetiştiriciliği. TAGEP Proje No.: 5.2.3.2 Düşük Soğuklamalı Bazı Kayısı Çeşitlerinin KKTC Ekolojik Koşullarına Adaptasyonları.

Poyraz, S. & Gül, M. (2023). Technical examination and future of apricot production in Isparta, Turkiye. Scientific Papers Series Management, EconomicEngineering in Agriculture & Rural Development. 23(3), 738-755.

Sarıbaş, E. B. (2012). Türkiye Kayısı Sektörünün Ekonomik Analizi. Malatya İli Üzerine Bir Araştırma. Yüksek Lisans Tezi, İstanbul Üniversitesi Sosyal Bilimler Enstitüsü, İktisat Anabilim Dalı. 103s.

Türkiye İstatistik Kurumu (TÜİK). (2024). Bitkisel İstatistikleri. Erişim Adresi (28.11.2024): https://biruni.tuik.gov.tr/medas/?locale=tr

STRUCTURAL ANALYSIS OF GOAT BREEDING IN TÜRKİYE

TÜRKİYE'DE KEÇİ YETİŞTİRİCİLİĞİNİN YAPISAL ANALİZİ

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Özet
Keçinin sütünden, etinden, derisinden, kılından ve tiftiğinden faydalanılarak çok yönlü gelir elde edilmektedir. Keçi sadece insanların beslenmesi için değil tekstil sanayine de hammadde sağlaması bakımından önemlidir. Bu çalışmada, dünya ve Türkiye'de keçi varlığının gelişiminin ortaya konulması amaçlanmıştır. Ayrıca Türkiye'nin çeşitli illerinde ve bölgelerinde keçi yetiştiriciliğinin ekonomik analizinin yapıldığı araştırmalardan yararlanılarak keçi yetiştiriciliği yapan işletmelerin ekonomik özellikleri incelenmiştir. Keçi yetiştiriciliği ile ilgili istatistik kayıtları ve literatürde keçi yetiştiriciliği ile ilgili yapılmış olan bilimsel çalışmalar çalışmanın materyallerini oluşturmaktadır. Dünya ve Türkiye'de, yıllar içerisinde keçi varlığındaki gelişmeler basit indeks hesabı yapılarak incelenmiştir. Araştırma bulgularına göre 2022 yılı itibariyle dünyada toplam keçi varlığı içerisinde Türkiye'nin payı %1,01'dir. Türkiye keçi varlığı bakımından dünyada 22. sırada yer almaktadır. 1961 yılında %7,07 olan Türkiye'nin payı 2010 yılına kadar düşüş eğilimi göstermiş olup 2015 yılında artış ve bu yıldan sonra yatay bir seyir izlemiştir. Türkiye'de yetiştirilen keçi ırklarının yaklaşık %98,00'i kıl keçisi, %2,00'si ise tiftik keçisidir. 2023 yılı verilerine göre toplam büyükbaş ve küçükbaş hayvan varlığı içerisinde keçinin payı %14,94, et üretiminde keçinin payı %5,41 ve süt üretiminde keçinin payı %2,53'tür. Sadece küçükbaş hayvan varlığı içerisinde keçinin payı %19,68, et üretiminde keçinin payı %18,48 ve süt üretiminde keçinin payı %36,78'dir. Yapılan çalışmalarda keçi yetiştiriciliğinde ortalama değişen masrafların oranı %59,82, ortalama sabit masrafların oranı ise %40,52 olarak belirlenmiştir. Keçi yetiştiriciliğinin nispi kârı ise ortalama 1,49 olarak tespit edilmiştir. Buna göre keçi yetiştiriciliği yapan işletmeler 100 birimlik masraf karşılığında 149 birimlik gelir elde etmekte olup bunun 49 birimi kârdır. Keçi yetiştiriciliği kârlı bir üretim faaliyeti olmasına karşın sürdürülebilirliğini etkileyen bazı faktörler vardır. Bunlar; yem fiyatlarındaki artışlar, yetersiz mera alanları, çoban bulma konusunda yaşanılan sıkıntılar, genellikle işletmelerin küçük ölçekli ve dağınık olmaları, ürünlerin pazarlanması sırasında karşılaşılan sorunlardır. Bu sorunlara odaklanılması Türkiye'de keçi yetiştiriciliğinin sürdürülebilirliği için önemlidir.

Anahtar Kelimeler: Keçi, Kıl Keçisi, Titfik Keçisi, Yapısal Analiz, Türkiye

Abstract
Goat's milk, meat, skin, hair and mohair are utilized to generate multifaceted income. Goat is important not only for human nutrition but also for providing raw materials for the textile industry. In this study, it is aimed to reveal the development of goat existence in the world and Türkiye. In addition, the economic characteristics of goat breeding enterprises were examined by utilizing the research on the economic analysis of goat breeding in various provinces and regions of Türkiye. Statistical records on goat breeding and scientific studies on goat breeding in the literature constitute the materials of the study. The developments in the goat population in the world and Türkiye over the years were analyzed by simple index calculation. According to the research findings, Türkiye's share in the total goat population in the world as of 2022 is 1.01%. Türkiye ranks 22nd in the world in terms of goat production. Türkiye's share, which was 7.07% in 1961, showed a downward trend until 2010, increased in 2015 and followed a horizontal course after this year. Approximately 98.00% of the goat breeds raised in Türkiye are hair goats, and 2.00% are Angora goats. According to 2023 data, the share of goat in total bovine and ovine livestock is 14.94%, the share of goat in meat production is 5.41%, and the share of goat in milk production is 2.53%. The share of goat in small ruminant livestock is 19.68%, the share of goat in meat production is 18.48%, and the share of goat in milk production is 36.78%. In the studies conducted, the ratio of average variable costs in goat breeding was determined as 59.82% and the ratio of average fixed costs as 40.52%. The relative profit of goat breeding was determined as 1.49 on average. Accordingly, goat breeding enterprises earn 149 units of income in return for 100 units of expenses, of which 49 units are profit. Although goat breeding is a profitable production activity, there are some factors affecting its sustainability. These are increases in feed prices, insufficient pasture areas, difficulties in finding shepherds, small-scale and dispersed enterprises, and problems encountered during the marketing of products. Focusing on these problems is important for the sustainability of goat breeding in Türkiye.
Keywords: Goat, Hair Goat, Angora Goat, Structural Analysis, Türkiye

Giriş

Türkiye coğrafi ve tarımsal yapısı, doğal kaynakları, ekonomik şartları ve gelenekleri bakımından keçi yetiştiriciliğine elverişli bir ülkedir (Kaymakçı ve Engindeniz, 2010). Türkiye'de keçi yetiştiriciliği, genellikle orman içinde ve kenarlarında kalan bölgelerde, bitkisel üretime ve diğer hayvan türlerinin yetiştirilmesine pek uygun olmayan alanlarda yapılmaktadır (Dellal ve Dellal, 2005). Bu bölgelerde yaşayan halklar için keçi yetiştiriciliği önemli bir geçim kaynağı olmaktadır.

Türkiye'de keçi yetiştiriciliği yapan işletmelerin büyük çoğunluğu küçük ölçekli işletmeler olup bu işletmelerin öncelikli amacı peynir, yoğurt, çiğ süt gibi tüketimlerini işletme içinden karşılayabilmek ve tarımsal gelir elde edebilmektir (Engindeniz vd. 2015). Keçi yetiştiriciliği ile elde edilen ürünlerden özellikle sütünün besin değeri açısından zengin olması, son yıllarda keçi sütüne olan talebi artırmıştır (Algül Karadaş, 2023).

Keçi yetiştiriciliği yapan işletmelerin genellikle küçük ölçekli olması ve söz konusu işletmelerin tek geçim kaynağının bu olmasından dolayı işletmelerin kâr elde etmeleri önemlidir. Kârlılığın artırabilmek için ise keçi yetiştiriciliği yapan işletmelerin yapısal özelliklerinin saptanması, yetiştiricilikle ve pazarlamada karşılaştıkları sorunların tespiti ve bu sorunları çözme konusunda önerilerin geliştirilmesi önemlidir (Çıtak, 2011).

Bu çalışmada, dünya ve Türkiye'de keçi varlığının gelişiminin ortaya konulması amaçlanmıştır. Dünyada keçi varlığının gelişimi ülkelere göre, Türkiye'de ise illere göre incelenmiştir. Ayrıca Türkiye'nin çeşitli illerinde ve bölgelerinde keçi yetiştiriciliğinin ekonomik analizinin yapıldığı araştırmalardan yararlanılarak keçi yetiştiriciliği yapan işletmelerin ekonomik özellikleri incelenmiştir.

Materyal ve Metot

Çalışmanın ana materyalini dünyada ve Türkiye'deki keçi varlığı ve konu ile ilgili yapılmış çalışmalardan elde edilen ikincil veriler oluşturmaktadır. Bu veriler; Türkiye İstatistik Kurumu (TÜİK), Birleşmiş Milletler Gıda ve Tarım Örgütü (FAO), ulusal ve uluslararası literatürdeki keçi yetiştiriciliği ile ilgili bilimsel yayınlardan elde edilmiştir. Dünya ve Türkiye'de keçi varlığına ilişkin verilere basit indeks hesabı yapılarak yıllar itibariyle değişim incelenmiştir.

Araştırma Bulguları ve Tartışma

Dünyada keçi sayısı 2000-2022 yılları arasında incelenmiştir. 2000-2004 yıllarını kapsayan beş yıllık ortalamaya göre dünyada keçi sayısı 787 milyon 801 bin baş olup 2022 yılında 1 milyar 145 milyon 386 bin başa yükselmiştir. Keçi sayısı bakımından önemli ülkeler sıralandığında, ilk sırada Hindistan, ikinci sırada Çin ve üçüncü sırada Nijerya yer almaktadır. Aynı tarihler itibariyle Hindistan'da keçi sayısı 124 milyon 797 bin baştan, 149 milyon 994 bin başa yükselmiş, Çin'de keçi sayısı 148 milyon 267 bin baştan, 132 milyon 243 bin başa gerilemiş, Nijerya'da ise keçi sayısı 46 milyon 82 bin baştan, 88 milyon 37 bin başa yükselmiştir. Türkiye, dünya keçi sayısı bakımından yirmi ikinci sırada yer almaktadır. Keçi sayısı 2000-2004 yılları ortalamasına göre 7 milyon 110 bin baş olup 2022 yılında 11 milyon 578 bin başa yükselmiştir (Çizelge 1).

Çizelge 1. Dünyada keçi varlığı (1.000 baş)

Sıra	Ülkeler	2000-2004	2005-2009	2010-2014	2015-2019	2020	2021	2022
1	Hindistan	124.797	137.375	135.148	144.214	150.884	149.174	149.994
2	Çin	148.267	145.386	139.060	139.593	133.453	133.316	132.243
3	Nijerya	46.082	52.520	67.090	77.702	84.039	86.140	88.037
4	Pakistan	50.985	56.144	63.191	72.230	78.207	80.326	82.503
5	Bangladeş	36.800	45.480	54.260	56.527	58.343	59.178	60.000
6	Etiyopya	11.214	20.078	25.347	36.422	52.464	45.716	49.323
7	Çad	14.047	18.958	25.586	34.532	41.190	43.736	46.439
8	Kenya	11.493	21.742	26.235	27.847	36.021	32.570	34.530
9	Sudan	0	0	18.570	31.647	32.228	32.420	32.599
10	Mali	10.602	13.007	17.390	23.592	27.811	29.201	27.833
22	Türkiye	7.110	6.330	7.256	10.647	11.986	12.342	11.578
	Diğer ülkeler	326.405	362.931	372.473	397.462	415.270	420.661	430.308
	Dünya	787.801	879.952	951.607	1.052.415	1.121.895	1.124.781	1.145.386

Kaynak: FAO, 2024

Dünyada keçi varlığının gelişimi 2000-2004 yılları ortalaması baz alınarak incelendiğinde, keçi varlığı 2022 yılında %45,39 artış göstermiştir. İlgili yıllar arasında keçi varlığı Etiyopya'da %339,84, Çad'da %230,60, Kenya'da %200,45, Mali'de %162,53, Nijerya'da %91,04, Bangladeş'te %63,04, Türkiye'de %62,85, Pakistan'da %61,82, Hindistan'da %20,19 artış göstermiştir. Çin'de ise %10,81 oranında azalış göstermiştir. Sudan'da ise 2010-2014 yılları baz alındığında keçi varlığı %75,55 oranında artmıştır (Çizelge 2).

Çizelge 2. Dünyada keçi varlığının gelişimi (2000-2004=100)

Sıra	Ülkeler	2000-2004	2005-2009	2010-2014	2015-2019	2020	2021	2022
1	Hindistan	100,00	110,08	108,29	115,56	120,90	119,53	120,19
2	Çin	100,00	98,06	93,79	94,15	90,01	89,92	89,19
3	Nijerya	100,00	113,97	145,59	168,62	182,37	186,93	191,04
4	Pakistan	100,00	110,12	123,94	141,67	153,39	157,55	161,82
5	Bangladeş	100,00	123,59	147,45	153,61	158,54	160,81	163,04
6	Etiyopya	100,00	179,05	226,04	324,79	467,85	407,67	439,84
7	Çad	100,00	134,96	182,15	245,84	293,24	311,36	330,60
8	Kenya	100,00	189,18	228,27	242,30	313,42	283,40	300,45
9	Sudan*	-	-	100,00	170,42	173,55	174,58	175,55
10	Mali	100,00	122,69	164,03	222,53	262,32	275,44	262,53
22	Türkiye	100,00	89,03	102,06	149,75	168,58	173,59	162,85
	Diğer ülkeler	100,00	111,19	114,11	121,77	127,23	128,88	131,83
	Dünya	100,00	111,70	120,79	133,59	142,41	142,77	145,39

Kaynak: FAO, 2024, *2010-2014=100 (Araştırmacı tarafından hesaplanmıştır)

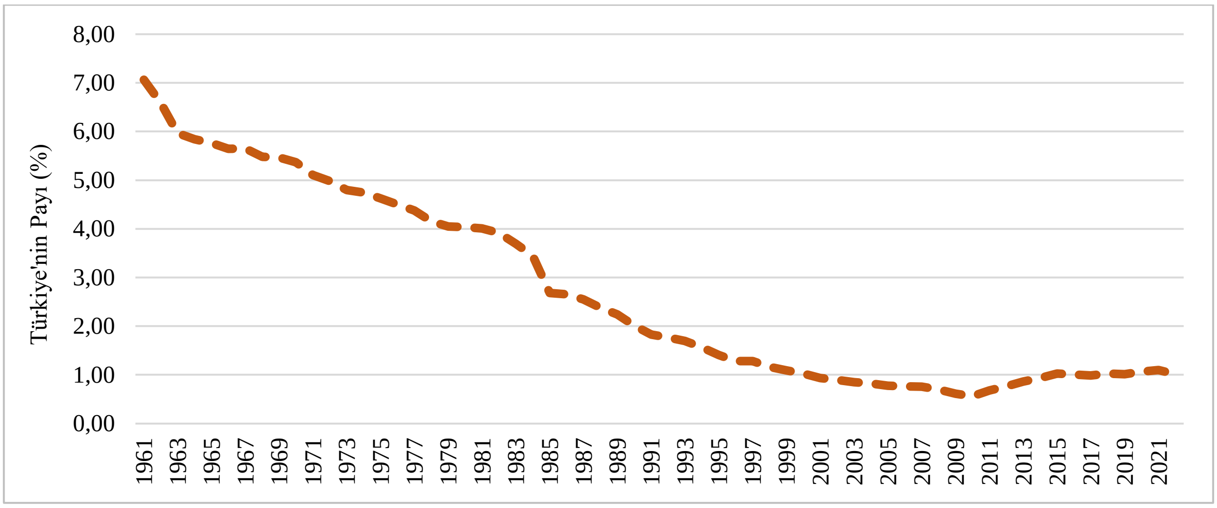
Dünyada keçi varlığının ülkelere göre dağılımları yıllara göre incelendiğinde, ilk sırada yer alan Hindistan'da %15,84'den %13,10'a, ikinci sırada yer alan Çin'de %18,82'den %11,55'e gerilemiştir. Üçüncü sırada yer alan Nijerya'da %5,85'den %7,69'a, dördüncü sırada yer alan Pakistan'da ise %6,47'den %7,20'ye çıkmıştır. Türkiye'de ise %0,72 ile %1,10 arasında değişmekte olup 2022 yılında %1,01 olarak gerçekleşmiştir (Çizelge 3).

Çizelge 3. Dünyada keçi varlığının ülkelere göre dağılımı (%)

Sıra	Ülkeler	2000-2004	2005-2009	2010-2014	2015-2019	2020	2021	2022
1	Hindistan	15,84	15,61	14,20	13,70	13,45	13,26	13,10
2	Çin	18,82	16,52	14,61	13,26	11,90	11,85	11,55
3	Nijerya	5,85	5,97	7,05	7,38	7,49	7,66	7,69
4	Pakistan	6,47	6,38	6,64	6,86	6,97	7,14	7,20
5	Bangladeş	4,67	5,17	5,70	5,37	5,20	5,26	5,24
6	Etiyopya	1,42	2,28	2,66	3,46	4,68	4,06	4,31
7	Çad	1,78	2,15	2,69	3,28	3,67	3,89	4,05
8	Kenya	1,46	2,47	2,76	2,65	3,21	2,90	3,01
9	Sudan	0,00	0,00	1,95	3,01	2,87	2,88	2,85
10	Mali	1,35	1,48	1,83	2,24	2,48	2,60	2,43
22	Türkiye	0,90	0,72	0,76	1,01	1,07	1,10	1,01
	Diğer ülkeler	41,43	41,24	39,14	37,77	37,02	37,40	37,57
	Dünya	100,00	100,00	100,00	100,00	100,00	100,00	100,00

Kaynak: FAO, 2024, (Araştırmacı tarafından hesaplanmıştır)

Dünya keçi varlığı içerisinde Türkiye'deki keçi varlığının payları 1961-2022 yılları itibariyle incelendiğinde, 1961 yılında Türkiye'nin payı %7,07 olup, 1970 yılında %5,37'ye, 1980 yılında %4,04'e, 1990 yılında %2,01'e, 2000 yılında %1,02'ye ve 2022 yılında %1,01'e gerilemiştir. Bu yıllar içerisinde Türkiye'deki keçi varlığı yaklaşık %53,00 azalmasından ve dünya keçi varlığının %228,55 artmasından dolayı dünya keçi varlığı içerisinde Türkiye'deki keçi varlığının payı ciddi derecede gerilemiştir (Şekil 1).



Şekil 1. Keçi sayısı bakımından dünyada Türkiye'nin payı (FAO, 2024)

Türkiye'de keçi sayısı; kıl keçisi ve tiftik keçisi olarak 2000-2023 yılları arasında incelenmiştir. 2000-2004 yıllarını kapsayan beş yıllık ortalamaya göre Türkiye'de kıl keçi sayısı 6 milyon 584 bin baş, tiftik keçisi 293 bin baş olup toplamda 6 milyon 877 bin baş olarak gerçekleşmiştir. Aynı dönemde toplam keçi varlığının içerisinde kıl keçisinin payı %95,74, tiftik keçisinin payı %4,26'dır. 2023 yılında kıl keçisi varlığı %53,30 artarak 10 milyon 93 bin başa yükselmiş, tiftik keçisi varlığı %28,28 azalarak 210 bin başa gerilemiştir. Toplam keçi varlığı ise %49,82 artarak 10 milyon 303 bin baş olarak gerçekleşmiştir. 2023 yılında toplam keçi varlığının içerisinde kıl keçisinin payı %97,96'ya çıkmış, tiftik keçisinin payı %2,04'e gerilemiştir (Çizelge 4).

Çizelge 4. Türkiye'de keçi varlığının gelişimi

Ülkeler	2000-2004	2005-2009	2010-2014	2015-2019	2020	2021	2022	2023
				1.000 baş				
Kıl keçisi	6.584	5.846	8.139	10.486	11.699	12.052	11.320	10.093
Tiftik keçisi	293	188	161	219	287	290	258	210
Toplam	6.877	6.034	8.300	10.705	11.986	12.342	11.578	10.303
				2000-2004=100				
Kıl keçisi	100,00	88,79	123,61	159,27	177,69	183,05	171,94	153,30
Tiftik keçisi	100,00	64,06	55,00	74,67	97,93	98,80	87,91	71,72
Toplam	100,00	87,74	120,69	155,66	174,29	179,46	168,36	149,82
				Pay (%)				
Kıl keçisi	95,74	96,89	98,06	97,96	97,61	97,65	97,77	97,96
Tiftik keçisi	4,26	3,11	1,94	2,04	2,39	2,35	2,23	2,04
Toplam	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00

Kaynak: TÜİK, 2024

Türkiye'de keçi varlığı, keçi sayısı bakımından önde gelen illere göre incelendiğinde 2004-2023 yılları arasında 5 milyon 128 bin baş ile 12 milyon 342 bin baş arasında değişmektedir. İlk sırada yer alan Mersin ilinde keçi sayısı 2009 yılında 291 bin başa kadar gerilemiş olup 2020 yılında 997 bin başa kadar çıkmıştır. Mersin ilinde 2023 yılında keçi sayısı 778 bin baştır. İkinci sırada yer alan Antalya ilinde keçi sayısı 2008 yılında 345 bin başa kadar gerilemiş olup 2021 yılında 846 bin başa kadar çıkmıştır. Antalya ilinde 2023 yılında keçi sayısı 648 bin baştır. Üçüncü sırada yer alan Siirt ilinde ise keçi sayısı 2004 yılında 137 bin baş olup 2018 yılında 507 bin başa kadar yükselmiştir. Siirt ilinde 2023 yılında keçi sayısı 494 bin baştır (Çizelge 5).

Çizelge 5. Türkiye'de keçi varlığı (1.000 baş)

Yıllar/İller	Mersin	Antalya	Siirt	Şırnak	Mardin	Adana	Diğer iller	Türkiye
2004	411	560	137	150	128	227	4.997	6.610
2005	400	547	138	174	139	203	4.917	6.517
2006	405	512	146	196	186	186	5.011	6.643
2007	355	493	149	204	137	148	4.801	6.286
2008	339	345	155	185	121	124	4.325	5.594
2009	291	357	140	165	182	125	3.868	5.128
2010	557	419	309	179	316	173	4.340	6.293
2011	617	470	279	188	311	182	5.231	7.278
2012	660	513	310	181	345	349	5.999	8.357
2013	640	538	360	255	379	384	6.670	9.226
2014	773	629	405	301	386	412	7.439	10.345
2015	763	654	454	270	406	372	7.496	10.416
2016	754	702	465	265	385	371	7.403	10.345
2017	756	687	481	472	440	417	7.383	10.635
2018	755	752	507	493	430	428	7.557	10.922
2019	920	753	377	491	433	440	7.791	11.205
2020	997	771	491	567	462	429	8.269	11.986
2021	911	846	490	535	461	489	8.609	12.342
2022	857	763	472	541	442	440	8.061	11.578
2023	778	648	494	438	406	389	7.149	10.303

Kaynak: TÜİK, 2024

Türkiye'de keçi varlığının gelişimi 2004 yılı baz alınarak incelendiğinde, keçi varlığı 2023 yılında %55,87 artış göstermiştir. İlgili yıllar arasında keçi varlığı Siirt'te %259,92, Mardin'de %217,67, Şırnak'ta %192,87, Mersin'de %89,28, Adana'da %71,61, Antalya'da %15,56 artış göstermiştir. Baz yılına göre Türkiye'de keçi varlığı 2009 yılında %22,42 azalmış ve bu yıldan 2021 yılına kadar artış eğilimi göstermiştir. 2022 ve 2023 yıllarında tekrar düşüş eğilimi görülmektedir (Çizelge 6).

Çizelge 6. Türkiye'de keçi varlığının gelişimi (2004=100)

Yıllar/İller	Mersin	Antalya	Siirt	Şırnak	Mardin	Adana	Diğer iller	Türkiye
2004	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00
2005	97,30	97,63	100,28	116,09	108,86	89,54	98,40	98,60
2006	98,65	91,40	106,65	130,88	145,52	81,93	100,29	100,50
2007	86,28	87,91	108,76	136,27	107,28	65,04	96,08	95,10
2008	82,46	61,50	112,74	123,55	94,72	54,74	86,55	84,62
2009	70,87	63,79	101,83	110,40	142,24	55,12	77,40	77,58
2010	135,57	74,81	224,99	119,22	247,47	76,43	86,85	95,21
2011	150,16	83,87	203,32	125,31	243,29	80,13	104,69	110,11
2012	160,69	91,48	225,71	120,88	270,40	153,70	120,06	126,44
2013	155,82	95,94	262,36	170,19	296,37	169,07	133,49	139,57
2014	188,09	112,28	294,51	201,18	301,95	181,68	148,87	156,51
2015	185,79	116,77	330,88	180,39	317,40	164,10	150,01	157,58
2016	183,58	125,20	338,90	176,84	301,20	163,46	148,16	156,51
2017	183,88	122,54	349,94	315,04	344,58	183,85	147,74	160,89
2018	183,73	134,15	369,37	329,40	336,89	188,50	151,23	165,24
2019	223,77	134,34	274,65	328,18	339,25	193,87	155,92	169,52
2020	242,53	137,52	357,68	378,79	361,68	189,06	165,48	181,33
2021	221,77	150,90	356,83	357,49	360,80	215,55	172,29	186,71
2022	208,66	136,18	343,89	361,41	346,10	194,12	161,32	175,16
2023	189,28	115,56	359,92	292,87	317,67	171,61	143,08	155,87

Kaynak: TÜİK, 2024, *2004=100 (Araştırmacı tarafından hesaplanmıştır)

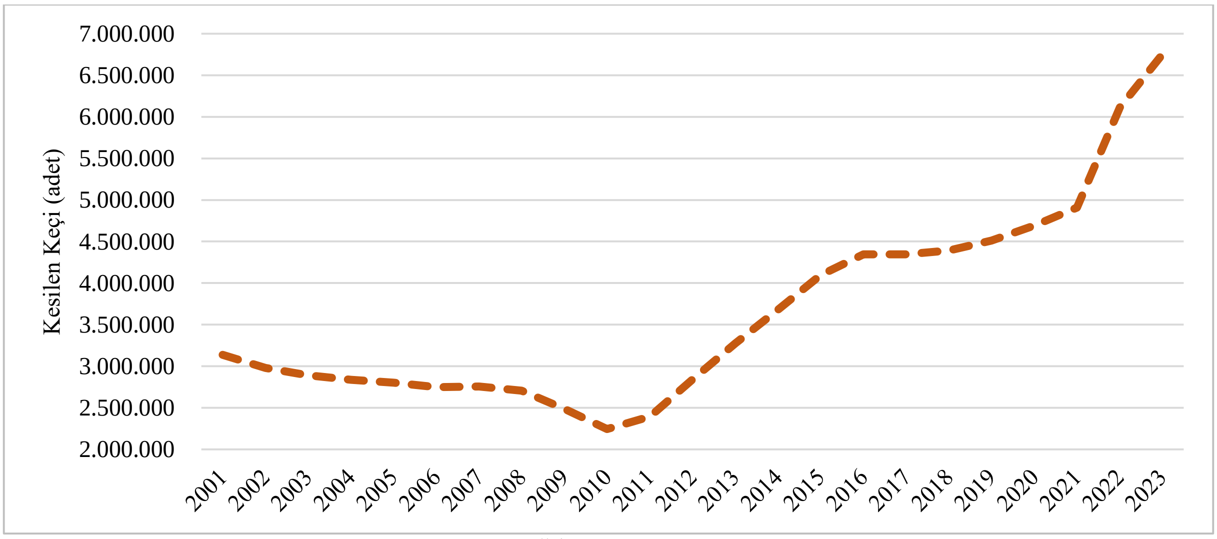
Türkiye'de keçi varlığının illere göre dağılımları yıllar itibariyle incelendiğinde, ilk sırada yer alan Mersin ilinin payı 2004 yılında %6,22 iken 2023 yılında %7,55 olarak, ikinci sırada yer alan Antalya ilinin payı 2004 yılında %8,48 iken 2023 yılında %6,29 olarak gerçekleşmiştir. Üçüncü sırada yer alan Şırnak'ta bu oranlar %2,27'den %4,26'ya, dördüncü sırada yer alan Mardin'de %1,93'den %3,94'e ve beşinci sırada yer alan Adana'da %3,43'ten %3,78'e yükselmiştir. Diğer illerin payları ise %75,60'dan %69,39'a gerilemiştir (Çizelge 7).

Çizelge 7. Türkiye'de keçi varlığının illere göre dağılımı (%)

Yıllar/İller	Mersin	Antalya	Siirt	Şırnak	Mardin	Adana	Diğer iller	Türkiye
2004	6,22	8,48	2,08	2,27	1,93	3,43	75,60	100,00
2005	6,13	8,39	2,11	2,67	2,13	3,12	75,44	100,00
2006	6,10	7,71	2,21	2,95	2,80	2,80	75,44	100,00
2007	5,64	7,84	2,38	3,25	2,18	2,35	76,37	100,00
2008	6,06	6,16	2,77	3,31	2,16	2,22	77,32	100,00
2009	5,68	6,97	2,73	3,22	3,54	2,44	75,42	100,00
2010	8,85	6,66	4,91	2,84	5,02	2,76	68,96	100,00
2011	8,48	6,46	3,84	2,58	4,27	2,50	71,88	100,00
2012	7,90	6,13	3,71	2,17	4,13	4,17	71,78	100,00
2013	6,94	5,83	3,91	2,76	4,10	4,16	72,30	100,00
2014	7,47	6,08	3,91	2,91	3,73	3,98	71,91	100,00
2015	7,33	6,28	4,36	2,59	3,89	3,57	71,96	100,00
2016	7,29	6,78	4,50	2,56	3,72	3,59	71,56	100,00
2017	7,10	6,46	4,52	4,44	4,14	3,92	69,42	100,00
2018	6,91	6,88	4,64	4,52	3,94	3,92	69,19	100,00
2019	8,21	6,72	3,37	4,38	3,87	3,93	69,53	100,00
2020	8,31	6,43	4,10	4,73	3,86	3,58	68,99	100,00
2021	7,38	6,85	3,97	4,34	3,74	3,96	69,76	100,00
2022	7,41	6,59	4,08	4,67	3,82	3,80	69,63	100,00
2023	7,55	6,29	4,80	4,26	3,94	3,78	69,39	100,00

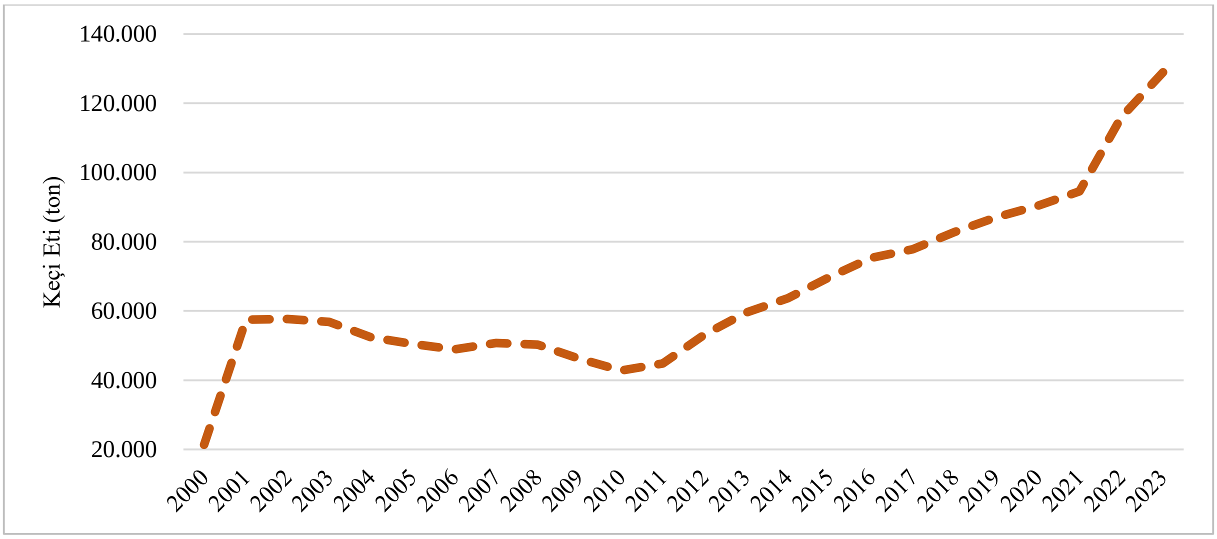
Kaynak: TÜİK, 2024, (Araştırmacı tarafından hesaplanmıştır)

Türkiye'de 2001 yılından itibaren kesilen keçi sayısı incelendiğinde, 2 milyon 245 bin baş ile 6 milyon 754 bin baş arasında değiştiği belirlenmiştir. En yüksek değer 2023 yılından, en düşük değer ise 2010 yılında gerçekleşmiştir. Kesilen keçi sayısı 2001 yılından 2010 yılına kadar azalış eğilimi göstermiş, 2011 yılından 2023 yılına kadar düzenli olarak artmıştır (Şekil 2).



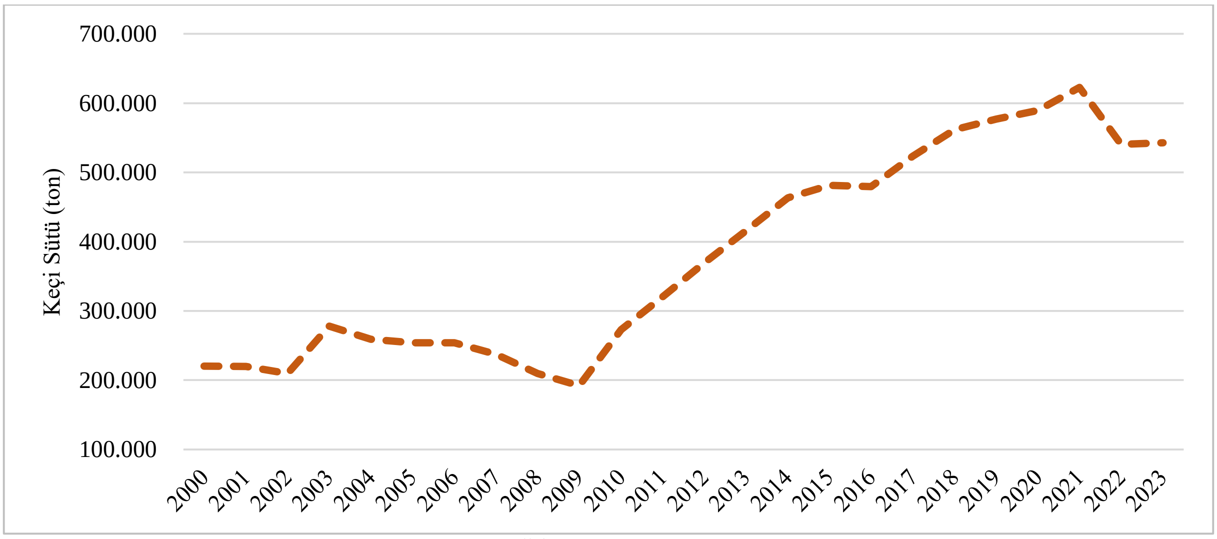
Şekil 2. Türkiye'de kesilen keçi sayısı (TÜİK, 2024)

Türkiye'de keçi eti üretimi 2000 yılında 21 bin 395 ton olup 2023 yılında yaklaşık 6 kat artarak 128 bin 989 tona yükselmiştir. İncelenen yıllar itibariyle keçi eti üretimi 2001 yılından 2010 yılına kadar azalan bir seyir izlemiş bu tarihten sonra ise artan bir seyir izlemiştir. En yüksek değerine 2023 yılında ulaşmıştır (Şekil 3).



Şekil 3. Türkiye'de keçi eti üretimi (TÜİK, 2024)

Türkiye'de keçi sütü üretimi 2000 yılında 220 bin 211 ton olup 2023 yılında 2,47 kat artarak 543 bin 58 tona yükselmiştir. İncelenen yıllar itibariyle keçi sütü üretimi 2009 yılından 2021 yılına kadar artan bir seyir izlemiş bu tarihten sonra ise azalış eğilimine geçmiştir. İncelenen yıllar arasında keçi sütü üretiminin en düşük değeri 2009 yılında 192 bin 210 ton olarak ve en yüksek değeri 2021 yılında 622 bin 785 ton olarak gerçekleşmiştir (Şekil 4).



Şekil 4. Türkiye'de keçi sütü üretimi (TÜİK, 2024)

Keçi yetiştiriciliğinde masraf ve kârlılık durumu, yapılan çalışmaların veri toplama yılları farklı olması sebebi ile oransal olarak incelenmiştir. Keçi yetiştiriciliğinde değişen masrafların oranı %33,55 ile %81,34 arasında değişmekte olup ortalama %59,82 olarak belirlenmiştir. Sabit masraflar ise %18,66 ile %66,45 arasında değişmekte olup ortalama %40,52 olarak tespit edilmiştir. Keçi yetiştiriciliğinde nispi kâr Aksaray ilinde 1,44, Çanakkale illerinde 1,09 ve

1,35, Balıkesir ilinde 1,12, İzmir ilinde 1,52, Batı Akdeniz Bölgesi'nde 1,91, Kahramanmaraş ilinde 1,40 ve Antalya ilinde 2,06 olarak hesaplanmıştır. Yapılan çalışmalar içerisinde en kârlı bölge Antalya ili olmuştur. Keçi yetiştiriciliğinde ortalama nispi kâr 1,49 olarak belirlenmiştir. Buna göre keçi yetiştiriciliği yapan işletmeler elde ettikleri gelir ile masraflarını karşıladıkları ve işletmelerin kâr ettikleri tespit edilmiştir (Çizelge 8).

Çizelge 8. Keçi yetiştiriciliğinde masraf ve kârlılık durumu

Yapılan çalışmalar	Değişen masraf (%)	Sabit masraf (%)	Nispi kâr
*Aksaray[1]	81,34	18,66	1,44
*Çanakkale[2]	67,09	35,31	1,09
*Balıkesir[3]	71,32	28,68	1,12
*Çanakkale[3]	76,70	23,30	1,35
*İzmir[3]	69,26	30,74	1,52
*Batı Akdeniz Bölgesi[4]	33,55	66,45	1,91
**Kahramanmaraş[5]	42,77	57,23	1,40
**Antalya[6]	58,06	41,94	2,06
Ortalama	59,82	40,52	1,49

*Sadece keçi için maliyet hesaplaması yapılmış, **İşletmedeki tüm ürünler için maliyet hesaplaması yapılmıştır.
1. Bakırtaş, 2017; 2. Gökdai, 2019; 3. Engindeniz vd., 2015; 4. Yılmaz, 2019; 5. Paksoy, 2007; 6. Dellal, 2000.

Keçi yetiştiriciliğinde üreticilerin en çok karşılaştıkları sorunlar; Kahramanmaraş ilinde %78,90 ile yeterli yem bulamama (Paksoy, 2007), Aksaray ilinde %27,04 ile girdi temini (Bakırtaş, 2017), Mersin ilinde %32,90 ile yeterli yem bulamama (Aydoğan, 2019), Batı Akdeniz Bölgesi'nde girdi fiyatlarının yüksekliği (Yılmaz, 2019), Balıkesir ilinde %84,93, Çanakkale ilinde %88,00, İzmir ilinde %85,25 ile yem tedariki ve maliyet yüksekliği (Engindeniz vd., 2015), Çanakkale ilinde yapılan bir başka çalışmada ise %59,80 ile süt fiyatlarının düşüklüğü (Gökdai, 2019) olarak tespit edilmiştir.
Yapılan çalışma sonuçlarında da ortaya konulduğu üzere yem fiyatlarındaki artışlara bağlı olarak girdi temininde yaşanılan sorunlar, yetersiz mera alanları, çoban bulma konusunda yaşanılan sıkıntılar, işletmelerin genellikle küçük ölçekli ve dağınık olmaları, ürünlerin pazarlanması sırasında karşılaşılan sorunlar Türkiye'de keçi yetiştiriciliğinin temel sorunlarıdır.

Sonuç ve Öneriler

Bu çalışmada, dünya ve Türkiye'de keçi varlığının gelişiminin ortaya konulması amaçlanmıştır. Ayrıca Türkiye'deki keçi yetiştiriciliğinin yapısal analizi üzerine bir inceleme yapılmıştır. Keçinin sütünden, etinden, derisinden, kılından ve tiftiğinden faydalanılarak çok yönlü gelir elde edilmektedir. Sadece insanların beslenmesi için değil tekstil sanayine de hammadde sağlaması bakımından önemlidir. Yapılan çalışma sonuçlarına göre keçi yetiştiriciliğinin kârlı bir üretim faaliyeti olduğu ancak üretimde karşılaşılan bazı sorunların olduğu belirlenmiştir. Sektörün sürdürülebilirliği açından şu öneriler geliştirilmiştir.

- Örgütlenme yoluna gidilerek çiftçilerin uygun vade oranları ve fiyatlarla yem temin edebilirler. Örgütlerin amacına uygun olarak etkin ve etkili şekilde çalışıp çalışmadıkları ise ilgili kurumlar tarafından denetlenmelidir.
- Mevcut meralar ıslah edilerek aşırı otlatılmanın önüne geçilebilir ve yeni mera alanları tahsis edilebilir.
- Çobanlık mesleği için sosyal imkânlar sağlanabilir ve mesleğe olan talep hem ekonomik hem sosyal olarak iyileştirilebilir.
- Küçük ölçekli ve dağınık olan işletmeler kooperatif veya birlik yolu ile bir araya gelerek hem maliyet avantajı elde edebilirler hem düşük faizli krediye daha rahat ulaşabilirler.

- Keçi ürünleri pazarlanırken markalaşma yoluna gidilerek ürünlerin değeri ve ürünlere olan talep artabilir.

Keçi yetiştiriciliğinde sıklıkla karşılaşılan sorunlara yönelik geliştirilen çözüm önerilerinin uygulanması sektörün sürdürülebilirliği açısından önemlidir.

Kaynaklar

Algül Karadaş, P. (2023). Halk Elinde Küçükbaş Hayvan Islahı Ülkesel Projesi Kapsamında Ankara (Tiftik) Keçisi Alt Projelerinde Yer Alan Yetiştiricilerin Sosyo-Ekonomik Yapılarının Belirlenmesi. Yüksek Lisans Tezi, Kırşehir Ahi Evran Üniversitesi Fen Bilimleri Enstitüsü, Tarım Ekonomisi Anabilim Dalı. 88s.

Aydoğan, İ. (2019). Mersin İlinde Kıl Keçisi Yetiştiriciliği Yapan İşletmelerin Özellikleri. Yüksek Lisans Tezi, Kahramanmaraş Sütçü İmam Üniversitesi Fen Bilimleri Enstitüsü, Tarım Ekonomisi Anabilim Dalı. 65s.

Bakırtaş, Ş. (2017). Aksaray İlinde Keçi Yetiştiren İşletmelerin Teknik ve Sosyo-Ekonomik Analizi. Yüksek Lisans Tezi, Selçuk Üniversitesi Sağlık Bilimleri Enstitüsü, Hayvancılık Ekonomisi ve İşletmeciliği Anabilim Dalı. 106s.

Birleşmiş Milletler Gıda ve Tarım Örgütü (FAO). (2024). Livestock Products Statistics. Erişim Adresi (15.11.2024): https://www.fao.org/faostat/en/#data/QCL.

Çıtak, D. (2011). Keçi Yetiştiren Tarım İşletmelerinin Ekonomik Analizi: Çanakkale İli Merkez İlçe Örneği. Yüksek Lisans Tezi, Çanakkale Onsekiz Mart Üniversitesi Fen Bilimleri Enstitüsü, Tarım Ekonomisi Anabilim Dalı. 85s.

Dellal, İ. & Dellal, G. (2005). Türkiye keçi yetiştiriciliğinin ekonomisi. Süt Keçiciliği Ulusal Kongresi, 26-27 Mayıs, İzmir. s, 39-48.

Dellal, İ. (2000). Antalya İlinde Kıl Keçisi Yetiştiriciliğine Yer Veren Tarım İşletmelerinin Ekonomik Analizi ve Planlaması. Doktora Tezi, Ankara Üniversitesi Fen Bilimleri Enstitüsü, Tarım Ekonomisi Anabilim Dalı. 130s.

Engindeniz, S., Savran, A. F., Aktürk, D., Koşum, N., Taşkın, T., Kesenkaş, H., Gökmen, M., Uzmay, A., (2015). İzmir, Çanakkale ve Balıkesir İllerinde Güvenli Keçi Sütü ve Ürünleri Üretiminin Geliştirilmesi ve Alternatif Pazar Olanaklarının Saptanması. TÜBİTAK, Program Kodu: 1001.

Gökdai, A. (2019). Çanakkale İli Saanen Keçi İşletmelerinin Teknik ve Ekonomik Analizi. Doktora Tezi, Selçuk Üniversitesi Sağlık Bilimleri Enstitüsü, Hayvan Sağlığı Ekonomisi ve İşletmeciliği Anabilim Dalı. 221s.

Kaymakçı, M. & Engindeniz, S. (2010). Türkiye keçi yetiştiriciliği: Sorunlar ve teknik-ekonomik çözümler. Ulusal Keçicilik Kongresi, 24-26 Haziran, Çanakkale. s, 1-25.

Paksoy, M. (2007). Kahramanmaraş İlinde Süt Üretimine Yönelik Keçi Yetiştiriciliğine Yer Veren Tarım İşletmelerinin Ekonomik Analizi. Doktora Tezi, Ankara Üniversitesi Fen Bilimleri Enstitüsü, Tarım Ekonomisi Anabilim Dalı. 146s.

Türkiye İstatistik Kurumu (TÜİK). (2024). Hayvancılık İstatistikleri. Erişim Adresi (15.11.2024): https://biruni.tuik.gov.tr/medas/?kn=101&locale=tr.

Yılmaz, Ş. G. (2019). Küçükbaş Hayvan İşletmelerinin Sosyo-Ekonomik Analizi ve Etkinliği: Batı Akdeniz Bölgesi Örneği. Doktora Tezi, Isparta Uygulamalı Bilimler Üniversitesi Lisansüstü Eğitim Enstitüsü, Tarım Ekonomisi Anabilim Dalı. 356s.

USE AND BENEFITS OF BIOFERTILIZERS

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ABSTRACT
Biofertilizers emerge as an eco-friendly alternative capable of replacing chemical fertilizers in agricultural production. The primary components of biofertilizers consist of biologically derived microorganisms that promote plant growth and improve soil health. When applied to the soil, these fertilizers enable plants to absorb nitrogen, phosphorus, and other nutrients more effectively. Nitrogen-fixing bacteria, in particular, live symbiotically in plant roots, converting atmospheric nitrogen into a form accessible to plants. Similarly, phosphate-solubilizing microorganisms break down phosphorus bound in the soil, making it available to plants. The use of biofertilizers reduces soil and water pollution caused by chemical fertilizers, protects environmental health, and ensures sustainable soil fertility. Furthermore, biofertilizers enhance the organic matter content in the soil, support microbial activity, and improve soil structure. This improvement boosts the soil's water retention capacity and enhances the aeration of plant roots. Regular application of biofertilizers not only accelerates plant growth but also increases plants' resistance to diseases, thereby improving crop quality. The widespread adoption of biofertilizers plays a role in reducing farmers' costs while supporting sustainability in agriculture. The purpose of this review is to explain the use of biofertilizers in agricultural production and highlight the contributions of this practice to the environment, soil health, and productivity.
Keywords: Biofertilizer, Crop Quality, Nitrogen Fixation, Soil Fertility

INTRODUCTION
The rapid growth of the global population has necessitated the widespread use of chemical fertilizers in agricultural production. However, this practice has brought numerous issues, including environmental degradation and economic challenges. The increasing global demand for food has shifted modern agricultural practices toward more efficient and sustainable methods. Yet, the intensive use of chemical fertilizers poses significant risks to both the environment and human health. Issues such as soil and water pollution, long-term loss of agricultural land productivity, and increased greenhouse gas emissions are just a few examples. Moreover, excessive use of chemical fertilizers disrupts the natural microbial balance of the soil, weakening plants' defense mechanisms against pests and diseases. These impacts highlight the urgency of implementing sustainable agricultural practices and environmentally friendly alternatives.

Biofertilizers have emerged as a natural and sustainable solution to minimize environmental impacts and enhance agricultural productivity. The purpose of this review is to emphasize the positive effects of biofertilizers on soil and plant health and to explain how these methods, which enhance the nitrogen cycle and nutrient availability for plants, address environmental challenges.

BIOFERTILIZERS

The rising global population and the resulting demand for food have made the use of chemical fertilizers in agricultural production almost unavoidable. However, this practice has led to significant environmental and economic challenges. The intensive application of chemical fertilizers not only provides essential nutrients for plant growth but also contributes to greenhouse gas emissions, groundwater pollution, and negative impacts on agricultural economies (Peng et al., 2022). These challenges underscore the importance of adopting new and environmentally friendly approaches in agricultural practices. Similarly, excessive fertilization is known to disrupt the natural structure of the soil, weakening plants' defense systems and making them more vulnerable to pests and diseases. Additionally, the leaching of unused nitrogen into groundwater poses pollution risks that threaten human and animal health (Prather et al., 2012).

Given nitrogen's critical role in agricultural production, its cycle in the soil is of utmost importance. Nitrogen, one of the most crucial elements for plant growth and productivity, exists in both organic and inorganic forms in the soil (Wang et al., 2010). The interaction of nitrogen with the soil's physical and chemical properties directly influences agricultural production. Plants can utilize only mineral forms of nitrogen, and organic nitrogen is converted into inorganic forms through microbial processes. The form and availability of nitrogen are directly related to environmental factors such as soil pH, moisture content, and temperature (Yang et al., 2023). For instance, ammonium is more prevalent in acidic soils, while nitrate is dominant in neutral to slightly alkaline soils (Kaiyrbekov, 2023).

In this context, the use of biofertilizers is crucial for reducing nitrogen losses in agricultural production and minimizing environmental impacts. Symbiotic microorganisms such as Rhizobium convert atmospheric nitrogen into a form usable by plants, thus naturally meeting nitrogen needs (Feng et al., 2014; Muthusamy et al., 2023). Additionally, the nitrogen-fixing capacity of biofertilizer microorganisms, such as species of Bacillus, has been reported to support plant growth and development (Dinesh et al., 2013). Strains of Bacillus megaterium not only fix nitrogen but also promote root development and shoot growth in plants (Antil et al., 2022).

Biofertilizers also play a vital role in making other nutrients more available to plants. Mycorrhizal fungi transport minerals like phosphorus from the soil to roots, enhancing their solubility and contributing to plant nutrition (Ortaş, 2019). This process supports plant development and improves soil quality. Furthermore, mycorrhizae are known to enhance plant resistance to soil-borne fungal pathogens and support plant growth under environmental stress conditions (Yıldız, 2019; Dinçel, 2018). Organic materials like leonardite and vermicompost further improve soil structure, increasing the effectiveness of biofertilizers. These amendments have shown positive results in promoting plant growth and achieving high success rates in various soil types (Yıldız et al., 2019).

According to TAGEM (2021), biofertilizers consist of commercial formulations produced with non-genetically modified microorganisms, playing a role in processes such as nitrogen fixation and phosphorus mobilization. This highlights the increasing significance of biofertilizers in agriculture. These products support agricultural sustainability and minimize environmental damage. Particularly in organic farming, biofertilizers contribute significantly to sustainable practices by reducing environmental harm and increasing agricultural productivity (Ergün, 2024).

In conclusion, biofertilizers provide an environmentally friendly and sustainable agricultural approach as an alternative to the environmental issues caused by chemical fertilizers. These fertilizers strengthen the sustainability of soil ecosystems while minimizing environmental impacts and enhancing agricultural productivity.

SOME BENEFITS OF BIOFERTILIZERS FOR SOIL AND PLANTS

Biofertilizers offer an eco-friendly and sustainable alternative to enhance plant growth and agricultural productivity. They are widely used in organic farming to improve plant growth, yield, and product quality. These methods have the potential to reduce chemical fertilizer usage, minimizing environmental damage. For example, amino acid applications in scarlet runner beans have increased grain yield and positively contributed to protein content (Kavasoğlu, 2018).

Liquid biochar of organic origin has been reported to improve soil nutrient content, although high EC (electrical conductivity) values can adversely affect plant growth (Dorak et al., 2019). Biochar applications have particularly increased soil levels of micronutrients such as Ca, Na, Fe, Cu, Mn, and Zn. Phosphate-solubilizing and nitrogen-fixing bacteria have been shown to enhance N, P, and K contents in leaves of important crops like maize, though these effects may vary depending on environmental conditions (Kadıoğlu & Canbolat, 2019). These findings demonstrate the flexibility of biofertilizers in soil and plant nutrition.

Plant biostimulants can bridge the productivity gap between organic and conventional farming by increasing nutrient availability. Pescale et al. (2019) highlighted the importance of specific applications of plant biostimulants in organic horticulture. For instance, combining humic-fulvic acid with amino acids significantly improved yield and quality traits of curly-leaf lettuce. The highest total plant weight was obtained with 4000 ml/da of humic-fulvic acid and amino acids (Aslan et al., 2019). These studies showcase the effectiveness of biofertilizers when applied in the right doses and combinations.

Applications of leonardite and vermicompost have been shown to significantly impact both soil and plants. Yıldız et al. (2019) reported that both treatments were effective in increasing phosphorus content and improving overall soil quality, with vermicompost achieving higher success. This emphasizes the importance of biofertilizers that facilitate nutrient transfer to plant roots and regulate soil structure.

In greenhouse tomato cultivation, mycorrhiza and vermicompost applications increased yield by 2.5% and 8.3%, respectively, with mycorrhiza also improving total soluble solids (Brix) content (Daşgan et al., 2019; Ergün, 2024). These results show that the yield-enhancing effects of biofertilizers depend on plant species and application methods. Proper evaluation of application conditions is critical for maximizing the benefits of biofertilizers.

Certain bacterial strains have also been proven to promote plant growth. For example, Herbaspirillum huttiense, Virgibacillus pantothenticus, and Brevibacillus parabrevis strains have shown positive effects on curly lettuce in terms of plant weight, height, and root weight (Alpago et al., 2019). Although these effects may vary depending on the plant species, the overall trend highlights an increase in plant growth and productivity. This underscores the importance of microbial diversity in biofertilizers.

Biostimulants can also mitigate yield losses caused by stress in plants. Garcia et al. (2020) emphasized the positive effects of these products on plant growth, as they contain various compounds other than pesticides and chemical fertilizers. These characteristics make biofertilizers a significant tool in sustainable agricultural practices, offering an alternative to the environmental problems caused by chemical fertilizers. All these findings demonstrate the potential of biofertilizers as an effective agricultural tool and the breadth of their application areas.

CONCLUSION

Biofertilizers stand out as a significant alternative in modern agriculture for balancing environmental sustainability with high productivity. By minimizing the environmental damage caused by chemical fertilizers, biofertilizers support soil and plant health, enabling long-term agricultural production. Their roles in nitrogen fixation, phosphorus mobilization, and contributions of organic matter not only enhance plant growth but also preserve the natural structure of the soil. These natural solutions are gaining increasing importance in both organic and conventional agricultural practices.

Despite the growing global food demand, these environmentally conscious approaches are poised to become indispensable in future agricultural applications. The development and widespread use of biofertilizers represent a crucial step toward sustainable agriculture.

REFERENCES

Alpago Ö., Dönmez M.F. 2019 bitki gelişimini uyaran kök bakterilerinin (pgpr) kivircik marul (lactuca sativa var. crispa) yetiştiriciliğine etkisi

Antil, S., Kumar, R., Pathak, D., Kumar, A., Panwar, A. and Kumari, A. (2022). Plant growthpromoting rhizobacteria-Bacillus cereus KMT-5 and B. megaterium KMT-8 effectively suppressed Meloidogyne javanica infection. Applied Soil Ecology 174, 104419. doi.org/10.1016/j.apsoil.2022.104419

Aslan Y., 2019 Humik-fulvik asit ile amino asitin kıvırcık yapraklı baş salatanın verim ve kalitesi üzerine etkisi

Dinçel, B. (2018). Farklı gibberellik asit (ga3) ve mikoriza (glomus spp.) dozlarının patates (solanum tuberosum l.) mini yumrularının çoğaltımına etkileri (Master's thesis, Fen Bilimleri Enstitüsü).

Dinesh, R., Anandaraj, M., Kumar, A., Srinivasan, V., Bini, Y., Subila, K., Aravind, R. and Hamza, S. (2013). Effects of plant growth-promoting rhizobacteria and NPK fertilizers on biochemical and microbial properties of soils under ginger (Zingiber officinale) cultivation. Agricultural Research 2, 346-353. doi.org/10.1007/s40003-013-0080-8

Dorak, S., ve Aşık, B.B. 2019. Sıvı form biocharin toprak özellikleri ve marul bitkisi üzerine etkisi. 8. Ulusal Bitki Besleme ve Gübre Kongresi, 12-15 Mart 2019, Antalya

Ergün, O. (2024). Organik marul yetiştiriciliğinde biyogübre ve biyostimülantlar kullanılarak bitki beslemenin iyileştirilmesi ile verim ve kalitenin artırılması. Doktora Tezi, Çukurova Üniversitesi, Fen Bilimleri Enstitüsü, Bahçe Bitkileri Anabilim Dalı,

Feng, S., Wang, L., Chen, C., Lin, Z., Cheng, H., Wei, K. and Zhang, C. (2014). Cloning and expressing analysis of a nitrogen transporter 2.5 gene from tea plant [Camellia sinensis (L.)]. Journal of Tea Science 34, 364-370. 20143329186

García-García, A. L., García-Machado, F. J., Borges, A. A., Morales-Sierra, S., Boto, A., & Jiménez-Arias, D. (2020). Pure Organic Active Compounds Against Abiotic Stress: A Biostimulant Overview. Frontiers in plant science, 11, 575829. https://doi.org/10.3389/fpls.2020.575829

Kadıoğlu, B. ve Canbolat, M. Y. (2019). Farklı yetiştirme ortamlarında bazı bakterilerin buğday ve mısır gelişimi üzerine etkisi. Toprak Bilimi ve Bitki Besleme Dergisi, 7(2), 139-148.

Kaiyrbekov, T. (2023). Nitrogen management in crop cultivation using biofertilizer containing free-living nitrogen fixing bacteria. Master's Thesis, Ondokuz Mayıs University, Department of Soil Science and Plant Nutrition, Samsun.

Kavasoğlu, A. 2018. Aminoasit uygulamasının kınalı fasulye çeşidinin tarımsal özellikleri üzerine etkileri. Selçuk Üniversitesi, Fen Bilimleri Enstitüsü, Tarla Bitkileri Anabilim Dalı, Yüksek lisans tezi, Konya, 36 s

Muthusamy, S., Kasilingam, N., Sophia Silvestar, S. M. and Alagarsamy, P. (2023). Chapter 21 - Exploration of Rhizobium for its mass production and plant growth promoting properties. In "Microbial Symbionts" (D. Dharumadurai, ed.), pp. 385-396. Academic Press. doi.org/10.1016/B978-0-323-99334-0.00022-0

Ortas, E., Gallego-Álvarez, I., & Alvarez, I. (2019). National institutions, stakeholder engagement, and firms' environmental, social, and governance performance. Corporate Social Responsibility and Environmental Management, 26(3), 598-611.

Peng, C., Zhang, Z., Li, Y., Zhang, Y., Dong, H., Fang, Y., Han, L., Xu, W. and Hu, L. (2022). Genetic improvement analysis of nitrogen uptake, utilization, translocation, and distribution in Chinese wheat in Henan Province. Field Crops Research 277, 108406. doi.org/10.1016/j.fcr.2021.108406

Pescale,De S.,Rouphael Y.,Colla G. 2019 Protein Hydrolysate or Plant Extract-based Biostimulants Enhanced Yield and Quality Performances of Greenhouse Perennial Wall Rocket Grown in Different Seasons

Prather, M. J., Holmes, C. D. and Hsu, J. (2012). Reactive greenhouse gas scenarios: Systematic exploration of uncertainties and the role of atmospheric chemistry. Geophysical Research Letters 39. doi.org/10.1029/2012GL051440

TAGEM 2021. Biyostimulant ve Biyogübre (www.tagem.gov.tr)

Wang, X., Li, G., An, S., Xiong, S. and Ma, X. (2010). Effects of nitrogen forms on rhizosphere microorganisms and soil enzyme activity for nitrogen transform of wheat cultivar during elongation and grain filling Stage. J Soil Water Conserv 24, 204-7. doi:10.11733/j.issn.1007-0435.2010.04.007

Yang, M., Dong, C. and Shi, Y. (2023). Nano fertilizer synergist effects on nitrogen utilization and related gene expression in wheat. BMC Plant Biology 23, 26. doi.org/10.1186/s12870-023-04046-9

Yıldız, A. (2009). Mikoriza ve arbusküler mikoriza bitki sağlığı ilişkileri. Adnan Menderes Üniversitesi Ziraat Fakültesi Dergisi, 6(1), 91-101.

Yıldız, K. Y., Demirer, T., & Kiliç, Ö. G. (2019). Farklı dozda uygulanan leonardit ile vermikompostun ıspanakta verim ve bazı kalite kriterlerine etkisi. Turan: Stratejik Arastirmalar Merkezi, 11(43), 468-481.

FOOD ADULTERATION IN OLIVE OIL: DETECTION METHODS, ECONOMIC AND HEALTH IMPACTS

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ABSTRACT

Introduction and Aim:
Food adulteration in olive oil is a widespread issue that undermines consumer trust and poses economic and health risks. Fraudulent practices include mixing low-quality or other vegetable oils with olive oil, often sold as authentic products. These deceptions compromise the integrity of the olive oil market, harm the reputation of producers, and deprive consumers of olive oil's recognized health benefits. This study aims to summarize detection methods for olive oil adulteration, assess its economic and health impacts, and propose solutions to mitigate these challenges.

Discussion and Conclusion:
Adulteration in olive oil has far-reaching economic consequences. It disrupts market fairness by enabling counterfeit products to undercut authentic olive oils, causing financial losses for genuine producers and exporters. Regulatory authorities also incur significant costs for inspections and enforcement to combat fraud. Reputational damage to the olive oil industry diminishes consumer trust and stifles market growth.

From a health perspective, adulterated olive oils often lack key nutrients such as healthy fatty acids and antioxidants, which are vital for heart health. Mixed oils may introduce allergens, harmful compounds, and trans fats, increasing the risk of chronic diseases like heart disease and inflammation. Long-term consumption of these counterfeit products disrupts healthy dietary practices and may lead to digestive and overall health issues. Combating olive oil adulteration requires a multi-faceted approach, including robust regulatory frameworks, advanced detection technologies, and enhanced consumer awareness. Recent inspections by the Ministry of Agriculture and Forestry revealed the prevalence of seed oil mixtures and highlighted the need for stricter monitoring. Addressing these challenges is crucial to restoring consumer trust, protecting public health, and maintaining the economic stability of the olive oil market. Ensuring access to authentic, high-quality olive oil must remain a priority for both industry stakeholders and regulators.

Keywords: Authenticity, consumer trust, nutritional integrity, regulatory enforcement, market stability.

GİRİŞ

Zeytinyağı, zeytin meyvesinden elde edilen, sağlıklı yağ asitleri, antioksidanlar ve vitaminler bakımından zengin bir bitkisel yağdır (Hernández & Llorente, 2015). Akdeniz ikliminin hakim olduğu bölgelerde yetişen zeytinlerden yapılan zeytinyağı, beslenme açısından çok değerli bir kaynaktır (International Olive Council, 2020). Ekonomik açıdan, özellikle Türkiye gibi zeytin üreticisi ülkelerde, zeytinyağı üretimi büyük bir endüstri oluşturur (International Olive Council, 2020). Zeytinyağı, hem iç hem de dış pazarlarda yüksek talep gören bir

üründür ve ülke ekonomisine önemli bir katma değer sağlar (Kang & Ryu, 2019). Halk açısından ise, zeytinyağı, sadece sağlıklı beslenme için değil, aynı zamanda geleneksel mutfak kültürünün vazgeçilmez bir parçasıdır (Sian & Batra, 2017). Zeytinyağının kullanımı, nesilden nesile aktarılan bir alışkanlık olup, hem sağlıklı yaşamı teşvik eder hem de yerel tarım ve üreticiler için önemli bir gelir kaynağı oluşturur (Hernández & Llorente, 2015). Zeytinyağının sağlığa olan katkıları ve ekonomik faydaları, onu hem bireysel hem de toplumsal açıdan önemli kılar (International Olive Council, 2020).
Ancak, zeytinyağının değerli içeriği bazen ticari çıkarlar uğruna bozulabilmektedir. Zeytinyağı tağşişi, kaliteli zeytinyağının daha ucuz yağlarla karıştırılması veya saf zeytinyağının yerine düşük kaliteli yağların kullanılması anlamına gelir (Sian & Batra, 2017). Zeytinyağında gıda tağşişi, hem tüketici sağlığını korumak hem de ürün kalitesini garanti altına almak açısından önemli bir sorundur. Bu nedenle, tağşişin tespiti ve bu tespitte kullanılan analitik yöntemlerin geliştirilmesi büyük önem taşımaktadır.

ARAŞTIRMA VE BULGULAR

Zeytinyağı tağşişi, yüksek kaliteli zeytinyağının yerine daha ucuz ve düşük kaliteli yağların karıştırılmasıyla gerçekleşir (Kang & Ryu, 2019). Tağşiş edilen zeytinyağlarında genellikle ayçiçek yağı, soya yağı, mısır yağı veya palm yağı gibi bitkisel yağlar kullanılır (Sian & Batra, 2017). Bu tür yağlar, zeytinyağının besin değerini düşürür ve sağlıklı yağ asidi profilini bozar (Kang & Ryu, 2019). Zeytinyağının sağlık yararları, bu tür tağşişler nedeniyle ciddi şekilde zarar görebilir (Hernández & Llorente, 2015). Örneğin, zeytinyağının içerdiği tekli doymamış yağ asitleri, kalp sağlığına faydalıyken, ucuz yağların karışımı kalp hastalıkları riskini artıran doymuş yağ asitlerini içerir (Sian & Batra, 2017). Ayrıca, tağşiş yapılan yağlar genellikle daha düşük kaliteli olup, genellikle sağlık açısından daha zararlı olan kimyasal işleme tabi tutulmuş yağlar olabilir (Kang & Ryu, 2019). Bu durum, hem tüketicilerin sağlıklarını tehdit eder hem de doğru zeytinyağı tüketimi konusunda güven kaybına yol açar (Sian & Batra, 2017). Zeytinyağı alırken, ürünün saf olduğundan emin olmak ve güvenilir markalar tercih etmek bu tür hilelerden korunmanın en etkili yoludur (International Olive Council, 2020).

Zeytinyağında Tağşiş

TARIM VE ORMAN BAKANLIĞI VERİLERİ

ÜRÜN ADI	**Zeytinyağı**
TAĞŞİŞ TESPİT EDİLEN TOPLAM FİRMA SAYISI	**350**
UYGUNSUZLUK SEBEPLERİ	**Tohum yağları karıştırılması, daha düşük kaliteli zeytinyağı karıştırılması ve pirina yağı tespiti.**
KAMUOYU DUYURU TARİHİ	**02.10.2024 – 21.11.2024**

Tablo 1: Tarım ve Orman Bakanlığı güncel tağşiş verileri.

Tarım ve Orman Bakanlığı tarafından yapılan denetim sonucunda 2024 yılında 350 adet firmada tağşiş tespit edilmiştir. Zeytinyağındaki uygunsuzluk nedenleri; tohum yağları karıştırılması, daha düşük kaliteli zeytnyağı karıştırılamsı ve pirina yağı tespiti olarak belirtilmiştir.

Taklit Amacıyla Kullanılan Yağ Kaynakları

Zeytinyağında taklit amacıyla kullanılan yağlar, genellikle zeytinyağının yerine kullanılan ve benzer özelliklere sahip olan daha ucuz alternatiflerdir. Bu taklit yağlar, ekonomik açıdan daha uygun olmaları nedeniyle, özellikle düşük kaliteli zeytinyağı yerine veya sahte zeytinyağı üretimi için kullanılır. Zeytinyağında taklit amaçlı en çok tercih edilen yağlar şunlardır:

- **Ayçiçek Yağı:** Ayçiçek yağı, zeytinyağının yerine sıklıkla kullanılan bir diğer bitkisel yağdır. Özellikle rafine ayçiçek yağı, tat ve kokusuz yapısıyla zeytinyağının yerine taklit amaçlı kullanılır (Alvarez et al., 2020).
- **Soya Yağı:** Soya fasulyesinden elde edilen bu yağ, genellikle düşük kaliteli zeytinyağlarının yerine kullanılır. Ayrıca, soya yağı, zeytinyağına benzer şekilde sıvı formda olup, daha ucuz bir alternatiftir (Santos et al., 2019).
- **Palm Yağı:** Palm yağı, özellikle zeytinyağının yapısına benzerliği nedeniyle, düşük kaliteli zeytinyağlarını taklit etmek amacıyla kullanılır. Ayrıca, bu yağ, sıvı ve katı formda bulunabilmesiyle de çeşitli taklit ürünlerde tercih edilir (Fernández et al., 2018).
- **Kolza Yağı (Canola Yağı):** Kolza yağı, zeytinyağının yerine kullanılan başka bir yağ kaynağıdır. Canola yağı, özellikle zeytinyağının olgunlaşmış tadını taklit etmek için kullanılır (Morales et al., 2021).
- **Mısır Yağı:** Mısır yağı, genellikle düşük kaliteli zeytinyağlarını taklit etmek amacıyla kullanılan bir yağdır. Zeytinyağının yerine, mısır yağı, daha uygun fiyatlı alternatifler sunar (Zhou et al., 2020).

Bu taklit yağlar, özellikle düşük kaliteli zeytinyağlarının fiyatını düşürmek ve kaliteyi artırmak amacıyla kullanılır. Ancak bu yağlar, zeytinyağının özgün besin değerleri ve tadı ile aynı özellikleri taşımaz. Bu nedenle, zeytinyağının gerçekliği ve kalitesi, özellikle gıda etiketlerinde ve laboratuvar analizlerinde sıkça sorgulanmaktadır.

METODOLOJİ

Zeytinyağı Tağşişinin Tespitinde Kullanılan Yöntemler

1. Kimyasal Analiz Yöntemleri

Kimyasal analizler, zeytinyağının bileşimini inceleyerek, adulterasyon yapılmış olup olmadığını belirlemede kullanılır. Bu yöntemler, zeytinyağındaki belirli bileşenlerin konsantrasyonlarını ölçerek, taklit yağların eklenip eklenmediğini tespit etmeye çalışır.

- **Serbest Yağ Asidi (FFA) Analizi:** Bu test, yağın asidik içeriğini belirler. Saf zeytinyağında genellikle düşük FFA seviyeleri bulunur. Taklit yağlar genellikle bu asidik bileşenleri arttırabilir (Mousavi et al., 2020).
- **Peroksit Değeri Testi:** Zeytinyağının oksidasyonunu gösteren bu test, yağı taze ve oksitlenmemiş durumda tutmak için gereklidir. Taklit yağlar, saf zeytinyağına göre daha yüksek peroksit değerleri gösterebilir (Pérez et al., 2019).
- **Sterol ve Trigliserit Profili:** Zeytinyağındaki sterol bileşenlerinin profili, her yağ türüne özgüdür. Bu yöntemle, saf zeytinyağının sterol bileşenlerinin profili karşılaştırılır ve taklit yağlar tespit edilebilir (Sánchez et al., 2021).

2. Gaz Kromatografisi (GC)

Gaz kromatografisi, yağda bulunan uçucu bileşenleri ayırmak için kullanılır ve zeytinyağındaki bileşenlerin profiline dayalı olarak taklit ve tağşiş tespiti yapılır. Bu yöntem, zeytinyağındaki serbest yağ asitlerinin ve diğer uçucu bileşenlerin oranlarını ölçer. Taklit yağlar, saf zeytinyağının uçucu bileşenlerinden farklı bir profil gösterir.

GC-MS (Gaz Kromatografisi-Kütle Spektrometrisi): Bu yöntem, daha spesifik bir analiz sağlar ve saf zeytinyağındaki bileşenlerin kütle spektrumları ile karşılaştırılır. Palm yağı veya soya yağı gibi taklit yağlar, farklı bileşikler içerir ve bu da GC-MS ile tespit edilebilir (Romero et al., 2020).

3. Nükleer Manyetik Rezonans (NMR) Spektroskopisi

NMR, zeytinyağının kimyasal yapısını detaylı bir şekilde analiz etmek için kullanılır. Bu yöntem, özellikle yağ asidi zincirlerinin yapısını ve diğer organik bileşiklerin yerini belirlemeye yardımcı olur. Zeytinyağındaki belirli bileşenlerin NMR spektrumu, saf ve taklit yağları ayırt etmeye olanak tanır. Taklit yağlar genellikle farklı NMR spektrumları gösterir (Delgado et al., 2018).

4. IR (Infrared) Spektroskopisi

IR spektroskopisi, zeytinyağındaki bileşenlerin karakteristik titreşimlerini ölçer ve bu da yağın kimyasal bileşenleri hakkında bilgi verir. Özellikle FTIR (Fourier Transform Infrared) Spektroskopisi zeytinyağlarında adulterasyon tespitinde kullanılır. IR spektrumu, saf zeytinyağının doğal bileşenlerini ve taklit yağların içerdiği farklı maddeleri analiz ederek, adulterasyonu tespit etmeye yardımcı olur (García et al., 2020).

5. Yüksek Performanslı Sıvı Kromatografisi (HPLC)

HPLC, zeytinyağındaki polar bileşiklerin (özellikle fenolik bileşenlerin) ayrılması ve analizi için kullanılır. Zeytinyağında taklit yağı, genellikle fenolik bileşenlerin konsantrasyonunda değişikliklere neden olur. Bu nedenle, HPLC yöntemi, zeytinyağının fenolik bileşenlerini analiz ederek, saf ve taklit yağları ayırt edebilir (Martin et al., 2020).

6. Duyusal Testler (Tadım Testi)

Zeytinyağındaki tat, koku ve renk özelliklerini inceleyen duyusal testler, zeytinyağının kalitesini değerlendirmek için kullanılır. Zeytinyağındaki taklit yağı, genellikle organoleptik özellikler üzerinde değişikliklere yol açar. Zeytinyağında herhangi bir değişiklik (örneğin, acılık, meyvemsilik gibi tat özelliklerinin kaybı), taklit veya tağşiş yağların varlığına işaret edebilir. Ancak, bu testler daha subjektif olabilir ve genellikle diğer analitik yöntemlerle birlikte kullanılır (Hernández et al., 2019).

7. Raman Spektroskopisi

Raman spektroskopisi, zeytinyağındaki bileşenleri incelemek için kullanılan bir diğer güçlü tekniktir. Bu yöntem, yağın kimyasal yapısının incelemesini sağlar ve farklı yağ türlerinin birbirinden ayırt edilmesinde etkilidir. Raman spektrumu, zeytinyağındaki ester gruplarını ve diğer bileşenleri inceleyerek, saf ve taklit yağlar arasındaki farkları belirler (Cunha et al., 2017).

TARTIŞMA VE SONUÇ

Zeytinyağında gıda tağşişi, hem ekonomik hem de sağlık açısından önemli bir sorun olarak gün geçtikçe daha ciddi bir hal almaktadır. Özellikle düşük kaliteli yağların veya diğer bitkisel yağların zeytinyağına karıştırılması, tüketiciyi yanıltmanın ötesinde, ürünlerin besin değerini ve sağlık yararlarını düşürmektedir (Diraman, 2018; Callao & Ruisánchez, 2018). Tağşişin önlenmesi ve tespiti için, kullanılan analitik yöntemlerin doğru, hızlı ve hassas olması kritik öneme sahiptir. Türkiye' de Tarım ve Orman Bakanlığı tarafından yapılan denetimler, tağşişin tespiti ve kamuoyuna duyurulması konusunda büyük bir rol oynamaktadır. Bakanlık, zeytinyağı analizlerinde spektrofotometri, gaz kromatografisi (GC), sıvı kromatografisi (HPLC), ve NMR (Nükleer Manyetik Rezonans) gibi yöntemler kullanmaktadır. Bu yöntemler, zeytinyağının yağ asit profili, sterol kompozisyonu, mumsu madde miktarı ve ECN-42 farkı gibi parametreleri inceleyerek tağşişin türünü ve kaynağını belirlemeye olanak sağlar (Hilal Zade Sarıkaya, 2023; ca, 2018).

Bir analiz yönteminde dikkat edilmesi gereken temel unsurlar, güvenilirlik, tekrarlanabilirlik ve hassasiyettir. Tağşişin önlenmesinde, kullanılan analiz yöntemlerinin geliştirilmesi ve standardizasyonu büyük avantajlar sağlamaktadır. Bu gelişmeler sayesinde daha az insan hatasıyla, daha hızlı ve kesin sonuçlar elde edilebilmektedir. Ancak, tağşiş edilmiş ürünlerin piyasada kolay ulaşılabilir ve daha ucuz olması, tüketici farkındalığını artırmanın da önemli olduğunu göstermektedir (Gurdeniz & Ozen, 2009). Bu durum, etik ticaret ve halk sağlığı açısından hem zorluklar hem de fırsatlar sunmaktadır.

Zeytinyağında tağşişin önlenebilmesi için kapsamlı bir strateji geliştirilmelidir. Öncelikle, üretimden tüketime kadar olan tedarik zincirinde şeffaflık sağlanmalı ve izlenebilirlik artırılmalıdır. Ürünlerin, kaynağından itibaren uygun şekilde belgelendirilmesi ve dijital takip sistemlerinin kullanımı bu konuda etkili olabilir (Callao & Ruisánchez, 2018). Ayrıca, denetimlerde spektroskopik ve kromatografik analizler gibi ileri teknoloji yöntemlerinin yaygınlaştırılması, tağşişin hızlı ve doğru bir şekilde tespit edilmesine olanak tanır (Gurdeniz & Ozen, 2009).

Eksiklikler ve Mevcut Zorluklar

- **Dar Hedefli Analizler**: Bazı yöntemler (ör. yağ asidi profili analizi), yalnızca belirli türde tağşişleri tespit edebilir. Örneğin, düşük miktarda karıştırılmış yağlar ya da aynı kimyasal profile sahip farklı yağlar gözden kaçabilir (Frankel, 2010; Aparicio et al., 2013).
- **Kimyasal ve Fiziksel Benzerlikler**: Tağşişte kullanılan bazı yağlar, zeytinyağına kimyasal ve fiziksel olarak çok benzer olabilir (ör. rafine zeytinyağı). Bu durum, klasik yöntemlerle tespiti zorlaştırır (Bajoub et al., 2018).
- **Coğrafi ve Botanik Kaynağın Ayrımı:** Mevcut analizler genellikle tağşişi tespit etmek için yeterli olsa da, zeytinyağının coğrafi ya da botanik kökenini doğru şekilde belirlemekte sınırlamalar gösterir(Gomez-Coca et al., 2015; Karabagias et al., 2016).
- **Hız ve Maliyet**: İleri teknolojik yöntemler (ör. NMR, GC-MS) yüksek hassasiyet sunsa da, zaman alıcı ve maliyetlidir. Küçük üreticiler veya denetim kurumları için uygulanabilirlikleri sınırlıdır (Vigli et al., 2003; Morales et al., 2014).
- **Tümleşik Veri Eksikliği**: Analiz sonuçlarını birleştirerek daha bütüncül bir değerlendirme yapılması için yöntemler arasında entegrasyon eksikliği bulunmaktadır (Brescia et al., 2013).
- **Biyolojik veya DNA Analiz Eksikliği**: Karıştırılan bitkisel yağların türlerini doğrulamak için biyomoleküler veya DNA temelli yöntemler yeterince yaygın kullanılmamaktadır (Testolin et al., 2005).

Eklenebilecek Özellikler ve İyileştirmeler

- **Multidisipliner Yaklaşımlar:** Farklı analiz birleştiren entegre analiz sistemleri geliştirilebilir. Örneğin, NMR ve DNA barkodlama bir arada kullanılabilir (Cunha et al., 2015).
- **Yapay Zeka ve Makine Öğrenimi:** Analiz sonuçlarını yorumlamak için yapay zeka ve makine öğrenimi algoritmaları geliştirilebilir. Bu sayede, farklı yöntemlerden gelen veriler birleştirilerek tağşişin türü ve kaynağı daha hassas şekilde belirlenebilir (Grassi et al., 2018).
- **Hızlı Saha Test Kitleri:** Zeytinyağında tağşişi sahada hızlıca tespit edebilecek taşınabilir cihazlar veya test kitleri geliştirilebilir. Bu kitler, kimyasal reaksiyonlar ya da spektral analiz temelinde çalışabilir (Koidis et al., 2011).
- **İzotopik Analizler**: Karbon, hidrojen ve oksijen izotop analizleri kullanılarak zeytinyağının coğrafi ve botanik kaynağı daha kesin belirlenebilir. Bu yöntemler, sahteciliği kökünden tespit etmekte etkili olur (Kelly et al., 2005).
- **Sterol ve Triaçilgliserol Analizleri**: Daha detaylı ve geniş kapsamlı sterol ve triaçilgliserol analizleri yapılabilir. Özellikle düşük miktarda yapılan tağşişlerde bu bileşenlerin oranları kritik bilgiler sunar (Martínez et al., 2010).
- **Blockchain ile İzlenebilirlik**: Tedarik zinciri boyunca blockchain tabanlı bir izlenebilirlik sistemi oluşturularak, zeytinyağının kaynağı ve işlenme süreçleri doğrulanabilir (Kamble et al., 2019).

KAYNAKLAR

Alvarez, R., Gutiérrez, M. R., & García, J. A. (2020). Use of sunflower oil in olive oil adulteration: A review. Journal of Food Quality, 43(4), 1-12. https://doi.org/10.1002/jfq.11075

Aparicio, R., Morales, M. T., & García-González, D. L. (2013). Authentication of European Virgin Olive Oils by Their Chemical and Sensory Features. Journal of Agricultural and Food Chemistry, 61(25), 6026–6034.

Bajoub, A., Medina-Rodríguez, S., Ajal, E. A., & Fernández-Gutiérrez, A. (2018). Olive Oil Authentication and Traceability. Trends in Food Science & Technology, 71, 123–136.

Brescia, M. A., Monfreda, M., Buccolieri, A., & Carrino, C. (2013). Characterization of Olive Oils from Apulia Region. Food Chemistry, 89(4), 561–568.

Callao, M. P., & Ruisánchez, I. (2018). An overview of multivariate qualitative methods for food fraud detection. Food Control, 86, 283–293. https://doi.org/10.1016/j.foodcont.2017.11.034

Cunha, S. C., Faria, M. A., & Beatriz, M. (2015). Olive Oil Fingerprinting by Advanced Analytical Techniques. Analytica Chimica Acta, 853, 131–143.

Diraman, H. (2018). Olive oil authenticity and analytical approaches for detection of adulteration: A review. Journal of Food Science and Technology, 55(12), 1–15. https://doi.org/10.1007/s13197-018-3485-x

Fernández, A., Ramos, M., & Delgado, J. (2018). Palm oil as an adulterant in olive oil: Detection and challenges. Food Control, 89, 100-107. https://doi.org/10.1016/j.foodcont.2018.01.033

Frankel, E. N. (2010). Chemistry of Extra Virgin Olive Oil. Journal of Agricultural and Food Chemistry, 58(8), 5251–5261.

Gomez-Coca, R. B., Pérez-Camino, M. C., & Moreda, W. (2015). Analytical Methods for Olive Oil Authentication. Trends in Analytical Chemistry, 76, 14–25.

Grassi, S., Amigo, J. M., & Lyndgaard, C. B. (2018). Data-Driven Spectroscopy. Chemometrics and Intelligent Laboratory Systems, 175, 85–93.

Gurdeniz, G., & Ozen, B. (2009). Detection of adulteration of extra-virgin olive oil by chemometric analysis of mid-infrared spectral data. Food Chemistry, 116(2), 519–525. https://doi.org/10.1016/j.foodchem.2009.02.068

Hernández, M. T., & Llorente, A. (2015). Health benefits of olive oil and its components. Journal of Food Science and Technology, 52(4), 2103-2111. https://doi.org/10.1007/s11483-015-0912-7

Hilal Zade Sarıkaya, Ö. (2023). Gıda güvenliği ve zeytinyağında tağşiş: Türkiye'de durum analizi. Journal of Food Authenticity Studies, 3(1), 45–62.

International Olive Council. (2020). The economic importance of the olive sector. International Olive Council. Retrieved from https://www.internationaloliveoil.org

Kamble, S. S., Gunasekaran, A., & Dhone, N. C. (2019). Blockchain Technology in the Food Supply Chain. International Journal of Production Research, 57(7), 2009–2034.

Kang, S., & Ryu, S. (2019). Olive oil adulteration and the detection methods: A review. Journal of Food Quality, 42(7), 1-11. https://doi.org/10.1111/jfq.12497

Karabagias, I. K., Badeka, A., & Kontominas, M. G. (2016). Authentication of Olive Oil. Critical Reviews in Food Science and Nutrition, 57(12), 1–16.

Kelly, S., Heaton, K., & Hoogewerff, J. (2005). Tracing the Geographical Origin of Food. Food Chemistry, 100(3), 548–554.

Koidis, A., Osborn, H., & Gunning, Y. (2011). Portable Spectroscopic Tools for Food Fraud Detection. Journal of Food Quality, 34(4), 320–328.

Martínez, J., Gallegos, C., & Morales, J. G. (2010). Analysis of Sterols in Olive Oil. Journal of Food Lipids, 17(2), 100–109.

Morales, M. T., Aparicio, R., & Calvente, J. (2014). GC-MS Characterization of Olive Oil Volatiles. Journal of Agricultural and Food Chemistry, 62(2), 496–503.

Morales, M. T., Vázquez, M., & García-González, D. L. (2021). Canola oil in olive oil: A study on adulteration patterns and detection methods. Food Chemistry, 341, 127985. https://doi.org/10.1016/j.foodchem.2020.127985

Santos, J. M., Torres, S., & Ribeiro, M. (2019). Soybean oil as a replacement for olive oil: Implications in food labeling and quality control. Food Research International, 123, 101-110. https://doi.org/10.1016/j.foodres.2019.04.013

Sian, M. M., & Batra, S. (2017). Adulteration of olive oil: A growing problem in the food industry. Food Control, 75, 248-257. https://doi.org/10.1016/j.foodcont.2017.01.050

Testolin, R., Tartarini, S., & Sansavini, S. (2005). DNA Analysis for Olive Oil Authentication. Food Research International, 38(3), 181–187.

Vigli, G., Philippidis, A., Spyros, A., & Dais, P. (2003). Classification of Edible Oils by NMR Spectroscopy. Analytical Chemistry, 75(6), 1140–1149.

Yadav, R. (2018). Strategies for detection of adulteration in food products: Focus on edible oils. Journal of Food Science and Technology, 55(3), 657–669. https://doi.org/10.1007/s13197-017-2998-3

Zhou, T., Wang, X., & Zhang, W. (2020). Detection of corn oil in olive oil: A review of current methods. Food Chemistry, 315, 126281. https://doi.org/10.1016/j.foodchem.2020.126281

WILD PISTACHIO SPECIES DISTRIBUTED IN GAZİANTEP (TÜRKİYE) AND THEIR TAXONOMIC CHARACTERISTICS

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ABSTRACT
The genus Pistacia L., of which pistachio (Pistacia vera L.) is a member, belongs to the family Anacardiaceae and includes plants from the hard-shelled fruits group. Pistachio has been cultivated in the Southeastern Anatolia region of Turkey since ancient times. Pistachio is an economically more important species than its wild species and it is known that approximately 2 billion dollars of product is harvested annually. Because of this feature, pistachio trees are called 'Golden tree' or 'Green gold'. Pistachio has two gene centers. One is the Central Asian gene centre and the other is the Near East gene centre, including Anatolia. To determine the taxonomic characters and general characteristics of the genus Pistacia L., plant specimens were collected from Gaziantep. The collected plant specimens were identified using the Flora of Turkey. 175 leaf and fruit samples collected from 55 localities were measured. In this study, the distribution of P. vera, P. eurycarpa, P. terebinthus, P. atlantica, P. palaestina and P. khinjuk species in Gaziantep was determined and the taxonomic characters and general characteristics used in the classification of these taxa were revealed. According to the existing studies, it has been revealed that there is complexity in the kinship relationships of the genus due to the lack of genetic barrier between Pistacia L. species. In our field studies, it was observed that there are plants that differ from P. terebinthus in terms of some taxonomic characters.
Keywords: Pistachio, Pistacia, Wild Species, Taxonomic Characters.

INTRODUCTION
The genus Pistacia L., of which pistachio is a member, belongs to the family Anacardiaceae and includes plants from the hard-shelled fruits group (Gündeşli, 2022). Pistachios have been cultivated in the Southeastern Anatolia region of Turkey since ancient times. Pistachio is a cultivated plant with high added value since it has edible seeds. Pistachio has great economic importance in terms of both import and export with its production and agricultural area increasing every year worldwide. Pistachio is an economically more important species than its wild species and it is known that approximately 2 billion dollars of product is harvested annually. (Basrila et al., 2003; Al-Saghir & Porter, 2012; Onay et. al., 2012; Gündeşli, 2022). Because of this feature, pistachio trees are called 'Golden tree' or 'Green gold' (Ayfer, 1990). In Turkey, 95% of pistachio production areas are located in Şanlıurfa, Gaziantep, Adıyaman and Siirt and 91.4% of the production is carried out in these provinces (Eldoğan & Şahin, 2015; Tekin et al., 2020). 89.5 per cent of pistachio trees in Turkey are located in these provinces (Aslan et al., 2001).

Pistacia L. species grow in areas where the climate is favourable between 30-45° parallels in the world (Ak et al., 1999). The known gene centres of pistachio in the world are Central Asia and Near East. The first of these two gene centres is the north of India, Afghanistan, Tajikistan, and the other is the region including Anatolia, Caucasus, Iran and Turkmenistan (Onay, 1996; Parfitt & Badenes, 1997; Açar, 1997; Al-Saghir & Porter, 2012; Yavuz et al., 2016; Elbistanlı et al., 2020).

The genus Pistacia L. is known to have 13 species in the world (Zohary, 1952; Yaltırık, 1967a; Kokwaro & Gillett, 1980; Özuslu et al., 2009). The first detailed study on the genus was carried out by Zohary (1952). Zohary (1952) classified the genus into 11 species and four sections (Table 1).

Table 1: Sections and species of the genus Pistacia L. (Zohary, 1952).

Lenticella	Eu-Lentiscus	Butmela	Eu-Terebinthus
P. mexicana Swingle P. texana Swingle	P. lentiscus L. P. weinmannifolia Poission P. saportae Burnat	P. atlantica Desf.	P. terebinthus L. P. palaestina Boiss. P. khinjuk Stock P. vera L. P. chinensis Bunge

Following Zohary (1952), Yaltırık (1967a) described P. eurycarpa Yalt. and Kokwaro & Gillett (1980) described P. aethopica Kokwaro as new species. Al-Saghir & Porter (2012) classified the genus into 9 species and 5 subspecies. The genusPistacia L. has six species and two subspecies in Turkey (Yaltırık, 1967ab). Among these taxa, P. terebinthus L. is mostly found in Şanlıurfa, Gaziantep, Kahramanmaraş and Adıyaman provinces. P. khinjuk Stock is found in Gaziantep, Adıyaman, Siirt, Hakkari and Bitlis provinces and P. vera L. is found in Gaziantep and Kahramanmaraş provinces (Atlı et al., 1990; 2001; Tekin et al., 2020).

Pistacia L. species require a hot and sunny summer period and a temperature of 3600-4400 degrees for about four months after fertilisation. These climatic conditions are observed in and around Gaziantep (Tekin et al., 2001). For this reason, Gaziantep is one of the provinces with the most favourable climate for the growth of Pistacia L. species and it is stated that there are millions of wild pistachio species (Aslan & Çetin, 2011; Kuru & Özsabuncuoğlu, 1990). Due to the lack of genetic barriers and easy hybridisation among Pistacia L. species, kinship relationships are complex (Al-Saghir & Porter, 2012) and the exact number of species and subspecies of the genus in Turkey has not been established (Al-Saghir & Porter, 2012; Yılmaz et al., 2023; Yılmaz et al., 2024).

The aim of this study was to determine the species belonging to the genus Pistacia L., which has a natural distribution in Gaziantep province, and the morphological and general characteristics of these species used in taxonomy.

MATERIAL AND METHOD

The material of the study consists of leaf and fruit samples of Pistacia L. species collected from Gaziantep between 2020-2024. Leaf and fruit samples obtained from the study area were dried and arranged as herbarium specimens (Şeçmen et al., 2008). Plant specimens were identified using Post & Dinsmore (1932), Zohary (1952), Davis (1972), Yaltırık (1967), Yaltırık (1967a; 1967b) and AlSaghir & Porter (2012). The study area is located in square C6 according to the quadratic system used in Davis (1972). The collected plant specimens are kept in Igdir University Herbarium. Plant names were used according to Güner et al. (2012). The leaf length and width, number of leaflet pairs, leaflet length, width and tip shape and fruit size of the specimens obtained during field studies were measured using a ruler and callipers.

CONCLUSION AND DISCUSSION

Pistacia L. species can generally be grown in sloping, rocky, calcareous, barren, dry and arid areas where other cultivated plants do not grow (Gündeşli, 2022). When the studies on the distribution of Pistacia L. species are examined, P. vera is found in Adıyaman, Şanlıurfa, Gaziantep, Kilis, Siirt, Mardin provinces, P. khinjuk is found in Gaziantep, Siirt, Şanlıurfa, Adıyaman, Diyarbakır provinces, P. terebinthus is found in Gaziantep, Şanlıurfa provinces, P. eurycarpa Yalt. species in Bitlis, Hakkari, Siirt, Mardin, Gaziantep, Mersin, İzmir, Aydın, Denizli, Manisa and Balıkesir provinces, P. atlantica in İstanbul, Mersin, İzmir, Zonguldak, Karabük, Balıkesir, Antalya, Aydın, Manisa, Çankırı and Muğla provinces (Tekin, 2020; Aslan et al, 2001; Özuslu et al., 2009; Yılmaz et al., 2023; Yılmaz et al., 2024).

It is known that there is complexity in the kinship relationships of the genus due to the lack of genetic barrier betweenPistacia L. species (Al-Saghir & Porter, 2012). In our field studies, it was observed that there are plants that differ from P. terebinthus in terms of some taxonomic characters. The same findings were also revealed in the study conducted by Özuslu et al. (2009). P. palaestine was described as a subspecies in the Flora of Turkey (Yaltırık, 1967; Yaltırık, 1967a; 1967b; Davis, 1972). However, in many studies, this taxon is reported as a species (Ayfer, 1959; Bilgen, 1968; Özbek, 1978; Ayfer, 1990; Kaşka et al., 1995; Atlı et al., 1999, 2001; Özuslu et al., 2005; Tel et al., 2022; Oğuz & Oğuz, 2022; Atlı et al., 2022; Hamakhan & Kafkas, 2022; Topçu & Gündeşli, 2022; Gündeşli, 2022; Tel et al., 2023; Tel et al., 2024).

In our field studies, it was determined that P. terebinthus, P. vera, P. palaestina, P. atlantica, P. khinjuk, P. eurycarpa species belonging to the genus Pistacia L. were found in Gaziantep. It was determined that the species previously identified as P. khinjuk by Özuslu & Özaslan (2003) were misidentified and that these species were P. atlantica.

Although P. terebinthus L. subsp. terebinthus and P. terebinthus L. subsp. palaestina (Boiss.) Engler subspecies should not coexist in the same geographical area, studies show that these taxa are mixed in their distribution areas (Özuslu et al., 2005). Since these two subspecies should not be found in the same geographical area, it strengthens the argument that P. palaestina should be included in the species category.

The characters mainly used in the taxonomic classification of Pistacia L. species include leaf basal to midrib connections, leaflet size and shape, number of leaflet pairs, presence or absence of apex leaflet, leaflet tip shape, fruit size and shape (Zohary, 1952; Yaltırık, 1967; 1967a; 1967b; Kafkas & Perl- Treves, 2001; Özuslu et al., 2009; Al-Saghir & Porter, 2012). Specimens collected from Gaziantep and their morphological characters are given in Table 2.

Table 2: Morphological characters used in the taxonomy of Pistacia L. species

Morphological Character	P. terebinthus	P. palaestina	P. atlantica	P. eurycarpa	P. khinjuk	P. vera
Leaf	Imparipinnate or paripinnate	Paripinnate	Imparipinnate	Imparipinnate	Imparipinnate	Imparipinnate
Terminal Leaflet	Not wider than the sides or as wide as the sides	Absent, it is always smaller or smaller than the next one (if any)	Not wider than the next one or as wide as the next one	Bigger than the ones next door	Usually bigger than the ones on the side	Bigger than or as big as the ones next to it
Leaflet Shape	Ovate-oblong or oblong-lanceolate	Oblong-lanceolat	Ovate-oblong or lanceolat	Ovate or ovate-oblong	Ovate-oblong or oblong	Ovate or broadly lanceolate
Leaflet Apex	Obtuse, acute or acuminate always marked mucronate	Acut, Acuminate, mucronat	Obtuse, not mucronate	Obtuse, not mucronate	Acuminate, scarcely mucronate	Acute or obtuse, mucronat
Lateral leaflet size (cm)	3-7(-8) x 1.8-3(-4)	4.2-6 x 1.4-2.6	2.5-8 x 0.8-2.2	5-8.5 x 2-5	4-9 x 1.5-5.3	5-10 (-12) x 3-6
Number of leaflet pairs	(1)2-4 (-6) pair	3-7 pair	2-5(-6) pair	2-3 pair	2-4 pair	1-2 (-3) pair
Fruit shape	Globose or broadly ovate	Globose or broadly ovate	Obovate or broadly ovate	Broadly ovate or flaettened globose	Globose	Ovate-oblong
Fruit Size (mm)	5-6 x 4-6	5-6 x 4-5	(5-)6-7(-7.6) x (5-)6-7	6.4-8 x 7-8.1	4-6 x 4-5	16-29 x 9-12

General characteristics of Pistacia L. species distributed in Gaziantep:

P. atlantica Desf.

Deciduous trees up to 20 metres tall. The crown is dense, almost free and spherical. Leaves pinnate to imparipinnate, leaflets 2-5 pairs, ovate to oblong or lanceolate, 2.5-8 x 0.8-2.2 cm, obtuse, not mucronate, dark green on the upper surface, pale on the lower surface, glabrous except at the ciliate margin. The leaf rachis (petioles) has a narrow blade on the midrib. Female inflorescences sparse, male inflorescences dense. Fruits paniculate (panicle with the main axis longer than the lateral branches), elongated or longer in length than in width; 5-8 x 5-6 mm. The outer skin colour of the fruit is pistachio or bluish green. They are especially abundant in regions under the influence of the Mediterranean climate. Pistacia atlantica is a deciduous tree species and grows in humid, semi-arid and arid regions between 100-2000 metres altitude. Although it belongs to the Irano-Turanian phytogeographic region, it is most commonly found in the Mediterranean region (Zohary, 1952). It has a grey bark (Kafkas et al., 2001).

P. eurycarpa Yalt.

Trees and shrubs up to 5 metres tall. Leaves fall in winter, imparipinnate; leaflets 2-3 pairs, ovate or ovate-oblong, 5-8.5 x 2-5 cm, obtuse, not mucronate, glabrous except at the ciliate margin, bright green on both surfaces; rachis not winged or very narrow and not persistent. Fruits paniculate, always flattened, flattened, globose, 6-7 x 8-9 mm. Grows on rocky slopes with deciduous oak shrubs at 1100- 1720 m. Ir. Tur. Element.
P. eurycarpa is known as buttum and melengiç. This species grows mostly in semi-arid and arid regions, oak woodlands, stony and rocky slopes between 1100-1800 m. It has compound leaves. It is a dioecious tree that sheds its leaves in winter (Yaltırık, 1967a; Kafkas & Perl-Treves, 2001; Kafkas et al., 2002; Al-Saghir & Porter, 2012; Yılmaz et al., 2023; Yılmaz et al., 2024). It is a xerophyte species. It is distributed in Turkey, Syria, Jordan, Lebanon, Armenia, Iran, Afghanistan, Pakistan and northern Iraq. It is an element of Iran-Turanian phytogeographic region (Yaltırık, 1967; 1967a; 1967b; Atlı et al., 1999; Al-Saghir & Porter, 2012). The chromosome number is 2n=30 (Basrila et al., 2003). In Turkey, it is distributed in Bitlis, Mardin, Gaziantep and Hakkari (Yaltırık, 1967; 1967a; 1967b), Balıkesir, Manisa, İzmir, Aydın, Denizli, Mersin (Yılmaz et al., 2024).

P. khinjuk Stocks
Small trees up to 7 m. in height. Leaves fall in winter, imparipinnate; leaflets 2-4 pairs, ovate-oblong or oblong, 4-9x1.5-5.3 cm, acuminate (tapering abruptly towards the apex), but almost mucronate, clearly pinnate-veined, glabrous or with the lower surface covered with very short and dense hairs, ciliate at the basal margin, the terminal leaflet usually larger than the lateral ones; midrib with short soft hairs, cylindrical or slender, insignificantly angular, not winged. Fruits paniculate, globose, 4-6 x 4-5 mm. Grows between 1000-1800 m. on the rocky slopes of the dam gorge (Zohary, 1996).
In our country, it is found in the Southeastern Anatolia region, especially in all parts of Siirt province, Kermata and Mutki in Bitlis, Zap valley, Çukurca, Geyman and Beytüşşebap regions of Hakkari and partly in Mardin provinces. Its flowers are similar to pistachio flowers. Male inflorescences are more dense and reddish. Inflorescence stems are green or light green in colour. It is the species with the latest flowering time among Pistacia species. The outer shell colour of the fruits is green.

P. vera L.
Trees up to 10 metres tall. It sheds its leaves in winter. Leaf structure is similar to culture peanut, leaves can be double-leaved in single structure at the shoot tips. Terminal leaflets are present and equal in size with other leaflets. Leaflets trifoliate or imparipinnate, 1-2 (-3) pairs, ovate or broadly lanceolate, acute or obtuse, mucronulate 5-10 (-12) x 3-6 cm, conspicuously densely reticulate, apex larger or larger than lateral leaflets, sparsely covered with dense short hairs; midrib not winged, pubescent.
The leaves are dark green, glossy on the upper side and dull and matt on the lower side. Leaflets are ovate in female pistachio trees, narrow and pointed in male individuals. There is no wing on the leaflet stalk. Flowers have no petals and sepals and are greenish-yellow in racemes. Male flowers are larger and denser than other wild species (Bilgen 1968). There are 200-600 flowers in male inflorescences and 80-130 flowers in female inflorescences (Atlı et al., 1995). Pollination in pistachios is by wind. Fruits are paniculate, ovate-oblong, 10-29 x 5-12 mm, seed bears large green cotyledons, edible. Fruit colour varies from green, blue to pistachio-coloured and red, as in Buttum. Male flowers are larger and denser than other wild species (Bilgen 1968; Zohary, 1996). In female trees, the crown shape is umbrella-shaped. Branch colour varies between grey-brown.

P. terebinthus L.

They are trees up to 6 metres tall or shrubs of 2-3 metres. Thuja often forms on the branches. Leaves deciduous in winter, imparipinnate or paripinnate, leaflets (1-)2-4(-6) pairs. Ovate-oblong or oblong-lanceolate, 3-7(-8)x1.8-3(-4) cm, obtuse, acute or acuminate, always mucronate. Leaflets pubescent, dark green on upper surface, pale on lower surface, apex not broader than lateral ones. Inflorescences of different sizes, dense or sparse. Flower colour is red to dark red. Male inflorescences are red and scatter abundant flower powder. Fruits paniculate, globose or broadly obovate. 5-6 x 4-6 mm. The fruit is small, the outer skin is thin and turns green when well ripe. Since it has a strong root structure, it usually grows in rocky, calcareous, stony and arid land conditions (Zohary, 1996).

P. palaestina Boiss.

Deciduous trees, 2-6 metres tall. Leaf midrib is wingless. Leaves have double leaflets at the top. Although the terminal leaflet is rarely formed, it is usually absent. Leaflets are 3-7 pairs and 3x7 cm. long. Leaflets are arranged on a long stalk, drooping downwards, ovate-oblong, abruptly tapering towards the tip, pointed. Flowers in panicles with the main axis longer than the lateral branches. Fruit ovoid to ovoid-spherical, 5 mm. in diameter. The outer shell turns red when ripe (Zohary, 1996; İlikçioğlu, 2022). It grows between 50-1500 m. in rocky areas, maquis, pseudomaki and red pine forests.

They deciduousise their leaves in winter. Its leaves are similar to P. terebinthus leaves. Although it is similar to Melengiç in terms of its leaves, it is different from Melengiç due to its single stem and high stature. The trunk colour is ash-coloured, dark brownish (Bilgen, 1968).

In this research, 175 leaf and fruit samples from 55 localities were analysed and six Pistacia L. species were identified in Gaziantep province. These species are P. terebinthus, P. vera, P. palaestina, P. atlantica, P. khinjuk, P. eurycarpa. The characters and characteristics used in the systematics of the species identified in Gaziantep were determined.

Among the main characteristics used in the taxonomic identification of Pistacia L. species, it was determined that the main leaf junctions, leaflet size and shape, number of leaflet pairs, apex leaflet presence or absence, leaflet tip shape, fruit size and shape. However, the intense hybridisation tendency of these species, the inability to use flowers for classification and the absence of genetic barriers between species cause confusion in the phylogenetic structure of the genus. Therefore, a comprehensive revision of the genus Pistacia in Turkey is necessary.

REFERENCES

Açar, İ. (1997). Ceylanpınar Tarım İşletmesinde Seçilmiş Bazı Erkek Antepfıstığı Tiplerinin Morfolojik ve Biyolojik Özellikleri Üzerine Bir Araştırma. [Yüksek Lisans Tezi Harran Üniversitesi Fen Bilimleri Enstitüsü] Yükseköğretim Kurulu Ulusal Tez Merkezi.

Ak, B. E., Kaşka, N. & Açar, İ. (1999). Dünyada ve GAP bölgesinde Antepfıstığı (Pistacia vera L.) üretimi, yetiştirme ve işleme yöntemlerinin karşılaştırılması. GAP I. Tarım Kongresi, Şanlıurfa, Türkiye, 26–28 Mayıs 1999.

Al-Saghir, M. G. & Porter, D. M. (2012). Taxonomic revision of the genus Pistacia L. (Anacardiaceae). American Journal of Plant Sciences 3, 12-32. http://dx.doi.org/10.4236/ajps.2012.31002.

Anonymous (1998). Descriptors for Pistacia spp. (excluding Pistacia vera L.). Ipgri International Plant Genetic Resources Institute, Rome.

Aslan, M., Türkmen N. & Güzel, A. (2001). Determination of Weed Species in Pistachio (Pistacia vera L.) Orchards in the Southeastern Anatolia Region of Turkey. The journal of Turkish Weed Science, 4(1), 1-10.

Aslan, M. & Çetin, E. (2011). The distribution of Pistacia L. species living in GAP region of Turkey and their biogeographic, morphologic and taxonomic characteristics. Acta Hortic 912, 501-505. https://doi.org/10.17660/actahortic.2011.912.76

Atlı, H. S., Kaşka, N., Eti, S., (1995). Selection of Male Pistacia spp. Types Grown in Gaziantep. First International Syposium on Pistachio Nut, Adana, Türkiye, 20-24 september 1994. ss. 419: 319-322.

Atlı, H. S., Arpacı, S., & Ayanoğlu, H. (1999). Comparison of seedling characteristics of some Pistacia species. In Ak B.E. (Ed.), XI. Grempa seminar on pistachios and almonds. International Centre for Advanced Mediterranean Agronomic Studies. Grempa, Zaragoza.

Atlı, H. S., Arpacı, S., Kaşka, N., & Ayanoğlu, H. (2001). Willd pistacia species in Turkey. In S. Padulosi, & A. Hadj-Hassan (Eds.), Towards a comprehensive documentation and use of pistacia genetic diveristy in central & west asia, north africa and mediterranean europe. International Plant Genetic Resources Institute, Irbid, Jordan.

Atlı, H. S., Bozkurt, H. & Uğur, R. (2022). Antepfıstığında Çoğaltma ve Terbiye Sistemleri. In M. A. Gündeşli (Ed.), Antepfıstığı (Pistacia vera L.). Iksad Publications, Ankara.

Ayfer, M. (1959). Antep fıstığının döllenme biyolojisi üzerinde araştırmalar. Ankara Üniversitesi Ziraat Fakültesi Yayınları No: 148, Ankara Üniversitesi Basımevi, Ankara.

Ayfer, M. (1990). Antepfıstığının Dünü, Bugünü ve Geleceği. Türkiye 1. Antepfıstığı Sempozyumu, Gaziantep, Türkiye, 11-12 Eylül 1990, ss. 14-23.

Basrila, H., Kafkas, S. & Topaktaş, M. (2003). Chromosome Numbers of Four Pistacia (Anacardiaceae) Species. Journal of Horticultural Sciences & Biotechnology, 78(1), 35-38. https://doi.org/10.1080/14620316.2003.11511583.

Bilgen, A. M. (1968). Memleketimizde bulunan antepfıstığı anaçları ve aşılama tekniği. Tarım Bakanlığı Yayınları, Ankara.

Davis P. H. (1965-1988). Flora of Turkey and Aegean Islands volume 1-9. Edinburgh University Press, Edinburgh.

Davis, P. H. (1972). Flora of Turkey and Aegean islands. volume 2. Edinburgh University Press, Edinburgh.

Elbistanlı, Ö., Kantar Davran, M. & Emeksiz, Ö. F. (2020). Gaziantep İli Antepfıstığı İhracat ve Pazarlama Organizasyonu. Elektronik Sosyal Bilimler Dergisi, 19(74), 724-749.

Eldoğan, Ü. & Şahin, A. (2015). Gaziantep ilinde Antepfıstığı üretim ekonomisi araştırması. KSÜ. Doğa Bilim Dergisi, 18(3), 29-36.

Gündeşli, M. A. (2022). Antepfıstığı (Pistacia vera L.), Iksad Publications, Ankara.

Güner, A., Aslan, S., Ekim, T., Vural, M., & Babaç, M. T. (2012). Türkiye bitkileri listesi (damarlı bitkiler). Nezahat Gökyiğit Botanik Bahçesi ve Flora Araştırmaları Derneği Yayını, İstanbul.

Hamakhan, M. & Kafkas, S. (2022). Antepfıstığının Doku Kültürü ile Çoğaltımı. In M.A. Gündeşli (Ed.), Antepfıstığı (Pistacia vera L.), Iksad Publications, Ankara.

İlikçioğlu, E. (2022). Antepfıstığının kültür tarihi, sistematiği genealogisi ve ülkemizdeki yayılış alanları. In B. E. Ak ve M. Pakyürek M. (Eds.), Antepfıstığı Yetiştiriciliği, Iksad Publications, Ankara.

Kafkas, S. & Perl-Treves, R. (2001). Morphological and molecular phylogeny of Pistacia species in Turkey. Theoretical and Applied Genetics 102, 908-915.

Kafkas, S., Kafkas, E., & Perl-Treves, R. (2002). Morphological Diversity and a Germplasm Survey of Three Wild Pistacia Species in Turkey. Genetic Resources and Crop Evolation, 49, 261-270.

Kaşka, N., Çağlar, S., Kafkas, S. (1995). Genetic diversity and germplasm conservation of Pistacia species in Turkey. Taxonomy, Distribution, Conversation and Uses of Pistacia Genetic Resources. IPGRI, 46-50 p.

Kokwaro, J.O. & Gillett, J.B., 1980. Notes on the Anacardiaceae of Eastern Africa. Kew Bull. 34(4), 755-756.
Kuru, C. & Özsabuncuoğlu, İ. H. (1990). Yabani Pistacia Türlerinin Aşılanmasında Sorunlar ve Çözüm Yolları. Türkiye I. Antepfıstığı Sempozyumu, Gaziantep, Türkiye, 11–12 September 1990.
Oğuz, H. İ. & Oğuz, İ. (2022). Antepfıstığında Kullanılan Anaçlar. In M.A. Gündeşli (Ed.), Antepfıstığı (Pistacia vera L.), Iksad Publications, Ankara.
Onay, A. (1996). In Vitro Organogenesis and Embryogenesis of Pistachio, Pistacia vera L. Institute of Cell and Molecular Biology, University of Edinburg, Edinburgh.
Onay, A., Tilkat, E., Ersalı, Y., Ayaz Tilkat E. & Süzerer, V. (2012). Antepfıstığının (Pistacia vera L.) morfolojik ve biyolojik özellikleri ile verimini etkileyen faktörler. Batman Üniversitesi Yaşam Bilimleri Dergisi 2(1), 116-131.
Özbek, S. (1978). Özel Meyvecilik. Çukurova Üniversitesi Ziraat Fakültesi Yayınları: 128, Adana.
Özuslu, E. & Özaslan, M. (2003). Gaziantep Göksüncük Köyü Anıt Ağaçları. The Karaca Arboretum Magazine, 7(1), 37-44.
Özuslu, E., İskender, E. Özaslan, M. & Zeynalov, Y. (2005). The Investigation of the Flora Sof Mountain (Gaziantep, Turkey). Flora Mediterranea, 15, 359-391.
Özuslu E., İskender E., Tel A. Z. & İlçim A. (2009). Taxonomic situations of two subspecies of Pistacia (P. terebinthus sups. terebinthus and P. terebinthus subsp. palaestina) by morphological and area remarks. Biological Diversity and Conservation, 2(2), 100-109.
Parfitt, D. E. & Badens, M. L. (1997). Phylogeny of the genus Pistacia as determined from analysis of the chloroplast genome. Proceedings of the National Academy of Sciences of the United States of America, pp. 15, 7987-7992. doi:10.1073/pnas.94.15.7987
Post, G. E. & Dinsmore, J. E. (1932). Flora of Syria, Palastine and Sınai volume 1. American Univ. Press, Beirut, Lebanon.
Seçmen, Ö., Gemici, Y., Görk, G., Bekat, L. & Leblebici, E. (2008). Tohumlu bitkiler sistematiği. Ege Üniversitesi Fen Fakültesi Kitaplar Serisi No:116, İzmir.
Tekin, H. Arpacı, S., Atlı, S. Açar, İ., Yaman, A., Yükçeken, Y. & Karadağ, S. (2001). Antepfıstığı Yetiştiriciliği. Antepfıstığı Araştırma Enstitüsü Müdürlüğü Yayını, Gaziantep.
Tekin, H., Karagöz, D., Kılıç, İ.H., Simitçioğlu, B., & Yayla, F. (2020). Morphological-pomological characterıstics and ecologıcal requirements of Pistachio (Pistacia vera L.). Zeugma Biological Science 1(2), 15-27.
Tel, A.Z., Ortaç, İ. & Özuslu, E. (2022). Bazı mağara ve obrukların (Mersin/Türkiye) flora ve genel vejetasyon yapıları üzerine bir araştırma. Biological Diversity and Conservation, 15(3), 356-368. https://doi.org/10.46309/biodicon.2022.1180111
Tel, A.Z., Ortaç, İ., İlçim, A. & Özuslu, E. (2023). Mersin İlindeki (Türkiye) Bazı Doğal ve Kültürel Sit Alanlarının Floristik Yapısı Üzerine Bir Çalışma. KSÜ Tarım ve Doğa Dergisi, 26(5), 1056-1065.
Tel, A.Z., Ortaç, İ., Özuslu, E. & İlçim, A. (2024). Contributions of floristic and general vegetation characteristics of the Mavga Castle (Mut/Mersin, Türkiye). Biharean Biologist 18(1), 1 – 11.
Topçu, H. ve Gündeşli, M. A. (2022). Antepfıstığında Moleküler ve Geleneksel Islah. In M.A. Gündeşli (Ed.), Antepfıstığı (Pistacia vera L.), Iksad Publications, Ankara.
Yaltırık, F. (1967). Türkiye florası için yeni bir tür. İ.Ü. Orman Fakültesi Dergisi, 14(1), 148-153.
Yaltırık, F. (1967a). Pistacia. In P. H. Davis (Ed.), Flora of Turkey and the east Aegean islands volume 2. Edinburgh University Press, Edinburgh.
Yaltırık, F. (1967b). Contributions to the taxonomy of woody plants in Turkey. Notes from the Royal Botanic Garden, 28(1), 11-12.

Yavuz, M. A., Yıldırım, H. & Onay, A. (2016). Dünya Antepfıstığı Üretiminde Son On Yılın Değerlendirilmesi. Batman Üniversitesi Yaşam Bilimleri Dergisi 6(2/2), 22-31.

Yılmaz, A., Özuslu, E. & Sarpkaya, K. (2023). Pistacia atlantica Desf. Türünün Marmara, Ege ve Akdeniz Bölgelerinde Yayılış Alanları ve Taksonomik Özelliklerinin Belirlenmesi. KSÜ Tarım ve Doğa Dergisi, 26(6), 1259-1267. https://doi.org/10.18016/ksutarimdoga.vi.1239965.

Yılmaz, A., Özuslu, E., Sarpkaya, K., Tel, A. Z. (2024). Pistacia eurycarpa Yalt. (Anacardiaceae) Türünün Bazı Morfolojik Özellikleri ve Yeni Yayılış Alanları. KSÜ Tarım ve Doğa Dergisi 27(3), 548-555. https://doi.org/10.18016/ksutarimdoga.vi.1339649

Zohary, M. (1952). A monographical study of the genus Pistacia. Palestine Journal of Botany, 5(1), 187-228.

Zohary, D. (1996). The genus pistacia. (Taxonomy, distribution, conservation and uses of pistacia genetic resources). In S. Padulosii, T. Caruso & E. Barone (Eds.), International Plant Genetic Resources Institute. Palermo, Italy.

WHAT ARE THE CHALLENGES FACING EUROPEAN AGRICULTURE?

AVRUPA TARIMININ KARŞILAŞTIĞI ZORLUKLAR NELERDIR?

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Abstract
The Common Agricultural Policy (CAP) continues to enjoy a large share of the European budget. If the CAP constitutes the first budget of the European Union, it is not no longer the budgetary colossus of the 1960s and 1970s. Its share of community spending has continued to decrease, reaching less than 40% today, compared to two-thirds at the start of the 1980s, with the cost of the CAP per capita being approximately 100 euros per year. In reality, the CAP retains its legitimacy and modernity intact: responding to the food challenge, both quantitatively and qualitatively. Put simply, it is a strategic European policy. The objectives of the CAP are enshrined in the Treaty on the Functioning of the European Union. The objectives of the common agricultural policy are set out in Article 39.1, in a wording identical to that of the Treaty of Rome in 1957. In sixty years, it is only the numbering which has changed. All the added values linked to its implementation on a European scale make the CAP a European policy of the future for the European Union. One must recall that the CAP is a founding and structuring policy for European construction, which must today respond to fundamental issues for the future of the European ideal: challenges of food security and health, as well as economic, social, environmental, and geopolitical issues. Such challenges will be explored in detail in this research paper.
Keywords: Agriculture, Common Agricultural Policy, European Union, Food Security, Geopolitics

Özet
Ortak Tarım Politikası (OTP), Avrupa bütçesinde büyük bir pay almaya devam etmekte. Eğer OTP Avrupa Birliği'nin ilk bütçesini oluşturuyorsa, artık 1960'lı ve 1970'li yılların devasa bütçesi değil. Topluluk harcamalarındaki payı düşmeye devam ederek 1980'lerin başındaki üçte ikilik oranlarla karşılaştırıldığında bugün %40'ın altına düştü; OTP'nin kişi başına maliyeti yılda yaklaşık 100 avro civarında. Gerçekte OTP, meşruiyetini ve modernliğini olduğu gibi koruyor: gıda sorununa hem niceliksel hem de niteliksel olarak yanıt veriyor. Basitçe söylemek gerekirse, bu stratejik bir Avrupa politikasıdır. OTP'nin hedefleri Avrupa Birliği'nin İşleyişine İlişkin Antlaşma'da yer almaktadır. Ortak tarım politikasının hedefleri, 1957 Roma Antlaşması'ndaki ifadeyle tıpatıp aynı Madde 39.1'de belirtilmiştir. Altmış yılda değişen sadece numaralandırmadır. Avrupa ölçeğinde uygulanmasıyla bağlantılı tüm katma değerler, OTP'yi Avrupa Birliği için geleceğin Avrupa politikası haline getirmekte. OTP'nin, Avrupa idealinin geleceğine yönelik temel sorunlara bugün yanıt vermesi gereken Avrupa inşaatına yönelik kurucu ve yapılandırıcı bir politika olduğu unutulmamalıdır: gıda güvenliği ve sağlık sorunlarının yanı sıra ekonomik, sosyal, çevresel ve jeopolitik sorunlar. Bu tür zorluklar bu araştırmada ayrıntılı olarak incelenecektir.
Anahtar Kelimeler: Tarım, Ortak Tarım Politikası, Avrupa Birliği, Gıda Güvenliği, Jeopolitika

INTRODUCTION

In order to get a clear idea of the agricultural reforms espoused by the European Union (EU), it is best to study the legal framework of the new reform of the Common Agricultural Policy (CAP)and analyse its impact on sustainability and rural development. The EU has put in place a legislative package that will be in force until 2027, with important implications for the agricultural sector in the move towards a greener and more sustainable Europe.

Currently, the constitutive law consists of the Treaty on the Functioning of the European Union (TFEU) and the Treaty on European Union. The common agricultural policy is regulated in the TFEU, specifically in Title III on Agriculture and Fisheries (Jurcewicz & Popardowski, 2021). Article 384 states the mandate to create a common agricultural policy. In its first years, a mercantilist approach formed the vision of the CAP, which focused on intervening in the markets to promote more productive agriculture.

Article 39, for its part, establishes the objectives and the methods to be followed to achieve them. Again, the detailed objectives and methods correspond to the idiosyncrasy of the CAP in its early years, when it sought to increase agricultural productivity, stabilise markets, or ensure the supply of food at reasonable prices. These objectives are more than sensible if one takes into account that the start of the CAP coincided with the end of the Second World War.

On the other hand, the second section of article 39 provides that when drawing up the CAP, the importance of the agricultural sector in the economy, the inequalities between the different agricultural regions and the need to make appropriate adjustments in line with the socio-political context must be considered (Proelss & Houghton, 2012). The latter will be reflected in successive reforms. Article 43 provides that the Commission shall submit proposals for elaborating and implementing the common agricultural policy (Baayen at al., 2023). In this regard, the Commission submitted a communication on the future of food and agriculture before the 2023 reform.

Given its scope in the CAP reforms, it is appropriate to set out a series of notes on European environmental policy. Although environmental policy has become one of the EU's cross-cutting axes, the truth is that at the beginning of the European Economic Community, there was no legal basis for its development. It was not until the approval of the Single European Act in 1986 that the legal basis for the EU's environmental powers was definitively consolidated through the Treaty of the European Economic Community amendment and the inclusion of a new Title VII on "Environment" (Kalicka-Mikołajczyk, 2018). Currently, environmental policy is regulated in Title XX on Environment.

They establish the objectives of environmental principles and the issues for elaborating the policy. The objectives are broadly defined, legitimising the EU's adoption of almost any action and measure. With this foundation, eight environmental programs have been approved and gradually integrated into the CAP.

In the new CAP, the European policies that have had the greatest influence are the European Green Deal and the 2030 Agenda, from which a series of provisions have emerged that have shaped a greener CAP. This greening of the CAP is familiar, as it has already been present in previous stages. However, it is more intense, as mandatory environmental requirements have been established instead of complementary ones. This has materialised in two pillars: in Pillar I, with reinforced conditionality, and in Pillar II, with agri-environmental and climate interventions.

Two legislative initiatives derived from the European Green Deal have had the greatest impact on the new CAP: the Biodiversity by 2030 Strategy and the Farm to Fork Strategy (Wesseler, 2022). Regarding the first, among the 39 actions of the Biodiversity on the Horizon 2030, one can highlight two: the obligation that at least 10% of the agricultural surface be destined to landscape elements of great diversity and the objective of increasing 25% the agricultural land destined to organic products. The Farm to Fork Strategy, for its part,

results in obligations to reduce the use of fertilisers by 20%, chemical pesticides and antimicrobials by livestock both by 50%.
The 2030 Agenda for Sustainable Development sets out seventeen sustainable development goals (Weiland et al., 2021). The UN approved these goals in 2016 and provided a new vision of economic growth, social well-being, and environmental protection. The EU approved, among other actions, the European Green Deal to achieve these goals. The second Sustainable Development Goal is the most relevant for agricultural matters, as it aims to end hunger, achieve food security and improved nutrition, and promote sustainable agriculture (Yigit, 2024a). Based on this legal-administrative analysis, the new CAP is structured by several regulations that entered into force on 1 January 2023. These regulations regulate the financing, management, and monitoring of the CAP and lay down rules for supporting national strategic plans for the CAP.

HISTORICAL DEVELOPMENT

The CAP has evolved over the years in response to the social and economic needs of agriculture and livestock farming and to the political objectives of the time, as established in Article 39 of the TFEU. Over time, a type of agriculture and livestock farming adapted to political objectives and the socio-political context has been shaped.
The CAP was created after the Second World War, which caused a major food shortage. This set the initial objectives linked to it: to ensure the supply of food for the population at affordable prices and guarantee a decent standard of living for farmers. The means to achieve these results were direct aid to EU farmers and livestock breeders. This interventionist policy made EU products more economically attractive, creating inequality with products from third countries.
The main effects of this first stage were a spectacular increase in productivity, prices higher than those on the world market and the generation of large surpluses. This meant that, from the 1980s onwards, the EU went from being a net importer to a net exporter of food. In fact, in approximately 20 years, it became the second-largest exporter of agricultural products.
However, this productivist, intensive, industrialised model produced two unexpected results. On the one hand, surpluses were created, requiring a huge amount of public money to buy them, and, on the other hand, this type of model clashed head-on with environmental issues that were already beginning to cause concern at this time. The overall balance of the first years of application was positive, as it achieved the objectives set. However, the undesirable negative effects three decades after its creation led to the first major reform of the CAP.
In 1992, the first major reform of the CAP took place, known as the MacSharry reform (Daugbjerg, 2003). The context of this stage was characterised by the rise in energy prices following the oil crisis in 1973. This crisis led to increased production costs, which led to the implementation of innovative technologies and a reduction in energy consumption in agricultural production. In addition, there was a growing concern for the environment at the international and Union levels, introducing the environmental problem as a political axis for the first time.
These two realities marked the 1992 reform, in which the crops and animals covered were expanded. This led to a change from a system of support for market prices to a payment system in which payment was made by surface area or head of livestock. This changed the protectionist trend, equating domestic prices with those of third countries, leading to a reduction in the profits of farmers and ranchers.
Environmental practices are also beginning to be incorporated. For the first time, financing was available for both cultivated and uncultivated land. Financing for uncultivated land was higher than for cultivated land because obtaining a return on it was impossible. The MacSharry reform was highly successful, although, like the previous stage, it was not free

from criticism. It was, therefore, only the beginning of a major reorientation of the European Union's agricultural policy.

The start of the third stage was preceded by the 1999 negotiations between the World Trade Organisation (WTO) and the countries of Central and Eastern Europe (CEEC). These negotiations were followed by the approval and implementation of Agenda 2000, which introduces the second pillar of the CAP, rural development. It is worth highlighting the aids included in this: the improvement of land, the promotion of tourism and crafts, and environmental protection in relation to organic products; aid to young farmers; and the cessation of agricultural activity, forestry, and the protection and conservation of rural heritage. Regarding the first pillar, income aid is consolidated, leaving direct aid behind. Furthermore, to improve the CAP's efficiency and governance at this stage, the obligation to review the implementation and results halfway through the implementation period was introduced. This review, which took place in 2003, gave way to a real reform after only four years of application.

2003 and 2013 REFORMS

In the 2003 reform, aid linked to production was definitively abandoned, and aid to producers was consolidated. This aid was calculated through the Single Payment Scheme. For the first time, environmental conditions were included to obtain this aid, which was obligatory and different from the complementary payments for carrying out the so-called good agricultural practices. Compliance with these conditions was verified through the Integrated Management and Control System for direct payments, which is still in force (McMahon, 2019).

The 2013 reform was the penultimate reform, which, due to its magnitude, required creating a transition period from 2010 to 2014. During this period, new features were introduced to facilitate the adaptation of the Member States. The governance model is being changed, giving greater power to the Member States by entrusting them with implementing a national strategy, which is the predecessor to the current Strategic Plans. In other words, one is witnessing an evolution of the CAP in which more and more power is being given to the Member States.

Pillar I aid consisted of basic aid based on surface area or head of livestock, complementary aid for environmental measures (green payment) and other additional aid aimed at young or small farmers. Regarding Pillar II, there are no changes during this period. Reform is influenced by social, political, and economic realities. The two major events that have marked our current context are the COVID-19 pandemic and the war in Ukraine (Yigit, 2024). These events have had human and economic consequences at very different levels, which are also reflected in factors that directly impact the configuration of the CAP.

The global health crisis caused by the COVID-19 pandemic not only caused a great loss of human lives but also reduced productive capacity, collapsed international markets and demand, and, together with social isolation measures and movement restrictions, led to an unprecedented economic collapse (Yigit, 2021). What makes this crisis different from others is the response of the European institutions. This was articulated in the European Recovery Plan Next Generation EU, endowed with 750,000 Million Euros. To distribute these funds among the Member States, each prepared a Recovery, Transformation, and Resilience Plan. These funds not only aim to alleviate the negative consequences of the pandemic but have also been used to advance towards the green and digital transition.

The objective of this standard is to adapt our administrations to achieve the objectives pursued and execute the funds correctly. A comprehensive reform of the public administrations is necessary to manage all funds from the EU, including those derived from the CAP. The war in Ukraine, for its part, has had a significant impact on the current socio-political context. The conflict began on 24 February 2022 and is causing a large and growing number of victims, generating a major humanitarian crisis (Yigit, 2022). The Russian invasion of Ukraine has had a negative impact on the supply of raw materials due to the role of these countries in the world supply, affecting the supply of global chains (Yigit, 2023). Not only this, it has also caused a sharp increase in the prices of gas and oil, which has caused a severe energy crisis that has raised electricity prices. These increases and increased financial uncertainty have caused inflation to rise. In particular, world food prices have experienced a sharp rise that already existed in 2021 and have skyrocketed since the beginning of the war, being one of the highest increases since 1961. Rising prices in developed countries and food shortages in developing countries are now tangible realities threatening economic stability.

This has impacted the configuration of the CAP, with the specific objective of creating a safe and resilient food sector that takes advantage of new technologies and is respectful of the environment. The legal and administrative means of agricultural policy play a key role in achieving these objectives.

Thus, the current CAP is based on three elements:

i. A smart agricultural sector, competitive, resilient and diversified that guarantees food security

ii. Protection of the environment to contribute to achieving environmental objectives

iii. Strengthening the socio-economic fabric of rural areas

Future of Food and Farming

Within the EU, the Commission has put forward a communication by the provisions of Article 43 of the TFEU. This communication sets out the current context and the changes that must be made in the agricultural sector through the CAP. The Future of Food and Agriculture document sets out the EU context for the green and digital transition, which aims to underpin the EU's political and economic direction (Chrysomallidis & Doukas, 2024). The agricultural sector and the rural environment play a prominent role in this green transition.

Specifically, farmers and livestock breeders are the primary preservers of the natural environment, taking care of the natural resources of soil, water, air, and biodiversity on 48% of EU land (foresters on 36%) and providing essential carbon sinks and the supply of renewable resources for industry and energy. Rural areas are also an important centre of employment, leisure, and tourism, home to 55% of EU citizens.

The communication also states that the agricultural sector has special characteristics that make it vulnerable. It is influenced by various factors, such as weather phenomena, prices, natural disasters, pests, diseases, etc., many of which are caused or intensified by current climate change. In this context, the communication establishes the need for the new CAP to guide the agricultural sector towards sustainability and resilience.

This communication refers to the public consultation carried out in mid-2017 on the Modernisation and simplification of the CAP. Another important aspect that can be drawn from this consultation and that has been a constant throughout all the CAP reforms is the demand to reduce bureaucracy, both for the administration and those administered. This communication led the European Commission to submit a legislative proposal to Parliament, but this resulted in lengthy negotiations that postponed the CAP reform. Therefore, during 2021 and 2022, the new reform was not applied, but rather, there was a transitional period in which the current CAP was continued.

PILLAR I

Considering the objectives pursued, one must examine the legal-administrative instruments used to achieve them. One of the main changes is the articulation of the policy, moving from a policy of obligation of means to a policy of obligation of results. This paradigm change was already present in the previous stage, but in the current one, the Member States are consolidated as necessary actors for the materialisation of the EU's general objectives in each member state.

The new approach has combined the need to reduce administrative procedures with the green-digital push and guaranteed a synergistic approach between them. The new CAP is structured around two pillars: the first regulating the common organisation of agricultural markets and direct payments to agricultural holdings, and the second regulating rural development interventions.

ECOREGIMES

The new Eco-regimes have replaced the previous green payments present in the previous CAP. These regimes can be divided into two types: obligatory compliance, the so-called reinforced conditionality and voluntary ones, the so-called eco-regimes. Despite the latter being voluntary regimes, as they represent almost a quarter of the budget of the first pillar, if the current level of aid is to be maintained, farmers will have to apply them.

This is a complementary aid to the previous ones and goes beyond the mandatory environmental requirements to receive basic aid and those derived from the interventions for rural development. It is a regime that the farmer may benefit from in full or in all or part of his surface, combining different practices on the same. Nine eco-regimes are established, for which certain characteristics must be met and validated in each plot (Montoliu, 2024). Therefore, the same farmer may be eligible for eco-regimes that do not even include all the plots subsidised by the CAP. The specific characteristics of each eco-regime are developed in article 27. One of the main novelties of this new CAP is the inclusion of eco-regimes. As has been done previously, it is committed to sustainable agriculture, far removed from the productivist agriculture of the beginning.

However, even though the green turn is desirable for a sustainable economy, many of these commitments reduce farm productivity and profitability, which is not compensated by the economic amount of aid. This has been highlighted by the main representatives of farmers and ranchers following the approval of the new CAP. Initially, CAP aid was linked to production. However, this link has gradually been eliminated to avoid overproduction and ensure that agricultural production meets market demands. Certain products require specific aid for economic, social, or environmental reasons. Otherwise, their production by EU farmers and livestock breeders would be considerably reduced.

In order to apply for this aid, unlike the previous ones, it is unnecessary to have been assigned rights to basic income support. Therefore, only the general requirements of the associated aid and the specific ones for each will have to be met. Among the general requirements is the minimum surface area, which will be 1 hectare in dry land and 0.5 in irrigated land. Each Member State will choose the specific sectors according to their specific circumstances, with a budget limit of 8 to 10%, which may be increased if certain conditions are met to 13-15%.

Regarding direct payments to farmers, aid is included for extensive beef cattle farming, for the fattening of calves on the farm where they are born; for the sustainable fattening of calves, for the sustainable production of cow's milk; extensive and semi-extensive beef sheep and goat farming; for the sustainable production of sheep and goat milk; and extensive and semi-extensive sheep and goat farmers without pastures at their disposal and who graze on stubble, fallow land and fruit and vegetable remains.

PILLAR II

The second pillar is dedicated to rural development, which was included after the entry into force of Agenda 2000 (Philippidis & Hubbard, 2003). Originally, this second pillar was intended to include an environmental and social perspective in the hands of rural territories, understanding that they played a fundamental role in environmental conservation and sustainable development.

The situation in which this new reform is approved is critical for rural communities. In this problem, the agricultural sector plays a dual role: productive and protecting the environment and rural development. Therefore, to achieve the much-desired rural development, the type of agricultural sector and its support are key. In this sense, the predominant agriculture in our country is characterised by being oriented towards global markets and marketing through large distributors, which generates serious environmental impacts and fewer benefits to rural areas than other alternative agri-food models would do.

The EU itself promotes this agricultural sector through the CAP, which is paradoxical if we take into account other policies and strategies that the EU approves. In this regard, it is worth mentioning the commitments materialised in the European Green Deal and the Farm to Fork Strategy. In these programmes, the Member States must configure more sustainable agri-food systems that provide affordable and healthy food with a distribution model oriented towards proximity.

The second pillar is financed by the European Agricultural Guarantee Fund (EAGF) and the European Agricultural Fund for Rural Development (EAFRD), channelled through a Strategic Plan drawn up by each Member. In this Plan, each of the Member States must specify its own objectives and definitions, creating a greater responsibility for the results. This is a policy of obligation to results, which can suppose a paradigm shift but needs time to confirm a real change. This new document will replace the regional rural development programmes.

Prior to preparing the PEPAC (Common Agricultural Policy Strategic Plan), the European Commission drafted a series of recommendations for each of the Member States. Rural development under the CAP is articulated through so-called interventions. These include payments for environmental and climate commitments and other management commitments that Member States must support in their territories by their specific national, regional or local needs.

These interventions must be included in the PEPAC by allocating financial resources to the objectives and needs of the specific State. These interventions are regulated in Chapter IV of the PEPAC, which sets out in Article 69 the types of interventions for rural development, which are the following (Viegas, Wolf & Cordovil, 2023):

a) Environmental, climatic and other management commitments
b) Natural or other area-specific constraints
c) Area-specific handicaps resulting from certain mandatory requirements
d) Investments, including investments in irrigation infrastructure
e) Establishment of young and new farmers and start-up of new rural businesses
f) Risk management tools
g) Cooperation
h) Exchange of knowledge and dissemination of information

These interventions listed in the above-mentioned article are transferred to PEPAC. Specifically, environmental and climate commitments are divided into agri-environmental commitments on agricultural areas, forest management commitments, commitments to maintain forestation and agroforestry systems, agri-environmental management commitments in organic farming, commitments to animal welfare and health, and commitments to conserve genetic resources. Each commitment is aimed at a territorial area and establishes certain objectives and eligibility conditions.

Investments are divided into productive and non-productive. Productive investments are directly linked to the agricultural sector and aim to improve infrastructure in multiple ways, including adapting crops to the new climate change scenario, modernising for the transformation, marketing, and/or development of agro-food products, promoting competitiveness, improving irrigation infrastructures, and diversifying agricultural production. Non-productive investments have a double aspect: on the one hand, investments in basic services and, on the other, investments related to forest management.

Specific interventions are also included for establishing young and new farmers and launching new rural businesses. As we have already analysed in this work, generational change is key to the future of the agricultural sector and rural communities. This intervention is intended to promote the inclusion of young people and women in the agricultural sector and help them overcome the additional obstacles they face to promote business and local development in rural areas.

Due to its territorial and budgetary scope, it focuses on treating LEADER, which is a local development method that has been utilized for thirty years to involve local actors in creating and implementing strategies, making decisions, and allocating resources for rural area development. This approach is carried out by approximately 2,800 Local Action Groups, which, as of the end of 2018, covered 61% of the rural population in the EU. It brings public, private, and civil society stakeholders together in specific areas. This information can be insightful in the context of PEPAC (Viegas, Wolf & Cordovil, 2023). Its territorial importance is relevant since it applies to all the Autonomous Communities. In terms of budget, by mandate of Article 92 of the RPEPAC, at least 5% of the total contribution of the EAFRD to the CAP strategic plan must be reserved for LEADER (Finta, 2019). This same provision was already in force in the period 2014-2020.

Until the current programming period, the regional governments were required to develop regulations for applying funds to LEADER. However, from 2023 onwards, the PEPAC will determine how funds are distributed to LEADER. The PEPAC establishes this intervention as mandatory and programmed in all Autonomous Communities. Through LEADER, all the CAP's specific objectives can be financed.

The PEPAC only indicates the contribution to strategic objective 8. This is because the PEPAC will be updated after the EDLP is selected and approved. With this form of intervention, the bottom-up approach is ensured since the LAGs will identify their needs and set the objectives of the PEPAC in this section. This new plan to centralise the distribution of LEADER funds in the PEPAC may be positive, considering the negative assessments of regional practices in recent years. The actions of the regional governments have been very heterogeneous, which is why harmonisation at the state level has been required. Another positive aspect is consolidating the commitment to bottom-up policies in which citizens participate and transfer their needs to public institutions.

CONCLUSION

The CAP reform, with its significant changes in implementation method, holds the potential to bring about positive outcomes. Member States are developing their own Strategic Plans, tailored to their specific needs, which could lead to more efficient fund allocation. While the impact of these changes is yet to be seen, the potential for a more efficient and effective system is promising. Furthermore, while Member States can tailor their strategic plans to their circumstances, they must ensure they align with the EU's general objectives, particularly sustainability and rural development. This ensures a level of consistency among the strategies of Member States, all of which are working towards a more environmentally friendly Europe.

Needless to say, agricultural policy support is crucial for the availability of primary sector support. With this support, many farmers and livestock breeders could maintain their farms. This aid ensures a strong and stable agricultural sector in the EU and provides a decent livelihood for farmers and breeders. CAP aid is essential for rural development economically by providing a decent livelihood for farmers and breeders and socially by supporting rural areas. Committing to this aspect of the policy and implementing innovative initiatives, such as LEADER through CAP funds, is important to combat rural depopulation. While the new CAP regulations aim to promote rural development and sustainability and reduce administrative burdens, farmers' and ranchers' demands indicate that these goals could be more effective. This underscores the need for public administrations to provide technical support and disseminate information to the territory's stakeholders.

REFERENCES

Baayen, R. P., Baltussen, W. H., Beldman, A. C., van Galen, M., Jongeneel, R., Logatcheva, K., ... & Schrijver, R. (2023). Sustainability agreements in agriculture: Horizontal and vertical agreements in agriculture for the benefit of nature, the environment, the climate, animal welfare and the earning capacity of farmers (No. 3239). Wageningen Environmental Research.

Chrysomallidis, C., & Doukas, Y. E. (2024). Building Networks in the Agri-Food Chain: EU as Facilitator Toward Digital Transformation and "Greening" of Agricultural Sector. Journal of International Food & Agribusiness Marketing, 36(1), 47-67.

Daugbjerg, C. (2003). Policy feedback and paradigm shift in EU agricultural policy: the effects of the MacSharry reform on future reform. Journal of European Public Policy, 10(3), 421-437.

Finta, I. (2019). The planned legal regulation of the EU's post-2020 development policy–or an assassination against the countryside. European Countryside, 11(1), 162-177.

Jurcewicz, A., & Popardowski, P. (2021). Article 38 [Common Agriculture and Fisheries Policy] (ex-Article 32 TEC). In Treaty on the Functioning of the European Union–A Commentary: Volume I: Preamble, Articles 1-89 (pp. 829-843). Cham: Springer International Publishing.

Kalicka-Mikołajczyk, A. (2018). External Dimension of the European Union Environmental Policy-Selected Legal Issues. Wroclaw Review of Law, Administration & Economics, 8(2), 447-462.

McMahon, J. A. (2019). The Direct Payments Regulation. In EU Agricultural Law and Policy (pp. 38-73). Edward Elgar Publishing.

Montoliu, J., Guzmán, G., Lora, Á., Mora, J., Auxiliadora Soriano, M., & Gómez, J. A. (2024, April). Vegetative barriers as a nature-based solution for agricultural landscapes diversification: design and management of this green infrastructure in a Mediterranean climate. In EGU General Assembly Conference Abstracts (p. 3052).

Philippidis, G., & Hubbard, L. J. (2003). Agenda 2000 reform of the CAP and its impacts on member member states: a note. Journal of Agricultural Economics, 54(3), 479-486.

Proelss, A., & Houghton, K. (2012). The EU Common Fisheries Policy in light of the precautionary principle. Ocean & coastal management, 70, 22-30.

Viegas, M., Wolf, J., & Cordovil, F. (2023). Assessment of inequality in the Common Agricultural Policy in Portugal. Agricultural and Food Economics, 11(1), 13.

Viegas, M., Wolf, J., & Cordovil, F. (2023). Assessment of inequality in the Common Agricultural Policy in Portugal. Agricultural and Food Economics, 11(1), 13.

Weiland, S., Hickmann, T., Lederer, M., Marquardt, J., & Schwindenhammer, S. (2021). The 2030 agenda for sustainable development: transformative change through the sustainable development goals?. Politics and Governance, 9(1), 90-95.

Wesseler, J. (2022). The EU's farm-to-fork strategy: An assessment from the perspective of agricultural economics. Applied Economic Perspectives and Policy, 44(4), 1826-1843.

Yiğit, S. (2021). The Economic and Political Effects of COVID- 19 on the Eurasian Economic Union, in AYHAN, F., Darici, B., CHIU, C., L. (2021). New Normal and New Rules in International Trade, Economics and Marketing. Berlin, Germany: Peter Lang Verlag. pp.35-55.

Yigit, S. (2022). Russia's Invasion of Ukraine: The First Seven Months. in Aydın, M., Şiriner, İ., & Koç, Ş. A., Global Agenda in Social Sciences: Global Studies Vol. 9, 417.

Yigit, S. (2023). European Union: Borders and Enlargement after the Russian Invasion of Ukraine, in Essays on Economics and International Relations, Global Studies Volume 11, Eds. Midelashvili, Şiriner & Koç, IJOPEC Publication. ISBN: 978-1-913809-33-1

Yigit, S. (2024). Post-Pandemic Higher Educational Challenges: Lessons Learnt From COVID-19. In S. Hai-Jew (Ed.), Navigating Teaching in an Era of Social Distancing and Global Conflict (pp. 1-34). IGI Global. https://doi.org/10.4018/979-8-3693-3382-2.ch001

Yigit, S. (2024a). Coming of Age: Sustainable Development, in 11th International Mardin Artuklu Scientific Researches Conference December 13-15, 2023 / Mardin, Turkiye Full Texts Book, Eds: SEYİS & GAFUROVA, IKSAD Publishing House, Issued: 25.12.2023, ISBN: 978-625-367 -566-0 p.983-1000.

help mitigate their harmful effects. The human body produces certain enzymes to combat oxidative stress. However, negative lifestyle choices and environmental factors can lead to a deficiency in natural antioxidants, allowing excess free radicals to damage cell membranes and their functions. Antioxidant-based medications are designed to lessen oxidative stress in the body. Excessive oxidative stress is associated with a variety of diseases, including neurodegenerative disorders, cardiovascular diseases, diabetes, cancer, and age-related conditions (Aissous et al., 2023; Sakrani et al., 2022; Zaoui et al., 2022). Natural antioxidants are increasingly preferred over synthetic ones in food and pharmaceutical applications due to concerns about their potential adverse effects (Saidi et al., 2022). Studies have suggested that some synthetic antioxidants might pose health risks, including a possible link to cancer, prompting a shift toward safer, natural alternatives.
Herein, a quantitative analysis of bioactive compounds in *Robinia pseudoacacia* stem was carried out, and antioxidant activity was evaluated.

MATERIALS AND METHODS

Quantitative analysis of phenolic compounds

LC-MS/MS was utilized to identify the bioactive compounds in the stem of Robinia pseudoacacia. The stem was dried and then extracted with 100 mL of methanol, using 5.0 g of the plant material. The solvent was evaporated using a rotary evaporator to obtain a crude extract. This crude extract (100 mg) was then dissolved in 10 mL of methanol and filtered through a 0.45 mm filter paper. The solution was diluted with a mixture of 50% methanol and water until the concentration reached 2.0 ppm. For phytochemical analysis, chromatographic separation of the components was performed using a Poroshell 120 EC-C18 column (100 mm × 4.6 mm I.D., 2.7 µm). A gradient program was applied, and the flow rate was set at 0.4 mL/min for the analysis of the diluted extract solutions (Erenler et al., 2023f).

Antioxidant Activity

Antioxidant activity of *Robinia pseudoacacia* stem was carried out using the DPPH free radical scavenging technique and ABTS radical cation scavenging technique (Gecer & Erenler, 2022).

RESULTS AND DISCUSSİON

Quantitative analysis of phenolics is significant for drug discovery (Houari et al., 2022). Phenolics are known for their potent antioxidant activity, which helps scavenge free radicals and protect cells from oxidative stress (Erenler et al., 2022). Many phenolics exhibit anti-inflammatory, antibacterial, antifungal, and antiviral properties, making them potential candidates for therapeutic drugs (Boulechfar et al., 2022). Certain phenolic compounds have been linked to anti-cancer properties, such as inhibiting tumor growth and metastasis. These compounds are abundant in plants, fruits, vegetables, and herbs (Bayram et al., 2022; Benguedouar et al., 2022). Quantifying these compounds helps identify promising natural sources of therapeutic agents. Quantitative analysis ensures the consistency and standardization of raw materials used in drug development (Djermane et al., 2020). By quantifying phenolics, manufacturers can ensure the active ingredient's potency, which is critical for efficacy and safety. Knowledge of phenolic content assists in determining optimal extraction methods and conditions to maximize yield and activity (Erenler et al., 2018a; Erenler et al., 2018b; Erenler et al., 2015; Genç et al., 2020).
The quantitative analysis of bioactive compounds in *Robinia pseudoacacia* stem was presented. Syringic acid (0.025 µg/ g extract), salicylic acid (0.015 µg/ g extract), hesperidin (0.012 µg/ g extract), and kaempferol (0.011 µg/ g extract) were detected as chief products (Table 1, Figure 1). The activity may be attributed to the chief compounds present in the extract or to the synergistic effects of the combination of the compounds. The silver nanoparticles synthesized from plants displayed considerable antioxidant activity. *Tagetes erecta* leaves were used for

capping, stabilizing, and reducing agents for the synthesis of silver nanoparticles that displayed excellent antioxidant activity (Erenler et al., 2021). In addition, oleuropein-mediated silver nanoparticles was achieved that showed good antioxidant effects (Genc et al., 2021). Silver nanoparticles were synthesized using *Origanum majorana* and exhibited excellent antioxidant activity (Erenler & Dag, 2022). Moreover, various plants were used for the synthesise of silver nanoparticles that revealed the antioxidant effects (Erenler et al., 2023b; Erenler & Gecer, 2022; Erenler et al., 2023c; Erenler & Hosaflioglu, 2023; Erenler et al., 2023e; Gecer, 2023).

Table 1. Quantitative analysis of phenolic compounds in *Robinia pseudoacacia* stem (µg/mL)

Compound	RT	Conc.
Gallic acid	3.23	0.003
Hydroxybenzaldeyde	7.60	0.002
Caffeic Acid	7.77	0.002
Syringic acid	8.41	0.025
Vanillin	8.66	0.003
o-coumaric acid	9.39	0.007
Salicylic Acid	9.54	0.015
Trans-ferulic acid	10.12	0.009
Sinapic acid	10.77	0.003
p-coumaric acid	11.54	0.001
Hesperidin	11.84	0.012
Fisetin	13.44	0.002
Naringenin	15.07	0.003
Hesperetin	15.87	0.003
Kaempferol	16.12	0.011

RT: Retention time

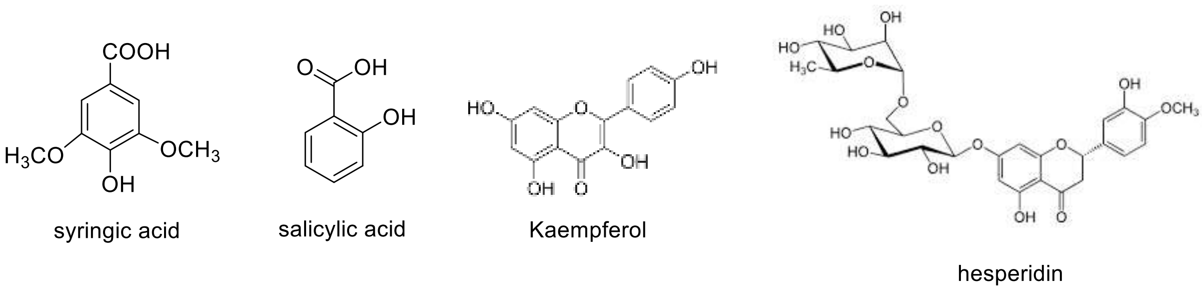

Figure 1. Major natural compounds found in *Robinia pseudoacacia* stem extract

Antioxidant activity of *Robinia pseudoacacia* stem (Rps) was carried out, and it displayed a considerable antioxidant effect. In the DPPH assay, Rps displayed excellent activity, with a value of 9.32±0.23 (IC_{50}, µg/mL) compared to the BHT (11.41±0.41). Furthermore, the ABTS radical scavenging effect of Rps was calculated as 8.62±0.23 (IC_{50}, µg/mL), which is higher than that of the BHT (9.41±0.37, IC_{50}, µg/mL) (Table 2).

Table 2. Antioxidant activity of *Robinia pseudoacacia* stem (Rps), IC_{50} (µg/mL)

Samples	DPPH$^{\bullet}$	ABTS$^{\bullet+}$
Rps	9.32 ± 0.23^{c}	8.62± 0.23^{c}
BHT	11.41 ± 0.41^{d}	9.41 ± 0.37^{d}
BHA	7.24 ± 0.61^{b}	6.36 ± 0.45^{a}
Trolox	6.51 ± 0.25^{a}	7.25 ± 0.62^{b}

Different letters indicate a significant difference in mean values.

CONCLUSION

Quantitative analysis of phenolic compounds of *Robinia pseudoacacia stem* resulted in the determination of significant biological active compounds. The antioxidant activity of this plant may be due to these compounds of the synthetic effect of the combination of these compounds.

REFERENCES

Aissous, I., Benrebai, M., Ameddah, S. et al. (2023). The preventive effects of *Centaurea maroccana* Ball. extract against oxidative stress induced by cisplatin in mice brains: in vitro and in vivo studies. *Drug and Chemical Toxicology*, 46(6): 1162-1175. https://doi.org/10.1080/01480545.2022.2139841.

Aydin, A., Erenler, R., Yılmaz, B. et al. (2016). Antiproliferative effect of *Cherry laurel*. *Journal of the Turkish Chemical Society, Section A: Chemistry*, 3(3): 217-228. https://doi.org/10.18596/jotcsa.21204.

Başar, Y., & Erenler, R. (2024). Phytochemical analysis of *Silybum marianum* flowers: Quantitative analysis of natural compounds and molecular docking application. *Turkish Journal of Biodiversity*, 7(1): 20-31. https://doi.org/10.38059/biodiversity.1450643.

Başar, Y., Hosaflıoğlu, İ., & Erenler, R. (2024). Phytochemical analysis of *Robinia pseudoacacia* flowers and leaf: quantitative analysis of natural compounds and molecular docking application. *Turkish Journal of Biodiversity*, 7(1): 1-10. https://doi.org/10.38059/biodiversity.1446241.

Bayram, M., Topuz, S., Karabıyıklı, Ş. et al. (2022). Isolation of oleuropein from olive leaf by effective method and investigation of its antimicrobial properties. *Indian Journal of Traditional Knowledge (IJTK)*, 21(1): 215-223

Benguedouar, K., Betina, S. B., Erenler, R. et al. (2022). Evaluation of the antioxidant properties and total phenolic content of a dairy product (yogurt) supplemented with *Thymus willdenowii* essential oil from Algeria. *Journal of Food Measurement and Characterization*, 16: 3568-3577. 10.1007/s11694-022-01455-6.

Boulechfar, S., Zellagui, A., Asan-Ozusaglam, M. et al. (2022). Chemical composition, antioxidant, and antimicrobial activities of two essential oils from Algerian propolis. *Zeitschrift für Naturforschung C*, 77(3-4): 105-112. https://doi.org/10.1515/znc-2021-0028.

Cakmak, O., Erenler, R., Tutar, A. et al. (2006). Synthesis of new anthracene derivatives. *Journal of Organic Chemistry*, 71(5): 1795-1801. https://doi.org/10.1021/jo051846u.

Demirtas, I., Erenler, R., Elmastas, M. et al. (2013). Studies on the antioxidant potential of flavones of *Allium vineale* isolated from its water-soluble fraction. *Food Chemistry*, 136(1): 34-40. https://doi.org/10.1016/j.foodchem.2012.07.086.

Djermane, N., Gali, L., Arhab, R. et al. (2020). Chemical composition and in vitro evaluation of antioxidant, antimicrobial, and enzyme inhibitory activities of *Erucaria uncata* and *Thymeleae hirsuta*. *Biocatalysis and Agricultural Biotechnology*, 29: 101834. https://doi.org/10.1016/j.bcab.2020.101834.

Elmastaş, M., Telci, İ., Akşit, H. et al. (2015). Comparison of total phenolic contents and antioxidant capacities in mint genotypes used as spices/Baharat olarak kullanılan nane genotiplerinin toplam fenolik içerikleri ve antioksidan kapasitelerinin karşılaştırılması. *Turkish Journal of Biochemistry*, 40(6): 456-462. https://doi.org/10.1515/tjb-2015-0034.

Erenler, R., Atalar, M. N., Yıldız, İ. et al. (2023a). Quantitative analysis of bioactive compounds by LC-MS/MS from Inula graveolens. *Bütünleyici ve Anadolu Tıbbı Dergisi*, 4(3): 3-10. https://doi.org/10.53445/batd.1278048.

Erenler, R., & Biellmann, J. F. (2005). Facile conversion of pyridine propargylic alcohols to enones: Stereochemistry of protonation of allenol. *Tetrahedron Letters*, 46(34): 5683-5685. https://doi.org/10.1016/j.tetlet.2005.06.087.

Erenler, R., & Cakmak, O. (2004). Synthesis of hexabromo, hydroxy, epoxy, methoxy and nitroxy derivatives of tetralins and naphthalenes. *Journal of Chemical Research*(8): 566-569. https://doi.org/10.3184/0308234042563947.

Erenler, R., Chaoui, R., Yildiz, I. et al. (2023b). Biosynthesis, Characterisation, and Antioxidant Activity of Silver Nanoparticles using Schinus molle L. *Trends in Sciences*, 20(10): 6105-6105. https://doi.org/10.48048/tis.2023.6105.

Erenler, R., & Dag, B. (2022). Biosynthesis of silver nanoparticles using *Origanum majorana* L. and evaluation of their antioxidant activity. *Inorganic and Nano-Metal Chemistry*, 52(4): 485-492. https://doi.org/10.1080/24701556.2021.1952263.

Erenler, R., Demirtas, I., Karan, T. et al. (2018a). Chemical constituents, quantitative analysis and insecticidal activities of plant extract and essential oil from *Origanum onites* L. *Trends in Phytochemical Research*, 2(2): 91-96

Erenler, R., & Gecer, E. N. (2022). Green synthesis of silver nanoparticles from *Astragalus logopodioides* L. leaves. *Turkish Journal of Agriculture-Food Science and Technology*, 10(6): 1112-1115. https://doi.org/10.24925/turjaf.v10i6.1112-1115.5190.

Erenler, R., Gecer, E. N., Genc, N. et al. (2021). Antioxidant activity of silver nanoparticles synthesized from *Tagetes erecta* L. leaves. *International Journal of Chemistry and Technology*, 5(2): 141-146. https://doi.org/10.32571/ijct.1005275.

Erenler, R., Gecer, E. N., Hosaflioglu, I. et al. (2023c). Green synthesis of silver nanoparticles using *Stachys spectabilis*: Identification, catalytic degradation, and antioxidant activity. *Biochemical and Biophysical Research Communications*, 659: 91-95. https://doi.org/10.1016/j.bbrc.2023.04.015.

Erenler, R., Geçer, E. N., Alma, M. H. et al. (2022). Quantitative Analysis of Bioactive Compounds by High-Performance Liquid Chromatography in *Origanum bilgeri*. *Journal of Integrative and Anatolian Medicine*, 4(1): 15-20. https://doi.org/10.53445/batd.1210373.

Erenler, R., & Hosaflioglu, I. (2023). Green synthesis of silver nanoparticles using *Onobrychis sativa* L.: Characterization, catalytic degradation of methylene blue, antioxidant activity, and quantitative analysis of bioactive compounds. *Materials Today Communications*, 35: 105863. https://doi.org/10.1016/j.mtcomm.2023.105863.

Erenler, R., Karan, T., & Hosaflioglu, İ. (2023d). Phytochemical analysis of Syringa vulgaris: Quantitative analysis of natural compounds by LC-ESI-MS/MS. *Turkish Journal of Biodiversity*, 6(2): 75-78. https://doi.org/10.38059/biodiversity.1312872.

Erenler, R., Ojelade, R. A., Karan, T. et al. (2023e). Facile, efficient synthesis of silver nanoparticles using *Salvia absconditiflora*: Assessment of their antioxidant capacity and catalytic activity. *Inorganic Chemistry Communications*, 158: 111623. https://doi.org/10.1016/j.inoche.2023.111623.

Erenler, R., Telci, İ., Elmastaş, M. et al. (2018b). Quantification of flavonoids isolated from *Mentha spicata* in selected clones of Turkish mint landraces. *Turkish Journal of Chemistry*, 42(6): 1695-1705. https://doi.org/10.3906/kim-1712-3.

Erenler, R., Telci, I., Ulutas, M. et al. (2015). Chemical Constituents, Quantitative Analysis and Antioxidant Activities of *Echinacea purpurea* (L.) Moench and *Echinacea pallida* (Nutt.) Nutt. *Journal of food biochemistry*, 39(5): 622-630. https://doi.org/10.1111/jfbc.12168.

Erenler, R., Uno, M., Goud, T. V. et al. (2009). Preparation of some heterocyclic enones and ynones by isomerisation of the propargylic alcohols. *Journal of Chemical Research*, 2009(7): 459-464. https://doi.org/10.3184/030823409X464467.

Erenler, R., Yaman, C., Demirtas, I. et al. (2023f). Phytochemical Investigation of *Hypericum heterophyllum* Flowers: LC-ESI-MS/MS Analysis, Total Phenolic and Flavonoid Contents, Antioxidant Activity. *The Natural Products Journal*, 13(7): e120123212672. https://doi.org/10.2174/2210315513666230112165545.

Erenler, R., Yilmaz, S., Aksit, H. et al. (2014). Antioxidant activities of chemical constituents isolated from *Echinops orientalis* Trauv. *Records of Natural Products*, 8(1): 32-36

Gecer, E. N. (2023). Synthesis and characterization of silver nanoparticles using *Origanum onites* leaves: Cytotoxic, apoptotic, and necrotic effects on Capan-1, L929, and Caco-2 cell lines. *Green Processing and Synthesis*, 12(1): 20228126. https://doi.org/10.1515/gps-2022-8126.

Gecer, E. N., & Erenler, R. (2022). Biosynthesis of silver nanoparticles using *Dittrichia graveolens* (Asteraceae) leaves extract: characterisation and assessment of their antioxidant activity. *Turkish Journal of Biodiversity*, 5(1): 50-56. https://doi.org/10.38059/biodiversity.1090549.

Genc, N., Yildiz, I., Chaoui, R. et al. (2021). Biosynthesis, characterization and antioxidant activity of oleuropein-mediated silver nanoparticles. *Inorganic and Nano-Metal Chemistry*, 51(3): 411-419. https://doi.org/10.1080/24701556.2020.1792495.

Genç, N., Elmastaş, M., Telci, İ. et al. (2020). Quantitative analysis of phenolic compounds of commercial basil cultivars (*Ocimum basilicum* L.) by LC-TOF-MS and their antioxidant effects. *International Journal of Chemistry and Technology*, 4(2): 179-184. http://dx.doi.org/10.32571/ijct.795629.

Guemidi, C., Ait Saada, D., Ait Chabane, O. et al. (2024). Enhancement of yogurt functionality by adding Mentha piprita phenolic extract and evaluation of its quality during cold storage. *Food Science & Nutrition*. https://doi.org/10.1002/fsn3.3981.

Houari, F. Z., Brahmi, M., Erenler, R. et al. (2024). Chemical profile, antibacterial and antioxidant properties of *Rubia tinctorum* L. essential oils. *Natural Product Research*: 1-10. https://doi.org/10.1080/14786419.2024.2356670.

Houari, F. Z., Erenler, R., & Hariri, A. (2022). Biological activities and chemical composition of *Rubia tinctorum* (L.) root and aerial part extracts thereof. *Acta Biológica Colombiana*, 27(3): 403-414. https://doi.org/10.15446/abc.v27n3.95476.

Kaya, G., Karakaya, R., Tilgel, E. et al. (2014). Essential Oil Constituents of *Thuja orientalis* Berries. *Journal of new results in science*, 7(7): 1-6

Lu, J., Maezawa, I., Weerasekara, S. et al. (2014). Syntheses, neural protective activities, and inhibition of glycogen synthase kinase-3β of substituted quinolines. *Bioorganic and Medicinal Chemistry Letters*, 24(15): 3392-3397. https://doi.org/10.1016/j.bmcl.2014.05.085.

Newman, D. J., & Cragg, G. M. (2007). Natural products as sources of new drugs over the last 25 years. *Journal of Natural Products*, 70(3): 461-477. https://doi.org/10.1021/np068054v.

Sahin Yaglioglu, A., Akdulum, B., Erenler, R. et al. (2013). Antiproliferative activity of pentadeca-(8E, 13Z) dien-11-yn-2-one and (E)-1,8-pentadecadiene from *Echinacea pallida* (Nutt.) Nutt. roots. *Medicinal Chemistry Research*, 22(6): 2946-2953. https://doi.org/10.1007/s00044-012-0297-2.

Saidi, A., Hambaba, L., Kucuk, B. et al. (2022). Phenolic Profile, Acute Toxicity, and Hepatoprotective and Antiproliferative Activities of Algerian *Ruta tuberculata* Forssk. *Current Bioactive Compounds*, 18(3): 72-83. https://doi.org/10.2174/1573407217666211119092552.

Sakrani, I., Ameddah, S., Benrebaia, M. et al. (2022). Algerian Capparis spinosa n-BuOH Extract Alleviates Diabetic Neuropathy Induced with Streptozotocin in Rats. *Egyptian Journal of Chemistry*, 65(132): 519-538. https://doi.org/10.21608/EJCHEM.2022.156714.6790.

Türkmen, N., Öz, A., Sönmez, A. et al. (2014). Chemical Composition of Essential Oil from *Rosmarinus Officinalis* L. Leaves. *Journal of New Results in Science*, 6(6): 27-31

Yaman, C., Önlü, Ş., Ahmed, H. et al. (2022). Comparison of phytochemicals and antioxidant capacity of *Hypericum perforatum;* wild plant parts and in vitro samples. *Journal of Animal & Plant Sciences*, 32(2): 596-603. https://doi.org/10.36899/JAPS.2022.2.0459.

Zaoui, H., Boutaoui, N., Menad, A. et al. (2022). Phytochemical Profile, Anti-lipid peroxidation and Anti-diabetic activities of *Thymus algeriensis* Boiss. & Reut. *Egyptian Journal of Chemistry*, 65(12): 695-705

IMPACTS OF AGRIVOLTAIC SYSTEMS ON SOIL ECOSYSTEMS IN SEMI-ARID REGIONS

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ABSTRACT

This review evaluates the potential impacts of agrivoltaics (AV) systems as an innovative sustainability approach that integrates agricultural production and solar energy generation, particularly in semi-arid regions. By synthesizing the findings and results from original research articles in the literature, the study highlights the role of AV technology, especially in areas such as combating climate change, conserving water resources, and ensuring economic resilience. The focus is placed on the effects of AV systems on soil temperature, moisture content, microbial activity, soil structure, and erosion control. Additionally, the contributions of these systems to mitigating and adapting to climate change are examined in detail. The study emphasizes the multifaceted environmental benefits of AV systems. The shading effect of solar panels prevents excessive soil heating, reduces water loss through evaporation from the soil surface, and preserves soil moisture. Research shows that these systems improve soil structure and increase agricultural productivity by reducing wind and water erosion. Furthermore, AV systems contribute to reducing greenhouse gas emissions by decreasing reliance on fossil fuels through renewable energy production. This review also discusses the role of AV systems in ensuring sustainable water management in agricultural lands, enhancing carbon sequestration capacity, and maintaining soil health. It concludes that AV systems provide an integrated solution for both agricultural sustainability and energy security, marking a critical area for future research and development.

Keywords: Agrivoltaics, Sustainable agriculture, Renewable energy, Soil health, Climate change adaptation, Water management

ÖZET

Bu derleme çalışması, tarımsal üretim ile güneş enerjisi üretimini entegre eden yenilikçi bir sürdürülebilirlik yaklaşımı olarak agrovoltaik (AV) sistemlerin yarı kurak bölgelerdeki potansiyel etkilerini değerlendirmektedir. Literatürdeki özgün araştırma makalelerinin bulgularının sentezlenmesi yoluyla, AV teknolojisinin iklim değişikliğiyle mücadele, toprak ekosisteminin, su kaynaklarının korunması ve ekonomik dayanıklılık sağlama gibi alanlardaki rolü vurgulanmıştır. Çalışmada, AV sistemlerin toprak sıcaklığı, nem içeriği, mikrobiyal aktivite, toprak yapısı ve erozyon kontrolü üzerindeki etkilerine odaklanılmıştır. Ayrıca, bu sistemlerin iklim değişikliğiyle mücadele ve uyum sağlamadaki katkıları detaylı şekilde incelenmiştir. Güneş panellerinin gölgeleme etkisi, aşırı toprak ısınmasını engellerken toprak yüzeyinden buharlaşma yoluyla su kaybını azaltır ve toprak nemini korur. Araştırmalar, bu sistemlerin rüzgar ve su erozyonunu azaltarak toprak yapısını iyileştirdiğini ve tarımsal verimliliği artırdığını göstermektedir. Yenilenebilir enerji üretimiyle fosil yakıt kullanımını azaltarak sera gazı emisyonlarının düşürülmesine katkıda bulunan AV sistemlerin, tarım alanlarında sürdürülebilir su yönetimi sağlama, karbon tutma kapasitesini artırma ve toprak sağlığını koruma gibi özellikleri de ele alınmıştır. AV sistemlerin tarımsal sürdürülebilirlik ve enerji güvenliği için bütünleşik bir çözüm sunduğu belirtilmiş ve bu alandaki gelecekteki araştırmalar için kritik bir alan olduğu vurgulanmıştır.

Anahtar Kelimeler: Agrovoltaik, Sürdürülebilir tarım, Yenilenebilir enerji, Toprak ekosistemi, İklim değişikliğine uyum

INTRODUCTION

Agrivoltaic (AV) systems provide a sustainable solution by integrating agriculture and solar energy generation on the same land, addressing the dual goals of food security and renewable energy production. These systems are particularly suited for semi-arid regions, which face challenges such as water scarcity, high temperatures, and frequent droughts. By utilizing the region's abundant solar resources, AV systems generate electricity while offering the potential to enhance agricultural productivity. Through the combined use of land for solar energy and farming, AV systems maximize resource efficiency and land productivity. For instance, a 25% ground coverage ratio can sustain an 80% relative plot yield, effectively balancing energy generation with crop production (Dupraz, 2023). This dual-purpose approach not only ensures efficient resource utilization but also provides a viable strategy for meeting the increasing global demand for food and energy (Pascaris et al., 2021).

Key soil processes, including temperature, moisture content, microbial activity, and erosion control, are significantly influenced by AV systems. Understanding these impacts is crucial for optimizing system design and maximizing both agricultural and energy benefits. By adapting to climate change and strengthening economic resilience, AV empowers farmers to embrace sustainable practices. This study delves into the potential impacts of AV systems on soil ecosystems in semi-arid regions and explores their role in sustainable agriculture and energy production. This study delves into the potential impacts of AV systems on soil ecosystems in semi-arid regions and explores their role in sustainable agriculture and energy production. In AV systems, solar panels serve a dual purpose: energy generation and physical protection of agricultural land. These panels act as shields against heavy rainfall and strong winds, mitigating the effects of physical disturbances. This is especially beneficial in regions prone to intense weather events, where soil erosion is a significant concern. Research has shown that AV systems can reduce wind erosion by up to 30% and enhance soil aggregate stability, preserving soil structure and supporting vital processes like water retention and nutrient cycling (Adeh al., 2018). While AV systems hold immense potential for agricultural and energy benefits in semi-arid regions, their impact on soil ecosystems is multifaceted and influenced by factors such as shading intensity, soil type, and environmental conditions. Therefore, the design and implementation of AV systems must prioritize the preservation and sustainability of soil ecosystems. Dupraz et al. (2011) highlighted the potential of AV systems to influence soil microbial communities, creating novel ecosystem engineering opportunities.

Agrivoltaics offer a promising approach to sustainable agriculture and energy production. By integrating solar energy generation with agricultural practices, these systems contribute to climate change mitigation, water conservation, and soil health. AV systems not only reduce greenhouse gas emissions but also enhance agricultural productivity and resilience to climate change. As research continues to explore the potential of AV systems, it is crucial to consider the specific ecological and socio-economic contexts of different regions. By optimizing system design and management practices, AV systems can be effectively implemented to maximize their benefits while minimizing potential negative impacts.

The Impact of Agrivoltaics on Climate Change

Climate change, marked by rising temperatures, unpredictable precipitation patterns, and an increasing frequency of extreme weather events, presents major challenges to global agriculture and energy production. Agrivoltaic systems, which combine agricultural production with solar energy generation, provide a promising solution to address these challenges. By integrating renewable energy with agricultural practices, AV systems contribute to combating climate change through three critical mechanisms: mitigation, adaptation, and resilience to extreme weather conditions (Time et al., 2024; Marcuta et al., 2023).

One of the key benefits of AV systems lies in their ability to reduce greenhouse gas (GHG) emissions. By replacing high-carbon fossil fuels with low-carbon renewable energy, solar panels installed in AV systems drive a transformation in the energy sector. Studies have demonstrated that solar panels on agricultural land can reduce carbon emissions from energy production (Marcuta et al., 2023), significantly decreasing reliance on fossil fuels and playing a crucial role in climate change mitigation. Additionally, AV systems, particularly when coupled with conservation agriculture management practices, enhance soil carbon sequestration and reduce GHG emissions. The shading provided by solar panels helps stabilize microclimates, improving crop resilience and water-use efficiency while moderating the impacts of climate extremes (Dupraz, 2023; Time et al., 2024).

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Optimizing Land Use and Enhancing Resilience with Agrivoltaics

Agrivoltaics optimize land use by enabling the simultaneous production of food and energy on the same land. Unlike traditional energy and agricultural practices, which often lead to deforestation and land conversion, AV systems minimize such impacts. Research suggests that dual-use areas integrating food and energy production can reduce carbon emissions from land-use changes by up to 70% (Cardinael et al., 2017). Preventing deforestation not only limits carbon emissions but also contributes to ecosystem conservation and biodiversity sustainability. These features make AV systems a critical tool for climate change adaptation. By providing protection against adverse climate conditions such as high temperatures, drought, and strong winds, AV systems enhance the sustainability of agricultural production. Consequently, they offer an integrated solution that delivers environmental, economic, and agricultural benefits as part of climate change adaptation strategies.

In addition, solar panels in AV systems reduce surface runoff caused by heavy rainfall, water balance in agricultural areas and prevent soil compaction (Marrou et al., 2013). As a result, soil fertility is preserved, while rainwater harvesting and natural water storage capacities are improved. Beyond these environmental benefits, AV systems increase farmers' economic resilience by providing income from both agricultural products and energy production. This diversification acts as a buffer against crop losses caused by climate-induced stresses. For example, studies have shown that farmers using AV systems can offset up to 20% of crop losses through income generated from energy production (Agostini et al., 2021). This stabilizes agricultural incomes and promotes economic stability in rural communities.

The shading effect of PV panels in AV systems led to increased soil moisture by reducing soil temperature and evaporation rates (Ya'acob et al., 2023). This enhancement in moisture levels significantly contributed to lowering soil resistivity, which facilitates better electrical conductivity. Additionally, fertilization practices in AV systems, such as the application of ammonium sulfate via drip irrigation, promoted nutrient leaching, raising soil electrical conductivity and further decreasing soil resistivity. This dual benefit supports both crop growth and the optimization of grounding systems in solar farms (Ya'acob et al., 2023).

The Impact of Agrivoltaic Systems on Soil Ecosystems

The integration of crop cultivation with solar energy systems presents a viable strategy to mitigate soil degradation and promote sustainable land use in eco-fragile regions (Luo et al., 2024). Luo et al. (2024) demonstrated significant improvements in soil quality and multifunctionality under AV systems. Soil Quality Index (SQI) and Multifunctionality Index (MFI) showed substantial increases, with the gap areas and peanut cultivation delivering the most pronounced effects. Specifically, the SQI increased by up to 184.02%, and the MFI by 445.68%, compared to native land. These findings suggest that AV systems can enhance soil quality by improving moisture retention, nutrient availability, and microbial activity. Peanuts were particularly effective in boosting soil properties, underlining the importance of crop selection in AV systems. Overall, the integration of crop cultivation with solar energy systems presents a viable strategy to mitigate soil degradation and promote sustainable land use in eco-fragile regions.

Effects on Soil Temperature

Photovoltaic panels provide partial shading in agricultural lands, which can influence soil temperature through shading and changes in albedo (reflectivity). This shading effect directly impacts soil temperature, particularly by preventing overheating during the summer months. Marrou et al. (2013) reported that the shading effect stabilizes soil temperature throughout the day, preventing midday overheating and improving the performance of plant root systems.

In agrivoltaics, solar panels function to reduce extreme soil and air temperatures through partial shading. As global temperatures rise, plants are increasingly exposed to frequent and intense heat stress. The shade provided by solar panels helps mitigate this stress. Research has shown that shading can reduce average soil and air temperatures in agricultural lands by 2–5% (Barron-Gafford et al., 2019), a critical benefit in semi-arid and arid regions where high temperatures threaten crop yields.

The shading effect of photovoltaic panels reduces solar radiation reaching the soil surface, preventing excessive heating. Lower soil temperatures allow plant root systems to operate within optimal temperature ranges and help preserve soil moisture. By creating more balanced soil temperatures, the shading provided by solar panels supports plant growth and optimizes water management. Amaducci et al. (2018) found that AV systems reduce soil temperatures due to decreased radiation, creating more favorable conditions for plant development. This makes AV systems a valuable tool for sustainable agricultural practices, especially in hot and dry regions.

Agrivoltaics also create a more stable microclimate for plants. The shading effect not only reduces temperature fluctuations but also limits the impact of wind. By mitigating wind erosion and minimizing plant damage, this protective environment supports plant growth. For instance, a reduction in wind speed by 10–15% can significantly enhance the harvest efficiency of sensitive plant species (Dupraz et al., 2011).

Effects on Soil Moisture Content

Agrivoltaics can have significant positive impacts on water management. The partial shading provided by solar panels reduces evaporation, helping to preserve soil moisture. This is particularly beneficial in water-scarce regions, where it enhances irrigation efficiency and promotes more effective water use. By minimizing evaporation, these systems increase irrigation efficiency, contributing to the sustainable use of water resources and supporting sustainable agricultural practices. Using the Agrovoltaico model to simulate maize farming, Amaducci et al. (2018) found that these systems improved crop resilience to drought stress and optimized land productivity. This highlights their critical role in boosting agricultural production in semi-arid regions under water stress conditions. These benefits are likely due to the dual effect of AV systems: reducing evaporation through shading and increasing soil water retention capacity. The improvement in soil structure through increased organic matter and reduced soil tillage enhances infiltration, allowing more rainfall to percolate into the soil, while simultaneously increasing the soil's water retention capacity to store moisture.

The shading effect of solar panels also directly reduces soil evaporation, helping maintain moisture for longer periods. This significantly decreases the need for irrigation. For instance, a study reported that AV required 15–20% less irrigation compared to traditional farming methods (Adeh al., 2018). This efficiency is especially critical in water-scarce regions, as it not only conserves water resources but also promotes agricultural sustainability.

Soil Microbial Activity and Biodiversity

Shading and the resulting reduction in soil temperature can positively influence soil microbial activity, which plays a critical role in soil fertility and nutrient cycling for plant growth. Increased microbial activity enhances organic matter decomposition and nutrient availability, contributing to healthier soil ecosystems.

More stable microclimatic conditions under AV can improve the diversity and health of soil fauna. This enhanced biodiversity benefits plant growth and resilience by supporting a balanced ecosystem. The shading effect of solar panels and changes in soil temperature significantly impact soil microbiological activity. While shading may reduce the activity of photosynthetic microorganisms, it can stimulate other microbial processes, potentially improving nutrient cycling and soil health. The overall impact on soil microbiology depends on factors such as shading intensity, soil type, and environmental conditions (Chowdhury and Mandal, 2021). Luo et al. (2024) indicated that the AV system also enriched soil nutrient content, including total nitrogen, phosphorus, and potassium. Nutrient accumulation was higher in gap areas between panels than directly under the panels. Available nutrients, such as nitrate nitrogen, available phosphorus, and available potassium, were notably elevated, particularly in peanut-cultivated areas, highlighting the effectiveness of peanuts in biological nitrogen fixation. Furthermore, microbial biomass carbon, nitrogen, and phosphorus levels surged, especially in peanut plots and gap areas, indicating enhanced microbial activity and soil fertility. Urease activity improved, although phosphatase and sucrase activities declined, signaling changes in soil nutrient cycling dynamics.

Solar panels also influence the habitats and food resources of soil fauna. Changes in shading and soil temperature can positively or negatively affect the populations and activities of certain soil fauna species. For instance, shading may create favorable conditions for some organisms while limiting others. Care must be taken during the installation and maintenance of solar panels to avoid disrupting soil fauna and their habitats. These effects highlight the importance of carefully designing and implementing AV to maximize their benefits for microbial activity and biodiversity while minimizing potential disruptions to soil ecosystems (Gaikwad et al., 2023).

Soil Structure and Erosion Control

Agrivoltaic systems play a significant role in managing soil erosion, particularly by mitigating the impacts of heavy rainfall and runoff caused by photovoltaic (PV) installations. The integration of solar panels into agricultural lands can alter natural water flow patterns, leading to concentrated runoff along the edges of the panels, potentially increasing the risk of soil erosion. This phenomenon is especially pronounced when rainfall intensity exceeds the soil's infiltration capacity (Zahrawi and Aly, 2024).

Agrivoltaics improve the physical structure of soil by enhancing aggregate stability, which positively impacts the soil's water retention capacity and facilitates root penetration. This improvement in soil structure supports healthier plant growth and increases the resilience of agricultural systems. The physical barriers provided by solar panels reduce wind and water erosion, preventing soil loss—a particularly valuable advantage in semi-arid regions where erosion is a significant threat. By mitigating these processes, AV contributes to the long-term sustainability of soil resources. However, the installation and maintenance of solar panels can disturb the soil surface, potentially leading to localized erosion. To counteract this risk, appropriate soil conservation measures, such as minimizing ground disturbance and stabilizing the soil around panel structures, should be implemented (Wydra et al., 2023). In contrast, the presence of solar panels reduces the direct impact of rainfall on the soil beneath them, minimizing surface soil displacement. However, this benefit is countered by increased runoff at the panel edges, which requires effective management strategies (Zahrawi and Aly, 2024).

Soil and Water Management

Agrivoltaics enhance the soil's water retention capacity and reduce erosion. In partially shaded areas created by photovoltaic panels, evaporation decreases, helping preserve soil moisture. This reduction in evaporation improves infiltration rates, allowing rainwater to penetrate deeper soil layers while supporting natural filtration processes. This enhances the soil's ability to purify contaminants and improve water quality. Research indicates that crops grown under AV use water more efficiently, contributing to the preservation of groundwater resources (Weselek et al., 2021). Additionally, AV systems create a microclimate that can support vegetation under the panels. The vegetation not only stabilizes the soil but also reduces erosion by intercepting runoff (Zahrawi and Aly, 2024).

Luo et al. (2024) investigated the early effects of AV systems on soil quality in dry-hot valley eco-fragile areas, focusing on peanut and ryegrass cultivation under photovoltaic (PV) panels. Results revealed significant improvements in soil physicochemical properties. Soil moisture, pH, electrical conductivity, and soil organic carbon levels increased in the AV system compared to native land. Enhanced water retention under PV panels, attributed to reduced evaporation and moderated temperatures, resulted in soil moisture increases of up to 56.06%. SOC levels also rose significantly, particularly in ryegrass plots, with an increase of 14.94%, reflecting improved carbon sequestration.

Studies suggest that incorporating vegetative buffer zones around panel edges can be a highly effective strategy for managing runoff and mitigating soil erosion in AV systems. Vegetative buffer zones consist of strategically planted grasses, shrubs, or other ground cover species capable of slowing down water flow and encouraging water infiltration into the soil. These plants act as natural barriers that intercept and absorb excess runoff generated by the concentration of rainfall at the edges of photovoltaic panels. This process significantly reduces the speed and erosive force of water, thereby minimizing soil displacement and sediment loss. Moreover, the dense root systems of these vegetative buffers stabilize the soil structure by binding soil particles together, which further enhances resistance to erosion. Vegetation also helps trap sediments suspended in runoff, preventing the accumulation of eroded material in downstream areas or adjacent farmlands. This sediment trapping function not only reduces soil degradation but also improves the quality of water in nearby waterways by preventing the transport of soil particles and associated nutrients or pollutants (Zahrawi and Aly, 2024).

Soil Nutrients and Chemical Properties

Organic matter plays a crucial role in soil structure by binding mineral particles into granular aggregates, which contribute to loose, easily cultivated fertile soils. A significant fraction of this organic matter, particularly effective in forming stable soil granules, originates from adhesive-like substances secreted by various soil organisms, including plant roots (Brady and Weil, 2016). Furthermore, organic matter enhances soil water-holding capacity and increases the proportion of water available for plant growth, a critical factor for sustainable agriculture. It also acts as a primary reservoir for essential macronutrients such as nitrogen, phosphorus, and sulfur, which are released as soluble ions during organic matter decomposition, rendering them available for plant uptake (Stevenson and Cole, 1999; Eriksen, 2005).

Agrivoltaic systems can modulate soil processes, notably influencing the rate of organic matter decomposition and nutrient mineralization through their shading effect. This regulated mineralization fosters a more balanced and sustained nutrient supply, which is vital for optimal plant growth and development. Moreover, AV systems can affect soil pH, a process associated with increased organic matter content, thereby contributing to the maintenance of soil health. These benefits are particularly significant in semi-arid regions, where effective management of soil parameters is critical to ensuring plant health and productivity.

However, the implementation of poorly designed AV systems, coupled with unsuitable soil management and crop cultivation practices, may lead to adverse effects. These include a reduction in soil organic matter and increases in soil pH and salinity, which can collectively suppress microbial activity. Declines in microbial functions, measured through respiration and enzymatic activities, further compromise soil fertility and resilience (Moscatelli et al., 2022).

CONCLUSION and RECOMMENDATONS

Recent advancements in renewable energy systems have significantly increased the demand for land, particularly for solar farms. This growing demand highlights the need to balance land acquisition for solar energy with the protection of soil ecosystems, making the sustainability of these ecosystems a critical priority.

In this context, agrovoltaic (AV) systems present a holistic solution to mitigate the impacts of climate change across both agricultural and energy sectors. These systems offer multiple benefits, including renewable energy generation, improved agricultural productivity, and the conservation of soil ecosystems. By regulating soil temperature and moisture, AV systems create optimal conditions for plant growth, while enhancing water use efficiency and stimulating microbial activity.

The role of AV applications in controlling erosion and improving soil structure is particularly vital for promoting sustainable agricultural practices in semi-arid regions. Additionally, their capacity to reduce greenhouse gas emissions and optimize land use underscores their potential as a key contributor to environmental sustainability.

To fully realize the benefits of AV systems, their design and implementation must integrate considerations of soil health, water management, and energy efficiency. This interconnected approach offers a strategic framework to advance both agricultural productivity and environmental sustainability. However, future research is essential to better understand the long-term implications of these systems and refine their applications.

Despite their numerous advantages, the installation and operation of AV systems may pose certain challenges. For instance, changes in shading and soil temperature can adversely affect the population and activity of some soil fauna. Similarly, the installation and maintenance of solar panels may disturb the soil surface, potentially increasing the risk of soil erosion. To address these issues, effective soil conservation strategies must be implemented to safeguard against wind and water erosion. Moreover, measures designed to protect solar farms must ensure the preservation of ecosystem integrity, avoiding unintended disruptions to ecological balance.

Thus, precautionary measures are essential during both the establishment and operation phases of AV systems. By avoiding practices that harm biodiversity and prioritizing sustainability, these systems can effectively achieve their dual objectives of energy production and ecological conservation.

REFERENCES

Adeh, E. H., Selker, JS., Higgins, CW. (2018). Remarkable agrivoltaic influence on soil moisture, micrometeorology and water-use efficiency. PLoS ONE 13(11): e0203256. DOI: 10.1371/journal.pone.0203256

Amaducci, S., Yin, X., Co Michele lauzzi, M. 2018. Agrivoltaic systems to optimise land use for electric energy production. Applied Energy 220(4):545-561**,** DOI: 10.1016/j.apenergy.2018.03.081

Barron-Gafford, G., Pavao-Zuckerman, M., Minor, R.L., Sutter, L.F., Barnett-Moreno, I., Blackett, D. T., Thompson, M., Dimond , K., Gerlak, A.K., Nabhan, G.P., Macknick, J.E. 2019. Agrivoltaics provide mutual benefits across the food–energy–water nexus in drylands. Agrivoltaics provide mutual benefits across the food–energy–water nexus in drylands**.** Nature Sustainability 2(9), DOI: 10.1038/s41893-019-0364-5

Brady, N. C., & Weil, R. R. (2016). The Nature and Properties of Soils (15th ed.). Pearson Education, ISBN: 978-0133254556. 912 p.

Cardinael, R., Chevallier, T., Cambou, A., Beral, C., Barthès, B.G., Dupraz, C., Durand, C., Kouakoua, E., Chenu, C.2017. Increased soil organic carbon stocks under agroforestry: A survey of six different sites in France. Agriculture, Ecosystems & Environment, 236, pp.243–255. DOI: 10.1016/j.agee.2016.12.011

Chowdhury, S., Pozzer, A., Haines, A., Klingmüller, K., Münzel, T., Paasonen, P., Sharma, A., Venkataraman, C., Lelieveld, J. 2022.Global health burden of ambient PM2.5 and the contribution of anthropogenic black carbon and organic aerosols. Environment International,Volume 159, 107020. DOI: 10.1016/j.envint.2021.107020.

Chowdhury, K., & Mandal, R. 2021. Agrivoltaic: a new approach of sustainable development. Advances in Water Resources Management for Sustainable Use, 513-522.

Dupraz, C. 2023. Assessment of the ground coverage ratio of agrivoltaic systems as a proxy for potential crop productivity. Agroforestry Systems, 1-18.

Dupraz, H. Marrou, G. Talbot, L. Dufour, A. Nogier, Y. Ferard, 2011. Combining solar photovoltaic panels and food crops for optimising land use: Towards new agrivoltaic schemes, Renewable Energy, Volume 36, Issue 10, Pages 2725-2732, DOI: 10.1016/j.renene.2011.03.005.

Elamria, Y. Chevirona B., Lopezc, J.M., Dejeana, C., Belaudd, G. (2018). Water budget and crop modelling for agrivoltaic systems: Application to C.irrigated lettuces. Agricultural Water Management, 208:440-453. DOI: 10.1016/j.agwat.2018.07.001.

Eriksen, J. 2005. Gross sulphur mineralization-immobilization turnover in soil amended with plant residues. Soil Biology and Biochemistry, 37(11), 2216-2224. DOI: 10.1016/j.soilbio.2005.04.003.

Gaikwad, N. A., Sreekar, V. S., Sathe, T., & Mangrulkar, C. 2023. Review on Recent Developments in Agrovoltaic System. Renewable Resources and Energy Management, 359-369.

Luo, J., Luo, Z., Li, W., Shi, W., & Sui, X. 2024. The Early Effects of an Agrivoltaic System within a Different Crop Cultivation on Soil Quality in Dry–Hot Valley Eco-Fragile Areas. Agronomy, 14(3), 584.

Marcuta, L., Tindeche, C., Nuta, A. C., Nuta, F. M., & Marcuta, A. 2023. Study on the Importance of Using Agrivoltaic Systems to Reduce the Effects of Climate Change. Scientific Papers Series Management, Economic Engineering in Agriculture & Rural Development, 23(3).

Marrou, H., Guilioni, L., Dufour, L. , Dupraz, C., Wery, J. 2013. Microclimate under agrivoltaic systems: Is crop growth rate affected in the partial shade of solar panels? Agricultural and Forest Meteorology 177(2):117-132 DOI: 10.1016/j.agrformet.2013.04.012

Moscatelli, M.C., Marabottini, R., Massaccesi, L., Marinari, S., 2022. Soil properties changes after seven years of ground mounted photovoltaic panels in Central Italy coastal area, Geoderma Regional, Volume 29, DOI: 10.1016/j.geodrs.2022.e00500.

Pascaris, A.S., Handler, R., Schelly, C., Pearce, J.M. 2021. Life cycle assessment of pasture-based agrivoltaic systems: Emissions and energy use of integrated rabbit production, Cleaner and Responsible Consumption, Volume 3, DOI: 10.1016/j.clrc.2021.100030

Randle-Boggis, R. J., Barron-Gafford, G. A., Kimaro, A. A., Lamanna, C., Macharia, C., Maro, J., ... & Hartley, S. E. 2025. Harvesting the sun twice: Energy, food and water benefits from agrivoltaics in East Africa. Renewable and Sustainable Energy Reviews, 208, 115066.

Stevenson, F. J., & Cole, M. A. 1999. Cycles of Soil: Carbon, Nitrogen, Phosphorus, Sulfur, Micronutrients (2nd ed.). Wiley. ISBN: 978-0-471-32071-5. 448 p.

Time, A., Gomez-Casanovas, N., Mwebaze, P., Apollon, W., Khanna, M., DeLucia, E. H., & Bernacchi, C. J. (2024). Conservation agrivoltaics for sustainable food-energy production. Plants, People, Planet, 6(3), 558-569.

Weselek, A., Bauerle, A., Hartung, J., Zikeli, S., Lewandowski, I., & Högy, P. 2021. Agrivoltaic system impacts on microclimate and yield of different crops within an organic crop rotation in a temperate climate. Agronomy for Sustainable Development, 41(5), 59.

Wydra, K., Vollmer, V., Busch, C., & Prichta, S. 2023. Agrivoltaic: solar radiation for clean energy and sustainable agriculture with positive impact on nature. IntechOpen.

Ya'acob, M. E., Lu, L., Zulkifli, S. A., Roslan, N., & Ahmad, W. W. 2023. Agrivoltaic approach in improving soil resistivity in large scale solar farms for energy sustainability. Applied Energy, 352, 121943.

Zahrawi, A. A., & Aly, A. M. 2024. A Review of Agrivoltaic Systems: Addressing Challenges and Enhancing Sustainability. Sustainability, 16(18), 8271.

A STUDY ON THE USE OF ELECTROSHOCK TECHNIQUES FOR WEED CONTROL

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ABSTRACT

Introduction and Purpose: The crop yield decreases considerably when weeds are not adequately controlled, and producer income decreases accordingly. Furthermore, the environmental damage caused by herbicides is increasingly prompting interest in alternative methods of control. In this context, this study aimed to develop a basic robot using electroshock technology to combat weeds in small production areas. This robot is intended to be used in the fight against weeds, thus aiming to reduce the damage caused by pesticides. **Materials and Methods**: The robot system was assembled in the following order: Installation of the electric shock system, object detection sensor, Bluetooth device, wheels, and Arduino UNO setup. Experiments were then conducted on different types of leaves and stems to evaluate the robot's performance. For the applications on potted plants, the shocking process was performed in three parts: large-leaf plants (group A, leaf length: 8-10 cm), small-leaf plants (group B, leaf length: 4-5 cm), and stems (group C, stem thickness: 5-10 mm). Each experiment was conducted with three replicates. The deformations of the plants were visually assessed immediately after the shocking procedure and 3 hours and 24 hours later for the same region. **Results and Discussion:** According to the results, localized small deformations were first observed in the leaves of group A, followed by growth in the area of the deformation and fractures after 3 and 24 hours. Group B leaves initially showed slight color changes and signs of deformation. After three hours, yellowing was observed, and after 24 hours, wilting and drying continued in some areas. In the stems, slight color changes and slight bending were initially observed; after three hours, the stems began to bend and wilt more severely, and after 24 hours, severe wilting and structural degradation of the plant stem were observed. **Conclusion:** The experimental results show that treatment with electric shocks led to yellowing, wilting, drying, and breaking of the leaves as well as wilting and twisting of the stems. In the context of these results, it was hypothesized that the electroshock treatment was successful and could be offered as an alternative to chemical control in weed management.

Keywords: Weed Control, Robotic, Electric Shock System, Environment.

GİRİŞ

Bitkisel üretim alanlarında istenmeyen, kültür bitkilerinin ışık, sıcaklık, nem, besin elementleri vb. alımını etkileyerek, bitkiyi strese sokan ve gelişimini engelleyen bitkiler yabancı ot olarak adlandırılmaktadır (Sujaritha et al., 2017). Yabancı otları tanımlama da dikkate alınması gereken bir husus, ekili alanlarda neyin istendiği ve neyin istenmediği sorusuna cevap bulmaktır. Diğer bir deyişle, ekili alanlarda kültür bitkisinin gelişimini engelleyen bitkiler yabancı ot olarak değerlendirilirken, aynı bitki bir bahçede süs bitkisi olarak değerlendirilebilir. Ancak tarımsal üretim alanlarında kültür bitkisi dışındaki diğer bitkiler genel olarak yabancı ot olarak değerlendirilmekte ve bunlar farklı mücadele yollarıyla bulunduğu alandan ya uzaklaştırılarak ya da yok edilerek bertaraf edilmektedir.

Yabancı otlar, ekosistemdeki faydalarının yanı sıra, tarımsal ürünlerle doğal kaynaklar için rekabete girerek ürün kalitesini ve üretkenliğini azaltmakta, verimi düşürmekte ve sonuç olarak çiftçilerin maliyetlerini artırmaktadır. Yabancı otlarla mücadelede, tarımsal ekosisteme zarar vermeden, çeşitli kontrol yöntemlerini uyumlu bir şekilde entegre eden etkili ve sürdürülebilir bir yönetim sürecine ihtiyaç vardır. Bu nedenle, yoğun mekanizasyon ve herbisit kullanımından kaçınılmalıdır (Monteiro and Santos, 2022). Bununla birlikte, yabancı otlarla mücadelede bilinen en yaygın yöntem kimyasal mücadele olup, bu yöntemde ise herbisit olarak bilinen yabancı ot öldürücüler kullanılmaktadır. Ancak, kimyasal ilaç kullanımının çevreye olan büyük zararları, çevre politikaları, sivil toplum kuruluşların aktif rol alması vb. faktörler alternatif yöntemlerin araştırılmasına neden olmuştur. Kimyasal mücadeleye alternatif olarak mekanik, fiziksel veya fiziko-mekanik yöntemler kullanılabilmektedir. Bu yöntemlerden yaygın kullanılan bazıları, malçlama, su altında bırakma, farklı toprak işleme tekniklerini kullanma, çapalama, termal yöntem, elektroşok uygulama ve robotiklerin kullanımı sayılabilir.

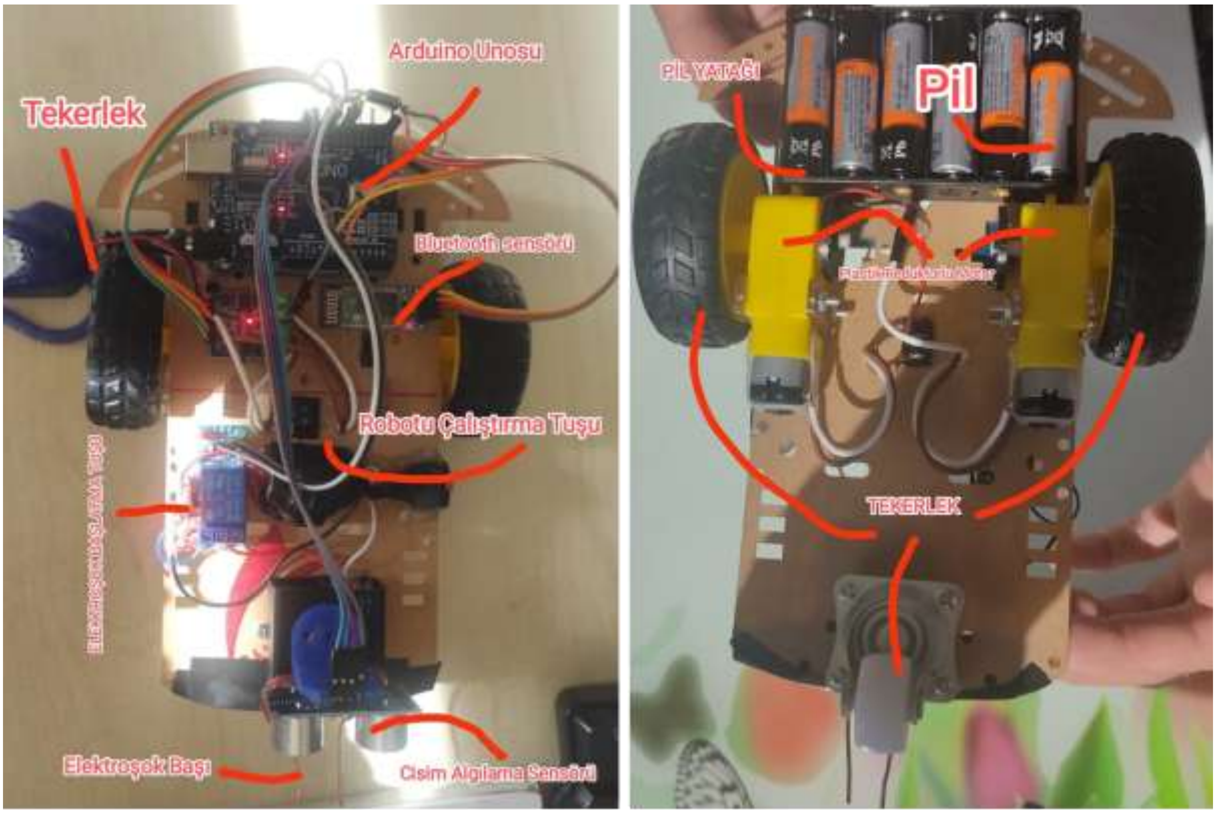
Yabancı otların zararını azaltmak veya ortadan kaldırmak amacıyla geçmişten günümüze farklı mücadele yöntemlerinin kullanıldığı birçok çalışma gerçekleştirilmiştir (Çolak ve ark., 2019). Shaner (2014), Sujaritha et al., (2017) ve McAllister et al., (2018), yabancı otlarla mücadelede farklı münavebe sistemlerinin, el veya aletler ile mekanik kontrol, biyolojik ve kimyasal mücadelelerin yapılabileceğini bildirmişlerdir. Hinds (2020), diğer yöntemler mümkün olmadığında bile mekanik yabancı ot temizlemenin, etkili bir yabancı ot yönetimi sağlayabildiğini ve bazı durumlarda onları geride bırakabildiğini ifade etmiştir. Bununla birlikte, Mohler et al., (1997) ve McAllister et al., (2018), mekanik olarak yapılan mücadelenin bitkinin gelişme durumuna göre değişeceğini ve yabancı ot boyunun artmasıyla ancak sıra arasında mücadele yapılabileceğini belirtmişlerdir. Partel et al., (2019) ve Rueda-Ayala et al., (2020) mekanik yöntemlerle ot kontrolünün toprak işleme yöntemleriyle güçlü bir ilişki içerisinde olduğunu, Lingenfelter and Curran (2001), ise farklı toprak işleme yöntemlerinin yabanı ot mücadelesinde kullanılabileceğini bildirmiştir.

Yabancı otlarla yapılan diğer bir yöntem termal kontroldür. Bu yöntem, toprakta ve suda kimyasal kalıntı bırakmadan hızlı bir yabancı ot kontrolü sağlayan ateş, alevleme, sıcak su, buhar ve dondurma tekniğine dayanır. Radicetti (2012), termal yöntemlerin yabancı otlara karşı seçici olduğunu, toprağı örselemediğini ve bu nedenle örtülü tohumları yetiştirme yöntemlerinde olduğu gibi toprak yüzeyine çıkarmadığını ifade etmektedir. Scavo and Mauromicale (2020) ise alevlemenin, organik ve geleneksel çiftçilik sistemlerinde en yaygın olarak uygulanan termal yöntem olduğunu bildirmiştir. Pérez-Ruíz et al., (2014), alevle yakmanın yabancı ot kontrolünde kullanılabileceğini, ancak bu yöntemin riskleri olduğunu ve maliyetinin yüksek olacağını bildirmektedirler. Bunların yanı sıra, yabancı otlarla mücadele de doğal düşman olarak bilinen biyolojik mücadele kullanılabilmektedir. Ancak biyolojik mücadelenin yapılacağı alanda tek çeşit bir yabancı ot olmayacağı için yöntemin uygulanması da zor olacaktır (Heap, 2014; Çolak ve Işık, 2021). Yabancı otlarla mücadele de günümüzde

rağbet görmeye başlayan bir mücadele şekli de robotiklerin kullanılmasıdır. Robotikler, hem fiziksel hem de kimyasal yöntemlerin uygulanmasında kullanılmaktadır. Bununla ilgili yapılan çalışmalar insansız kara araçları (İKA), insansız hava araçları (İHA) ve tam otomasyonlu robotları kapsamaktadır (Michaels et al., 2015; Pérez-Ortiz et al., 2016; Lottes et al., 2016; Lottes et al., 2017; Grimstad et al., 2017).
Geleneksel mücadele yöntemlerinin bitkilere ve çevreye olan zararları dikkate alındığında, yabancı otlarla mücadelede zararsız veya zarar riski daha düşük yöntemlerin tercih edilmesine neden olmaktadır. Günümüz tarımında sürdürülebilirliği sağlamak amacıyla hassas ot yönetim sistemleri tercih edilmektedir. Akıllı sensörler, uzaktan algılama sistemleri, hava araçları, uydular, robotikler, nesnelerin interneti gibi akıllı çiftçilik teknolojileri giderek daha yaygın hale gelmektedir (Monteiro et al., 2021). Bu teknolojilerin kullanılabileceği yöntemlerden biri de elektroşok yöntemidir. Elektroşok yönteminde kimyasalların kullanılmaması, çevre dostu olması, hızlı ve etkili sonuçlar sağlaması nedeniyle geniş alanlarda uygulanabilmektedir. Bu nedenle, bu çalışmada, küçük alanlarda kullanmak amacıyla, elektroşok yöntemini baz alan bir robotiğin tasarlanması ve performansının değerlendirilmesi amaçlanmıştır. Bu amaçla, yabancı otlarla mücadelede fiziksel bir yöntem kullanılarak, kimyasal kullanımının azaltılması ve çevre dostu uygulamayla yabancı ot kontrolü sağlanması hedeflenmiştir.

MATERYAL VE YÖNTEM

Bu araştırmada, küçük alanlarda kullanmak amacıyla yabancı otlara elektroşok uygulayacak robotik bir aracın tasarımı hedeflenmiştir. Elektroşok yöntemi, özel olarak tasarlanmış bir cihazla bitkiler üzerinden elektrik akımı geçirilmesini içerir. Akım, bitki hücrelerinin zarlarını bozarak hücre içi sıvıların dışarı çıkmasına ve bu sayede hücre hasarına, sonuçta da bitkinin ölmesine neden olmaktadır. Böylelikle, yabancı otlarla mücadelede fiziksel bir yöntem kullanılarak, kimyasal kullanımının azaltılması amaçlanmıştır. Robotik aracın tasarımında kullanılan malzemeler: elektroşok, tekerlek, arduino premium eğitim seti, güneş paneli, bluetooth sensörü, redüktörlü motor ve güç kaynağı olarak pil kullanılmıştır.
Robotik aracın tasarımı
Elektroşok sistemi ve montajı: robotik aracın yabancı otlarla etkin mücadele edebilmesi için elektroşok sistemi entegre edilmiştir. Piyasada güvenlik amacıyla kullanılan bir adet elektro-şok cihazını parçalarına ayırarak, robotik aracın şasisinin ön kısmına monte edilmiştir (Şekil 1a). *Cisim algılama sensörü;* aracın hareketi esnasında önüne çıkabilecek nesneleri algılayabilmesi için (yabancı otları algılama) ön tarafına bir cisim algılama sensörü monte edilmiştir. Sensörün doğru bir şekilde yerleştirilip yerleştirilmediğini tespit etmek amacıyla kalibrasyon işlemi yapılmıştır. *Bluetooth Aygıtının Yerleştirilmesi;* Aracın kontrolünün telefon vb. cihazlardan sağlamak amacıyla kullanılmıştır. Bu aygıt, robotun belirlenen yollar üzerinde hareket etmesini ve yönlendirilmesini sağlamakta, aynı zamanda sensörlerden gelen verilerle entegre bir şekilde çalışmaktadır. *Arduino UNO'nun Kurulumu;* robotik kodlama ile aracın uzaktan kontrolü, sensörlerden gelen verilerin kullanılabilmesi gibi işlemlerin gerçekleştirilebilmesi için aracın üzerine bir Arduino UNO mikro denetleyici kart monte edildi. Arduino, kolay bir şekilde çevresiyle etkileşime girebilen sistemler tasarlanabilir açık kaynaklı bir geliştirme platformudur. Kullanıcı, bir değişiklik veya ekleme yapması durumunda bu sayede istediği şekilde düzenlemeler yapabilmektedir. *Fotoelektrik sensör;* Bu sensör ve yazılımı sayesinde aracın yabancı otu ve kültür bitkisini ayırt etmesi amacıyla kullanılması planlanmıştır. Aracın hareket kabiliyetinin sağlanabilmesi amacıyla iki adet hareket tekerleği ve ön tarafında ise bir adet yönlendirme tekerleği monte edilmiştir. Güç kaynağı olarak ise pil kullanılmıştır (Şekil 1).



(a) (b)

Şekil 1. Elektro-şoklayıcı robotik araç: üst (a), alt (b)

Deneysel Dizayn

Robotik aracın montaj işlemleri tamamlandıktan sonra arazi çalışmalarının yapılması planlanmıştı. Ancak Tübitak'ın 2209-A projeleri kapsamında destek alan bu çalışmada, proje bütçesi, bitki ve yabancı otları ayırt edecek sensör alımına yetmediğinden, deneysel testler laboratuvar şartlarında saksı bitkileri üzerinden gerçekleştirilmiştir.

Elektroşokla yabancı otlarla mücadelede robotiğin performansını değerlendirmek için farklı yaprak ve gövde tipleri üzerinde denemeler yapılmıştır. Saksı bitkileri üzerinde yapılan uygulamalarda; Şoklama işlemi, büyük yapraklı bitkiler (A grubu), küçük yapraklı bitkiler (B grubu) ve gövde (C grubu) olmak üzere üç bölümde gerçekleştirilmiştir (Çizelge 2). Deneyler A, B ve C grubu bitkiler için 3 tekerrürlü olarak gerçekleştirilmiştir. Her bir tekerrürde bitkinin belirtilen kısımları şoklanmış ve zamana bağlı olarak değişimleri izlenmiştir. Yaprağa yapılan şoklamalarda; genel olarak yaprağın, yaprak gövdesine bağlı kısmı dikkate alınarak gerçekleştirilmiştir. Değişimleri değerlendirmek amacıyla, bitkiye şoklama yapıldıktan hemen sonra, 3 saat sonra ve 24 saat sonra aynı bölge fotoğraflanmış ve bitki üzerindeki deformasyonlar zamana bağlı olarak sunulmuştur. Çalışmada kullanılan A grubu bitkilerin yaprak boyu 8- 10 cm, B grubu bitkilerin 4 – 5 cm olarak ölçülmüştür. Gövde denemelerinde ise uygulama yapılan bitki gövde kalınlıkları (çapı) 5 – 10 mm arasında değişmektedir.

Çizelge 2. Deneme planı

Deneme Grubu	Uygulama	Tekerrürler
A (Büyük yapraklı)	Şoklamadan hemen sonra Şoklamadan 3 saat sonra Şoklamadan 24 saat sonra	A1, A2, A3
B (Küçük yapraklı)	Şoklamadan hemen sonra Şoklamadan 3 saat sonra Şoklamadan 24 saat sonra	B1, B2, B3
C (Gövde)	Şoklamadan hemen sonra Şoklamadan 3 saat sonra Şoklamadan 24 saat sonra	C1, C2, C3

BULGULAR VE TARTIŞMA

Elektroşoklu yabancı otlarla mücadele aracının etkinliğini değerlendirmek amacıyla aynı bitki türünde farklı yaprak ve gövde tipleri üzerinde yapılan denemelerden elde edilen görsel bulgulara dayanarak gözlemler yapılmıştır. Büyük yapraklı grubunda (A Grubu: A1, A2, A3); elektroşok uygulamasının hemen ardından bitkilerin fotoğraflanmasıyla yapılan gözlemde, yapraklarda bölgesel küçük deformasyonların oluştuğu; 3. ve 24. Saatte yapılan gözlemlerde ise deformasyon alanında büyüme ve yapraklarda kopmalar meydana geldiği tespit edilmiştir (Şekil 2, 3 ve 4).

Küçük yapraklı bitkiler (B Grubu: B1, B2, B3) üzerinde yapılan elektroşok uygulaması, yapraklarda daha çok solmaya ve kıvrılmalara neden olmuştur. Uygulamadan hemen sonra yapılan gözlemlerde ve çekilen fotoğraflarda, yapraklarda hafif renk değişiklikleri ve deformasyon belirtileri görülürken, üç saat sonra çekilen fotoğraflarda yaprakların sararmaya başladığı ve yapısal olarak zayıfladığı tespit edilmiştir. Bununla birlikte, 24 saat sonra çekilen fotoğraflar ise yaprakların solmaya devam ettiğini ve bazı bölgelerde kuruma oluştuğunu göstermiştir (Şekil 5, 6 ve 7).

Bitki gövdeleri (C Grubu: C1, C2, C3) üzerine yapılan elektroşok uygulaması sonrasında ise genel olarak gövdede belirgin derecede solma ve bükülme gözlemlenmiştir. Elektroşok uygulamasının hemen ardından çekilen fotoğraflarda gövdede hafif bir renk değişikliği ve eğilme meydana gelirken, üçüncü saatte yapılan gözlemlerde ve çekilen görüntülerde bu etkilerin arttığı, gövdenin daha belirgin bir şekilde büküldüğü ve solmaya başladığı belirlenmiştir. Yirmi dört saat sonra çekilen fotoğraflar ve yapılan görsel izlenimlere göre, gövdenin ciddi şekilde solduğu ve bitkinin yapısal bütünlüğünün bozulduğu tespit edilmiştir (Şekil 8, 9 ve 10).

1 2 3

Şekil 2. Kod A1, elektroşoktan hemen sonra (1), üç saat sonra (2) ve 24 saat sonraki (3) değişim

1 2 3

Şekil 3. Kod A2, elektroşoktan hemen sonra (1), üç saat sonra (2) ve 24 saat sonraki (3) değişim

1 2 3

Şekil 4. Kod A3, elektroşoktan hemen sonra (1), üç saat sonra (2) ve 24 saat sonraki (3) değişim

1 2 3

Şekil 5. Kod B1, elektroşoktan hemen sonra (1), üç saat sonra (2) ve 24 saat sonraki (3) değişim

1 2 3

Şekil 6. Kod B2, elektroşoktan hemen sonra (1), üç saat sonra (2) ve 24 saat sonraki (3) değişim

1 2 3

Şekil 7. Kod B3, elektro-şoktan hemen sonra (1), üç saat sonra (2) ve 24 saat sonraki (3) değişim

1 2 3

Şekil 8. Kod C1, elektroşoktan hemen sonra (1), üç saat sonra (2) ve 24 saat sonraki (3) değişim

1 2 3

Şekil 9. Kod C2, elektroşoktan hemen sonra (1), üç saat sonra (2) ve 24 saat sonraki (3) değişim

1 2 3

Şekil 10. Kod C3, elektroşoktan hemen sonra (1), üç saat sonra (2) ve 24 saat sonraki (3) değişim

SONUÇ

Deneysel bulgular, elektroşoklu yabancı otlarla mücadele robotunun, farklı yaprak ve gövde tiplerine sahip bitkiler üzerinde etkili olduğunu göstermektedir. Büyük yapraklı bitkilerde kopma, küçük yapraklı bitkilerde sararma ve solma, gövdede ise solma ve bükülme şeklindeki etkiler, elektroşok uygulamasının başarılı olduğunu ortaya koymaktadır. Bu sonuçlar, elektroşoklu yöntemin yabancı ot kontrolünde kimyasal kullanımına alternatif olarak etkili bir çözüm sunabileceğini ve çevre dostu bir yöntem olarak kullanılabileceğini göstermektedir. Her ne kadar yaprak grupları arasında farklılık olsa da, uygulamalar geniş yapraklı saksı bitkileri üzerinde gerçekleştirilmiştir. Sonuçlardan anlaşıldığı üzere elektro şok uygulaması bitkiler üzerinde renk değişimi, solma, kopma, kuruma ve çürüme gibi önemli etkilere neden olmuştur. Ancak sadece geniş yapraklar üzerinde yapılan uygulamanın bütün yabancı otları temsil etmeyeceği de bir gerçektir. Bu nedenle, aynı uygulamaların arazide yabancı otlar üzerinde denenmesinin daha iyi sonuçlar vereceği kanaatindeyiz.

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KAYNAKLAR

Çolak E.Ş. Yüksel, E., Canhilal, R. (2019). Yabancı otların kontrolünde biyolojik mücadele. *Erciyes Tarım ve Hayvan Bilimleri Dergisi*, 2(3), 23-29.

Çolak E.Ş. Işık D. (2021). Yabancı otlar ile mücadelede güncel yöntem: robotikler. *Turkish Journal of Weed Science* 24(2): 166-176

Grimstad L. From, P.J. (2017). The Thorvald II agricultural robotic system. *Robotics*, 6(4), 24.

Heap I. (2014). *Herbicide resistant weeds*. In Integrated pest management (pp. 281-301). Springer, Dordrecht.

Hinds, J.A. (2020). Whole-Farm Approach to Managing Pests. SARE-Sustainable Agriculture Research and Education. Available online: https://www.sare.org/wp-content/uploads/A_Whole-Farm_Approach_to_Managing_Pests.pdf. Son Erişim 20 Kasım 2024.

Lingenfelter, D. Curran, W. (2001). Weed Management in Pasture Systems. In Agronomy Facts 62; College of Agricultural Sciences, Penn State Extension: Pennsylvania, PA, USA, Available online: https://extension.psu.edu/weed-management-in-pasture-systems Son Erişim 25 Kasım 2024.

Lottes P., Hoeferlin, M., Sander, S., Müter, M., Schulze, P., & Stachniss, L.C. (2016). An effective classification system for separating sugar beets and weeds for precision farming applications. In 2016 IEEE International Conference on Robotics and Automation (ICRA) (pp. 5157-5163). IEEE.

Lottes P., Khanna, R., Pfeifer, J., Siegwart, R., & Stachniss, C. (2017). UAV-based crop and weed classification for smart farming. In 2017 IEEE International Conference on Robotics and Automation (ICRA) (pp. 3024-3031). IEEE.

McAllister W., Osipychev, D., Chowdhary, G., & Davis, A. (2018). Multi-agent planning for coordinated robotic weed killing. In 2018 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS) (pp. 7955-7960). IEEE.

Michaels A., Haug, S., & Albert, A. (2015). Vision-based high-speed manipulation for robotic ultra-precise weed control. In 2015 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS) (pp. 5498-5505). IEEE.

Mohler C. L., Frisch, J. C., & Mt, J. (1997). Evaluation of mechanical weed management programs for corn (Zea mays). *Weed Technology*, 123-131.

Monteiro, A. Santos, S. Gonçalves, P. (2021). Precision Agriculture for Crop and Livestock Farming—Brief Review. *Animals*, 11, 2345.

Monteiro, A., & Santos, S. (2022). Sustainable Approach to Weed Management: The Role of Precision Weed Management. *Agronomy*, *12*(1), 118. https://doi.org/10.3390/agronomy12010118

Partel, V. Kakarla, S.C. Ampatzidis, Y. (2019). Development and evaluation of a low cost and smart technology for precision weed management utilizing artificial intelligence. *Comput. Electron. Agric.* 157, 339–350.

Pérez-Ortiz M., Peña, J. M., Gutiérrez, P. A., Torres-Sánchez, J., Hervás-Martínez, C., & López-Granados, F. (2016). Selecting patterns and features for between-and within-crop-row weed mapping using UAV-imagery. *Expert Systems with Applications*, 47, 85-94.

Pérez-Ruíz M., Slaughter, D.C., Fathallah, F.A., Gliever, C.J., & Miller, B.J. (2014). Co-robotic intra-row weed control system. *Biosystems Engineering*, 126, 45-55.

Radicetti, E. (2012). Ecological Weed Management. Ph.D. Thesis, Università degli Studi della Tuscia Di Viterbo, Viterbo, Italy.

Rueda-Ayala, V. Rasmussen, J. Gerhards, R. (2020). *Mechanical Weed Control*. In Precision Crop Protection-the Challenge and Use of Heterogeneity; Oerke, E.C., Gerhards, R., Menz, G., Sikora, R., Eds.; Springer: Dordrecht, The Netherlands.

Scavo, A. Mauromicale, G. (2020). Integrated Weed Management in Herbaceous Field Crops. Agronomy, 10, 466.

Shaner D.L. (2014). Lessons learned from the history of herbicide resistance. *Weed Science*, 62(2), 427-431.

Sujaritha M., Annadurai, S., Satheeshkumar, J., Sharan, S. K., & Mahesh, L. (2017). Weed detecting robot in sugarcane fields using fuzzy real time classifier. *Computers and Electronics in Agriculture*, 134, 160-171.

USE OF A HYDROGEN EXTRACTION METHOD FOR THE EXTRACTION OF PHYTOCHEMICALS

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ABSTRACT
Plants are a rich source of phytochemicals, which are bioactive compounds that benefit human health. Phytochemicals play an important role in forming plants' distinctive color, aroma, and flavor. Moreover, these phytochemical compounds have antioxidant, anti-inflammatory, antimicrobial, antifungal, anticancer, antidiabetic, and antihypertensive properties. Several extraction techniques can be employed to recover these compounds from the plant materials. Hydrogen-rich solvent extraction is a novel method that our team has developed. The results of recent reports demonstrated that the extraction of phenolic compounds and antioxidant activity was enhanced when a hydrogen-enriched solvent extraction method was used for various plant materials, such as tomato peel, green apple peel, orange carrot peel, lemon peel, red cabbage leaves, red beet, olive leaf, pomace oil, and propolis products were processed. Furthermore, it was established that the extraction of phenolic compounds, organic acids, reducing sugars, antioxidant activity, pigments, and vitamin C content was enhanced by using a hydrogen-rich solvent to process cowslip (*Primula veris* L.) flowers. In these reports, it has been observed that molecular hydrogen, which demonstrates selective antioxidant properties, plays a significant role in increasing phytochemical compounds by exerting a synergistic effect with compounds present in plants. The use of molecular hydrogen (H_2) in the extraction of phytochemical compounds has been shown to have no adverse effects on products or the environment, while also improving the quality of foods and enhancing food safety.
Keywords: Phytochemicals; Extraction, Molecular hydrogen; Antioxidant

INTRODUCTION
Phytochemicals are bioactive compounds that play a role in the formation of the unique color, smell, and taste of plants (Balch and Balch, 1997). They occur as secondary metabolites and have been demonstrated to have beneficial health effects when consumed as nutrients (Visioli *et al.,* 2000). Phytochemicals are primarily characterized by their strong antioxidant activity (Schiassi *et al.,* 2018), which enables them to regulate intestinal flora, bile acids, and pH. Additionally, they serve as a protective barrier against external factors by maintaining the intracellular matrix structure. Moreover, it enhances the activity of anticarcinogenic enzymes and has a preventive effect on the formation of substances that are effective in tumor and cancer formation (Güney *et al.,* 2003). The significance of phytochemicals and their constituents in nutritional science is increasing due to advancements in scientific and technological fields, the rising costs of healthcare, heightened public awareness of the relationship between nutrition and health, and the adverse effects of excessive consumption of

animal foods on human health (Kırışoğlu and Velioğlu, 2001). The most well-known phytochemical compounds include tannins, phenolic compounds (polyphenols), carotenoids, saponins, coumarins, tocopherols, terpenes, isothiocyanates, sulfides, sulforaphane, terpenoids, alkaloids, flavonoids, phytosterols, phytoestrogens, indoles (Dündar, 2001; Güzel and Akpınar, 2019).

Phenolic compounds represent the largest group of phytochemicals (Haslam, 1998). In addition to their antioxidant properties, phenolics possess a range of other beneficial characteristics, including antiallergen, antimutagen, anticarcinogen, antiglycemic, anticholesterol, anti-inflammatory, antimicrobial, and sedative properties. These properties have led to their use as additives in a variety of industries, including cosmetics, pharmaceuticals, and food (Friedman and Levin, 2009). In recent years, waste materials from food processing have garnered attention as cost-effective and secure sources of phenolic compounds (Cam and Aaby, 2010). Phenolic substances are classified into the following categories: flavonoids (anthocyanidins, flavones, flavonols, flavanones, proanthocyanidins, catechins, and loycoanthocyanidins), phenolic acids, lignans, and stilbenes (Fernandez *et al.*, 2008). Flavonoid compounds have been demonstrated to possess antioxidant, antimicrobial, antiviral, antiulcer, hypolipidemic, hepatoprotective, anti-inflammatory, antimutagenic, and anticarcinogenic properties (Deschner *et al.*, 1991; Güzel and Akpınar, 2019).

As water-soluble pigments, anthocyanin flavonides (formed by glycosides of anthocyanidins with sugars) are responsible for various colors, including pink, red, and purple tones in fruits and vegetables (Nizamlıoğlu and Nas, 2010). It is estimated that approximately 90% of carotenoids, which are natural color pigments commonly found in nature, are α- and β-carotene. These represent an important group of phytochemicals, particularly due to their provitamin A activity (Larson, 1997).

PHYTOCHEMICAL COMPOUNDS IN PLANTS

Historically, plant extracts or plant-based products have constituted the primary source of herbal medicine utilized for the treatment of human and plant diseases. (Chandler *et al.*, 2011; Pan and ark., 2014). It is estimated that there are more than 250 thousand plant species in the world today (Zhao *et al.*, 2017). These plants have played a crucial role in human life, providing essential nutrients, chemicals, medicines, cosmetics, and industrial materials (Salimon *et al.*, 2012). By the end of the 20th century, 10% of these plants had been characterized for their chemical composition (Wu *et al.*, 1998), and approximately 2,400 plants with anti-biotic properties had been successfully identified (Ndjonka *et al.*, 2013; Çandar and Şavkan, 2024).

Phytochemicals are naturally occurring chemical compounds found in plants that are responsible for various biological activities and contribute to the color and flavor of the plant. Although they are not considered essential nutrients for human survival, they are recognized as micronutrients in our diets (Cemeroğlu, 2004) and have been demonstrated to possess important health benefits when consumed, including antioxidant, anti-inflammatory, and anti-carcinogenic properties (Dündar, 2001; Sevindik, 2018).

EXTRACTION METHODS

Solid-liquid extraction

The solid-liquid continuous extraction method is a commonly employed technique for the separation of phenolic compounds from fruits and vegetables. The most commonly used solvents are methanol, ethanol, and acetone, which are often employed in mixtures with varying concentrations or in combination with water (Cong-Cong *et al.*, 2017). The principle of the Soxhlet extraction method is based on the boiling of the solvent to the point of evaporation, followed by dripping the solvent onto the sample, resulting in the condensation of the vapor formed. The targeted compounds penetrate the solvent structure until the solvent reaches the siphon level, a process that can take several hours. The polarity of the solvent is the most important criterion affecting extraction (Çolak, 2019). The major disadvantage of Soxhlet extraction is that it requires a high amount of solvent and a long time, which makes it an unfavorable method (Taşkıran *et al.,* 2023).

Ultrasound-assisted extraction

Conventional extraction techniques have been demonstrated to exert a negative impact on the quality and quantity of phenolic compounds obtained, largely due to the prolonged extraction time and elevated temperatures typically employed in such processes. It is evident that innovative technologies are required to enhance the yield and quality of extracted phenolic compounds. The ultrasound-assisted extraction method, developed in response to the identified need, is an environmentally friendly method that offers numerous advantages, including the production of high yields, the reduction of extraction time, and the minimization of extraction costs through the reduction of solvent usage (Fu *et al.,* 2021; Nie *et al.,* 2021). The ultrasound-assisted extraction process is based on the principle that the bioactive compounds in the plant are transferred to the solvent structure by the changes caused by ultrasonic waves, changes in the plant matrix, and cellular disruptions (Rahman *et al.,* 2021; Hadidi *et al.,* 2020). With a frequency exceeding 20 kHz, the cavitation bubbles generated by ultrasound energy exert mechanical and thermal effects on plant cells, resulting in the disruption of the cell wall and the penetration of bioactive compounds into the solvent through dissolution or diffusion (Bi *et al.,* 2019; Qian *et al.,* 2020).

Microwave-assisted extraction

Microwave-assisted extraction (MAE) is a method that employs the use of microwave energy to facilitate the extraction of bioactive substances from plant materials. This process involves the use of phenolic compounds, such as carbohydrates and lipids, which are capable of extracting these bioactive substances from the plant material. The method is straight forward and does not require prior experience, exhibits high extraction efficiency, and saves energy and time (Moradi *et al.,* 2018). The term "microwaves" is used to describe electromagnetic waves with a frequency range of 300 MHz to 300 GHz. The heating of substances in the presence of a microwave process is attributed to the combined effects of ionic conduction and dipole motion. The use of microwaves in conjunction with polar solvents results in the triggering of the heating process (Bagade and Patil, 2021). The fundamental principle of MAE is the molecular motion of microwave energy, which increases the structural components of food. This process involves the penetration and heating of microwave energy, as well as the separation of compounds from the food structure (Li, 2015). In plants, the formation of water in the cell is the underlying mechanism behind the heating of the matrix. In MAE, the use of dried plant material allows the plant to heat the small amount of water present in the cell. The application of microwave energy to the water within the plant matrix results in the generation of substantial pressure on the cell wall. The pressure exerted on the cell wall results in its weakening and subsequent rupture from within. This leads to the deformation of the cell wall, allowing the bioactive compounds present in the plant matrix to emerge and initiate the extraction process. The solvents utilized during the extraction of phenolic compounds from plants play a pivotal role in the absorption of bioactive components excreted outside the cell, enhancing the efficiency of the extraction process (Bagade and Patil, 2021).

Supercritical Fluid Extraction

Supercritical fluid extraction (SFE) is founded upon the principle of dissolving bioactive compounds in a fluid at supercritical conditions, subsequently recovering the gaseous solvent and separating the compounds by reducing the pressure (Güvenç, 1997; Khaw *et al.,* 2017). In this method, carbon dioxide (CO_2) is employed as the solvent due to its low cost, non-flammability, and significantly lower critical point compared to other liquids. One disadvantage of CO_2 is its low polarity. To address this issue, high polarity can be achieved by adding low concentrations of ethanol, methanol, or water (Pereira and Meireles, 2010;

Khaw *et al.,* 2017). SFE is a sustainable and safe method to obtain plant extracts with high antioxidant activity. It has been documented from over 300 species (Gündüz and Çiçek, 2019).

MOLECULAR HYDROGEN

Hydrogen is a colorless, odorless, tasteless, and non-toxic gas. Its solubility in water at 20°C is 1.62 mg/L. However, its solubility in organic solvents such as ethanol, methanol, and hexane (about 8.5, 9.5, and 16.5 mg/L, respectively) is higher than in water (Jáuregui-Haza *et al.,* 2004). Hydrogen-rich water (HRW) prepared in an open container must be stored in an airtight container at room temperature, as it loses approximately 2-5% of its hydrogen content every three minutes (Ryu *et al.,* 2019; Alwazeer *et al.,* 2021).

The hydrogen molecule is a gaseous entity at standard conditions and exists in a solid state at temperatures below 14.72 degrees Celsius (Aziz, 2021). Its nonpolar structure endows it with the capacity to diffuse through cellular biomembranes, yet simultaneously reduces its solubility in water.

The free radical scavenging properties of H_2 are useful for protecting antioxidants, phenolics, flavonoids, and other sensitive substances from oxidative reactions (Ohsawa *et al.,* 2007; Sundararajan, 2022). The scavenging activity ratio of hydrogen-rich water (HRW) on $O_2^{\cdot -}$ was found to be 4.3 times that of ascorbic acid (Fan *et al.,* 2021).

MOLECULAR HYDROGEN EXTRACTION METHOD

The reduction in the utilization of toxic solvents in recent years has resulted in a novel approach to the extraction of phytochemicals. Consequently, the preference is for safe, environmentally friendly, and non-toxic alternative solvents, which are beneficial for both the environment and the consumer. This has led to the development of new sustainable methods and the identification of various solvents for the extraction of phytochemicals (Ameer et al., 2017).

The dissolution of H_2 in the presence of the solvents used for the extraction of phytochemicals resulted in an increased yield of anthocyanins, flavonoids, and polyphenolic compounds. The precise mechanism by which H_2 operates within the cell remains unclear. However, the capacity of H_2 to function as an effective antioxidant in plants and production is now well documented (Cacace and Mazza, 2003; Ohsawa *et al.,* 2007; Nn, 2015). The infusion of hydrogen gas in the extraction process has been demonstrated to significantly enhance the efficiency of the extraction process (Alwazeer *et al.,* 2023b; Alwazeer and Elnasanelkasım, 2023; Zor *et al.,* 2023). This innovative method is environmentally friendly in that it has the potential to reduce the hazards associated with the use of chemical solvents, which can be harmful to the environment (Alwazeer, 2024a, 2024b).

In their study of tomatoes, Alwazeer and Elnasanelkasım (2023) the peel of the tomato (*Lycopersicon esculentum*), the green apple peel (*Malus communis* L.), the lemon peel (*Citrus limon* L.), the red cabbage leaves (*Brassica oleracea* var. *Capitata* F.), and the orange carrot peel (*Daucus carota* subsp. stavis) were extracted with hydrogen rich water in order to increase the content of phenolics, flavonoids, anthocyanins, and antioxidants (Engin *et al.,* 2024a).

Hydrogen-rich solvent extraction increased phenolic compounds, antioxidant activity, and extraction efficiency of lemon peel (Alwazeer *et al.,* 2023b), pomace oil (Ceylan *et al.,* 2023), and propolis (Yurt, 2023) products. Hydrogen-rich water extraction of red beets (Alwazeer *et al.,* 2023c), olive leaves (Alwazeer *et al.,* 2023d), and green tea leaves (Ryu *et al.,* 2019) increased the phenolic, flavonoid, anthocyanin, and antioxidant content of the products. Hydrogen solvent extraction increased the phenolics, organic acids, sugars, vitamin C, and pigments of cowslip (Engin *et al.,* 2024).

CONCLUSION

The extraction of phytochemicals is a crucial step in the determination of their phenolic, flavonoid, and anthocyanin content, as well as their antioxidant activity. The addition of hydrogen to a variety of solvents, including both polar and non-polar substances, has been demonstrated to enhance the extraction of phenolic, flavonoid, and anthocyanin compounds, as well as the antioxidant activity of these compounds. This process also facilitates the extraction of other phytochemicals. It is postulated that this method of introducing hydrogen into solvents may serve as an alternative to hazardous and costly organic solvents, offering a range of economic and ecological benefits.

REFERENCES

Alwazeer, D. 2024a. Use of Hydrogen Extraction in the Food Industry. 2nd Ed. Elsevier Inc. 1-19 p.

Alwazeer, D. 2024b. Hydrogen-rich solvent method in phytochemical extraction: Potential mechanisms and perspectives. Phytochemical Analysis 35:203-219.

Alwazeer, D., Elnasanelkasım, MA. 2023. Hydrogen-rich water as a green solvent for the extraction of phytochemicals from agri-food wastes. Sustainable Chemistry and Pharmacy 33:101035.

Alwazeer, D., Elnasanelkasım, MA., Çiçek, S., Engin, T., Çiğdem, A., Karaoğul, E. 2023a. Comparative study of phytochemical extraction using hydrogen rich water and supercritical fluid extraction methods. Process Biochemistry 128:218–226.

Alwazeer, D., Elnasanelkasım, MA., Çiğdem, A., Engin, T., Kanmaz, H., Hayaloğlu, AA., Hancock, JT. 2023c. Hydrogen incorporation into solvents can improve the extraction of phenolics, flavonoids, anthocyanins, and antioxidants: A case-study using red beetroot. Industrial Crops and Products 202:117005.

Alwazeer, D., Elnasanelkasım, MA., Çiğdem, A., Engin, T., LeBaron, TW. 2023b. Incorporation of molecular hydrogen into solvents increases the extraction efficiency of phenolics, flavonoids, anthocyanins, and antioxidants: the case of lemon peels. Frontiers in Sustainable Food Systems 7:1223027.

Alwazeer, D., Elnasanelkasım, MA., Engin, T., Çiğdem, A. 2023d. Use of hydrogen rich water as a green solvent for the extraction of phytochemicals: Case of olive leaves. Journal of Applied Research on Medicinal and Aromatic Plants 35:100472.

Alwazeer, D., Liu, FF., Wu, XY., LeBaron, TW. 2021. Combating oxidative stress and ınflammation in COVID-19 by molecular hydrogen therapy: mechanisms and perspectives. Oxid Med Cell Longev 2021:5513868.

Ameer, K., Shahbaz, HM., Kwon, J. 2017. Green extraction methods for polyphenols from plant matrices and their byproducts: A review. Comprehensive Reviews İn Food Science And Food Safety 16:295–315.

Aziz, M. 2021. Liquid hydrogen: A review on liquefaction, storage, transportation, and safety. Energies, 14(18), 5917.

Bagade, SB., Patil, M. 2021. Recent advances in microwave assisted extraction of bioactive compounds from complex herbal samples: a review. Critical Reviews in Analytical Chemistry, 51(2), 138- 149. https://doi.org/10.108 0/10408347.2019.1686966.

Balch, JF., Balch, PA. 1997. Prescription for nutritional healing. 2nd Edition, Avery Publishing Group, Garden City Park, New York.

Bi, Y., Lu, Y., Yu, H., Luo, L. 2019. Optimization of ultrasonic-assisted extraction of bioactive compounds from Sargassum henslowianum using response surface methodology. Pharmacognosy Magazine, 15, 156- 163. https://doi.org/10.4103/pm.pm_347_18.

Cacace, JE., Mazza, G. 2003. Mass transfer process during extraction of phenolic compounds from milled berries. Journal of Food Engineering 59:379-389.
Cam, M., Aaby, K. 2010. Optimization of extraction of apple pomace phenolics with water by response surface methodology. Journal of Agricultural and Food Chemistry, 58, 9101-9111.
Cemeroğlu, B. 2004. Meyve ve sebze işleme teknolojisi 1. cilt. Gıda Teknolojisi Derneği Yayınları No: 35: 77-88 s, Ankara.
Ceylan, MM., Silgan, M., Elnasanelkasım, MA., Alwazeer, D. 2023. Impact of washing crude olive pomace oil with hydrogen-rich water and incorporating hydrogen into extraction solvents on quality attributes and phytochemical content of oil. Journal of Food Measurement and Characterization 17:2029-2040.
Chandler, D., Alastair, S., Bailey, G., Tatchell, M., Davidson, G., Greaves, J., Wyn, P. 2011. Grant the development, regulation and use of biopesticides for integrated pest management. Philosophical Transactions of The Royal Society B, 366,1987-1998.
Cong-Cong, XU., Bing, WANG., Yi-Qiong, PU., Jian-Sheng, TAO., Zhang, T. 2017. Advances in extraction and analysis of phenolic compounds from plant materials. Chinese journal of natural medicines, 15(10), 721-731. https://doi.org/10.1016/S1875-5364(17)30103-6.
Çandar, A., Şavkan, AN. 2024. Fitokimyasal bileşikler ve bitki hastalıklarındaki etkileri. International Scientific Compilation Research Congress, Ankara-Türkiye.
Çolak, M. 2019. *Prunus laurocerasus* meyvesi yağ asidi bileşenlerinin ultrason destekli mikrodalga ekstraksiyon yöntemi kullanılarak belirlenmesi. Yüksek Lisans Tezi, Fen Bilimleri Enstitüsü, Niğde.
Deschner, EE., Ruperto, J., Wong, G. Newmark, HL., 1991. Quercetin and rutin as inhibitors of azoxymethanol-induced colonic neoplasia. Carcinogenesis, 7, 1193-1198.
Dündar, Y. 2001. Fitokimyasallar ve sağlıklı yaşam. Kocatepe Tıp Dergisi. 2, 131-138.
Engin, T., Çiğdem, A., Alma, MH., Alwazeer, D. 2024. Hydrogen-rich solvent method enhances the extraction of phenolics, pigments, reducing sugars, organic acids, and vitamin C from cowslip (*Primula veris* L.) flower. Food Chemistry, 463, 141271.
Engin, T., Elnasankasım, MA., Çiğdem, A., Kavrut, E., Alwazeer, D. 2024b. Tarım ve gıda atıkları fitokimyasallarının ekstraksiyonunda hidrojen yönteminin kullanımı. Bitki ve Hayvan Üzerine Yapılmış Bilimsel Çalışmalar. 7. Bölüm, ISBN: 978-625-430-308-1. https://doi,org/10,5281/zenedo,13743511.
Fan, L., Chen, H., Liang, J., Chen, D., Huang, Y. 2021. Controllable synthesis of hydrogen bubbles via aeration method for efficient antioxidant process. Applied Nanoscience, 11, 833-840.
Fernandez-Panchon, MS., Villano, D., Troncoso, AM. Garcia-Parrilla, MC. 2008. Antioxidant activity of phenolic compounds: From in vitro results to in vivo evidence. Critical Reviews in Food Science and Nutrition, 48, 649- 671.
Friedman, M., Levin, C. 2009. Analysis and biological activities of potato glycoalkaloids, calystegine alkaloids, phenolic compounds and anthocyanins. In J. Singh, & L. Kaur (Eds.) Advances in Potato Chemistry and Technology, pp. 127-161.
Fu, X., Wang, D., Belwal, T., Xie, J., Xu, Y., Zou, L., Zhang, L., Luo, Z. 2021. Natural deep eutectic solvent enhanced pulse-ultrasonication assisted extraction as a multi-stability protective and efficient green strategy to extract anthocyanin from blueberry pomace. Food Science and Technology, 144, 111220. https://doi.org/10.1016/j.lwt.2021.111220.
Gündüz, M., Çiçek, ŞK. 2019. Fenolik bileşiklerin ekstraksiyon yöntemleri ve doğal içerik olarak kullanımı. Gıda ve Yem Bilimi Teknolojisi Dergisi, (32), 37-47.
Güney, O., Canbilen, A., Konak, A., Acar, O. 2003. The effects of folic acid in the prevention of neural tube development defects caused by phenytoin in early chick embryos. Spine, 28(5), 442-445.

Güvenç, A. 1997. Etanolün fermantasyon çözeltisinden süperkritik CO2 ekstraksiyonu. Doktora Tezi, Fen Bilimleri Enstitüsü, Ankara.

Güzel, M., Akpınar, Ö. 2019. Meyve ve sebze kabuklarının fitokimyasal ve antioksidan özelliklerinin incelenmesi. Gümüşhane Üniversitesi Fen Bilimleri Dergisi, 9(4), 768-780.

Hadidi, M., Ibarz, A., Pagan, J. 2020. Optimisation and kinetic study of the ultrasonicassisted extraction of total saponins from alfalfa (Medicago sativa) and its bioaccessibility using the response surface methodology. Food Chemistry, 309, 125786. https://doi.org/10.1016/j.foodchem.2 019.125786.

Haslam, E. 1998. Practical polyphenolics from structure to molecular recognition and physiological action. Cambridge University Press, Cambridge, UK.

Jáuregui-Haza, UJ., Pardillo-Fontdevila, EJ., Wilhelm, AM., Delmas, H. 2004. Solubility of hidrogen and carbon monoxide in water and some organic solvents. Latin American applied research 34:71-74.

Khaw, KY., Parat, MO., Shaw, PN., Falconer, JR. 2017. Solvent supercritical fluid technologies to extract bioactive compounds from natural sources: A review. Molecules, 22(7), 1186. https://doi.org/10.3390/molecules22071186.

Kırışoğlu, S., Velioğlu, S. 2001. Hiper besleyici gıdalar. Bilim Teknik Dergisi, 4, 56-57.

Larson, RA. 1997. Naturally Occurring Antioxidants. Boca Raton, Lewis Publishers, 202p., Newyork.

Li, Y. 2015. Explore microwave extraction technology and its application in food chemistry, Food Safety Guide, 3, 55-56.

Moradi, S., Fazlali, A., Hamedi, H. 2018. Microwave-assisted hydro-distillation of essential oil from rosemary: comparison with traditional distillation. Avicenna Journal of Medical Biotechnology, 10(1), 22-28.

Ndjonka, D., Rapado, LN., Silber, AM., Liebau, E., Wrenger, C. 2013. Natural products as a source for treating neglected parasitic diseases. International Journal of Molecular Science, 14, 3395-3439.

Nie, J., Chen, D., Ye, J., Lu, Y. Dai, Z. 2021. Optimization and kinetic modelling of ultrasonicassisted extraction of fucoxanthin from edible brown algae Sargassum fusiforme using green solvents. Ultrasonic Sonochemistry, 77, 105671. https://doi.org/10.1016/j.ultsonch.2021.105671.

Nizamlıoğlu, MN., Nas, S. 2010. Meyve ve sebzelerde bulunan fenolik bileşikler yapıları ve önemleri. Gıda Teknolojileri Elektronik Dergisi, 1(5), 20-35.

Nn, A. 2015. A review on the extraction methods use in medicinal plants, principle, strength and limitation. Medicinal & Aromatic Plants 04:3-8.

Ohsawa, I., Ishikawa, M., Takahashi, K., Watanabe, M., Nishimaki, K., Yamagata, K., Katsura, K., Katayama, Y., Asoh, S., Ohta, S. 2007. Hydrogen acts as a therapeutic antioxidant by selectively reducing cytotoxic oxygen radicals. Nature medicine 13:688-694.

Pan, SY,, Litscher, G., Gao, SH., Zhou, SF., Yu, ZL., Chen, HQ., Zhang, SF., Tang, MK., Sun, JN., Ko, KM. 2014. Historical perspective of traditional indigenous medical practices: the current renaissance and conservation of herbal resources. Evidence- Based Complementary and Alternative Medicine, 525340.

Pereira, CG., Meireles, MAA. 2010. Supercritical fluid extraction of bioactive compounds: Fundamentals, applications and economic perspectives. Food and Bioprocess Technology, 3(3), 340-372. https://doi.org/10.1007/s11947-009-0263-2.

Qian, J., Li, Y., Gao, J., He, Z., Yi, S. 2020. The effects of ultrasonic intensity on physicochemical properties of Chinese fir. Ultrasonic Sonochemistry, 64, 104985. https://doi.org/10.1016/j.ultsonch.2020.104985.

Rahman, MM., Byanju, B., Grewell, D., Buddhi, PL. 2021. High-power sonication of soy proteins: Hydroxyl radicals and their effects on protein structure. Ultrasonics Sonochemistry, 64, 105019. https://doi.org/10.1016/j.ultsonch.2020.105019.

Ryu, J., Kim, MJ., Lee, JH. 2019. Extraction of Green Tea Phenolics Using Water Bubbled with Gases. Journal of Food Science 84:1308-1314.

Salimon, J., Salih, N., Yousif, E. 2012. Industrial development and applications of plant oils and their bio based oleochemicals, Arabian Journal of Chem., 5, 135-145.

Schiassi, MCEV., de Souza, VR., Lago, AMT., Campos, LG. Queiroz, F. 2018. Fruits from the Brazilian Cerrado region: Physico-chemical characterization, bioactive compounds, antioxidant activities, and sensory evaluation. Food Chemistry, 245, 305-311.

Sevindik, M. 2018. Pharmacological properties of Mentha species. J Tradit Med Clin Natur., 7, 259-263.

Sundararajan, P. 2022. A systematic literature review of the effects of molecular hydrogen during exercise. Journal of the International Foot & Ankle Foundation, 1(7).

Taşkıran, ZG., Dündar, A., Yıldız, H. 2023. Bitkisel Materyallerdeki Biyoaktif Bileşenlerin Ekstraksiyonunda Kullanılan Konvansiyonel ve Yeni Nesil Ekstraksiyon Yöntemleri. Gıda Bilimi ve Mühendisliği Araştırmaları, 2(2), 50-58.

Visioli, F., Borsani, L., Gali, C. 2000. Diet and prevention of coronary heart disease: the potential role of phytochemicals. Cardiovascular Research, 47, 149-425.

Wu, WJ., Liu, HX., Zhu, JB. 1998. Natural products insecticidal principles, methods and practice. Shaanxi Science and Technology Press, Xi'an.

Yurt, B. 2023. Effect of Hydrogen-Enriched Solvents on the Extraction of Phytochemicals in Propolis. ACS Omega 8:14264-14270.

Zhao, L., Feng, C., Wu, K., Chena, W., Chen, Y., Hao, X., Wua, Y. 2017. Advances and prospects in biogenic substances against plant virus: A review. Pesticide Biochemistry and Physiology, 135, 15-26.

Zor, M., Bulut, M., Karagöz, SG., Çetintaş, Y., Alwazeer, D. 2023. Use of Hydrogen-Rich water in rice milk preparation improves the nutritional and sensory properties of product. Food Chemistry 137821.

POWERING INCLUSIVE GROWTH: SOCIO-ECONOMIC INEQUALITIES IN INDIAN AGRICULTURE AND SUSTAINABLE ENERGY INTERVENTIONS

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Abstract
Agriculture is a cornerstone of the Indian economy, deeply entwined with the nation's social fabric, especially the caste system. This paper examines the socio-economic inequalities in Indian agriculture, focusing on the relationship between rural caste hierarchies and land ownership, where caste often dictates access to resources. Despite India's remarkable agricultural growth-rising from 51 million tonnes of food grain production in 1950-51 to over 314 million tonnes in 2022-this progress has been unevenly distributed across social groups. Small landholdings dominate the sector, with 27% of farmers citing unprofitability as a key concern and 40% expressing a willingness to exit farming if given the chance. Land reforms post-Independence have made limited headway in addressing disparities, particularly for Dalits, who remain marginalized in land ownership. Population pressure and land fragmentation have further reduced landholding sizes, adversely affecting productivity, mechanization, investments, and farm incomes. This paper explores these challenges by analyzing the agrarian structure and caste-based landholding patterns, uncovering persistent inequalities that hinder access to resources and sustainable agricultural practices. This study, conducted in the Vidarbha region's Prabhani district of Maharashtra, uses a multi-stage sampling method and integrates both qualitative and quantitative research approaches, including semi-structured questionnaires and in-depth interviews. The findings highlight significant social inequalities, with Dalit farmers experiencing limited access to essential resources.
Keywords: Inclusive Growth, Agriculture, Socio-Economic Inequalities, Caste, Sustainable Energy Interventions

INTRODUCTION

A defining feature of developing societies is the gradual shift away from a subsistence-based rural agrarian economy towards the creation of an agrarian surplus. Agricultural surplus has long been acknowledged as a crucial driver for the growth of other sectors of economy. Despite 75 years of independence, agriculture continues to play a pivotal role in Indian politics and economy. According to the Periodic Labour Force Survey (PLFS) by the National Statistical Office (NSO), 58% of the rural workforce was engaged in agriculture in 2018-19, with 55% of the population depending on agriculture and allied sectors for their livelihood. These sectors contribute approximately 15% to the nation's Gross Value Added (GVA) (GoI, 2017a; Agricultural Statistics at a Glance, 2022).

Agriculture in India serves as a cornerstone for rural livelihoods, food security, and economic growth, driving not only farming but also allied industries such as wholesaling, warehousing, processing, and retailing. However, a critical feature of Indian agriculture is its intricate connection with the rural caste system. Historically, caste has determined land ownership, access to resources, and the distribution of economic and political opportunities. The caste system continues to underpin agrarian relations, influencing production structures and access to agricultural inputs. As Thorat (2009) and Shah (2001) argue, caste serves as a mechanism for the distribution and access of resources, institutions, and networks in rural India. Harris (2006) observes that caste persists as a dominant principle of social organization, with its hierarchical structure shaping socio-economic interactions and resource access in rural areas. In this context, this paper explores the informational needs of farmers, which vary significantly based on their social background. not only resolving caste-based inequalities but also fostering the adoption of sustainable energy solutions to create a more equitable and resilient agrarian economy.

LAND FRAGMENTATION AND INEQUALITIES

The state of rural landholdings in India reflects deep-rooted socio-economic inequalities and ongoing agrarian distress. According to the National Sample Survey Office (NSSO) 2019 (77th Round), approximately 27% of farmers expressed dissatisfaction with farming due to its unprofitability, while 40% indicated they would switch to other professions if given the opportunity. Factors such as low income, high risks, and lack of social status have left many farmers disillusioned with agriculture as a livelihood. Agrarian distress, compounded by a persistent lack of income security, has plagued the sector for over two decades, with the agricultural growth rate falling to 3% in 2021-22 from 3.3% in 2020-21.

Data from 1970-71 to 2015-16 reveal a significant fragmentation of landholdings, with small and marginal farmers comprising an increasing share of agricultural land. The average size of operational landholdings dropped from 1.33 hectares in 2000-01 to 1.15 hectares in 2010-11, driven by population pressures and inheritance practices. Marginal holdings (less than 1 hectare) now account for 67% of total operational holdings and 22% of the total area operated, up from 19% in 2000-01 (GoI, 2014).

LAND ACCESS AND SOCIAL INEQUALITY IN INDIAN AGRICULTURE

Since the advent of settled agriculture, access to land has been a cornerstone of social and economic relations in India. Historically, different social groups have experienced varied levels of access to this critical resource. While Scheduled Castes (SCs) have generally been landless, Scheduled Tribes (STs) often occupy less fertile land. According to the 2005-06 Agricultural Census, 87% of landholders among SCs and STs fall into the category of small and marginal farmers. Furthermore, 64% of SCs and STs work as agricultural laborers or workers, with this percentage increasing from 57% in 1961 to 78% in 2006 (Diwakar, 1999; Mungekar, 1999).

While SCs and STs are widely acknowledged as the most disadvantaged groups in terms of land ownership, landlessness is more pronounced among SCs. The SC share of operational holdings (OHs) and operated area is significantly lower than their share of the total and rural population. For instance, their share in OHs is approximately six percentage points lower than their share of the rural population, and their share in the operated area is about ten percentage points lower. The average landholding size among SC households (0.52 hectares) is half that of "Other" households (1.05 hectares). Nearly 50% of SC households have holdings smaller than 0.4 hectares, compared to 33% of "Other" households. In terms of larger holdings (more than 2 hectares), only 6% of SC agricultural households qualify, compared to 10% of STs, 12% of OBCs, and 16% of "Other" households.

CASE STUDY OF MAHARASHTRA

To substantiate inferences drawn from national-level data, a case study was conducted in the Parbhani district of Maharashtra, based on fieldwork in three villages: Asola, Nandgaon BK, and Malsonna. These villages, each with approximately 300 households and a population of around 4,000, were chosen for their relatively homogenous population characteristics. Agriculture is the predominant occupation in this region. Maharashtra, with its diverse topography, is divided into nine agro-climatic zones based on rainfall and soil types. According to the Agricultural Census 2010-11, 78.6% of the state's 1.37 crore operational land holdings belong to marginal and small farmers (less than or equal to two hectares). Land utilization data from 2014-15 indicates that of the state's 307.58 lakh hectares of geographical area, 173.45 lakh hectares (56.4%) is net sown area (Government of Maharashtra, 2014 & 2016).

The study aimed to construct the socio-economic profile of farmers, assess their needs, and identify challenges, particularly those faced by Dalit and Adivasi farmers. Data collection involved semi-structured questionnaires covering baseline household details, education, income, landholding, caste, agricultural practices, pesticide use, and ICT-based agricultural information access. Random sampling was used to select 120 households for the study. The region has been utilizing ICT-based agricultural extension services, specifically e-Choupal, since 2000 to provide agricultural information at the village level. Farmers in this region predominantly cultivate commercial crops like soybean and cotton alongside wheat and sugarcane. A mixed-methods approach incorporating both qualitative and quantitative data collection was adopted. In-depth interviews, participant observation, and intensive interactions with farmers were integral to understanding their perceptions of ICT-based agricultural initiatives. The leisurely interaction style ensured comfort and active engagement from the respondents.

The respondents belonged to various castes, including Kumbi, Patil, Dhangar, Vanjari, Mahar, and Mang. Dominant castes (OC), comprising 35% of the sample, are characterized by significant landholdings and political influence in the region. The study also included respondents from Scheduled Castes (SC), Backward Castes (BC), and Nomadic Tribes (NT), allowing for a nuanced understanding of caste-wise agricultural dynamics and challenges. This case study sheds light on how socio-economic factors and ICT-based interventions intersect to impact agricultural practices in rural Maharashtra.

LAND HOLDING PATTERN AMONG RESPONDENTS

The size of land holding plays a crucial role in accessing agricultural information, credit, and the commercialization and mechanization of agriculture. Most of the respondents in the study belong to the marginal and small farmer category. About sixty one percent of the respondents own less than five acres of land. About five percent of the respondents include farmers belonging to the large farmers category. Caste-wise distribution of land among respondents, as presented in Table 2. suggests that about 67 percent respondents belong to OC category who own more than five acres of land each, whereas a large majority of the SC and NT farmers (84 percent and 72 percent respectively) own less than five acres each. Out of 31 SC farmer respondents, 17 (55 percent) are marginal farmers. One respondent belonging to the NT category reported owning more than 25 acres of land. Data also reveals that the majority (59 percent) of the total land holdings is marginal and small.

Table 2 : Landholding pattern

Type of land holding	**Number of respondents (%)**
Marginal (below one 1 ha.)	43 (36)
Small (1to 2.0 ha.)	28 (23)
Semi-Medium (2 to 4 ha.)	26 (22)
Medium (4 to 10 ha.)	17 (14)
Large (above 10 ha.)	6 (5)
Total	120 (100)

(Source: Field work -2020)

DISCUSSION

The caste-based social stratification in India has had a lasting impact on the distribution of resources, with Dalits bearing the brunt of systemic exclusion. This systemic exclusion has not only perpetuated economic inequalities but also reinforced social hierarchies, making it difficult for Dalit farmers to break free from the cycle of poverty.

India's agricultural landscape remains deeply intertwined with the caste system, reinforcing social and economic hierarchies that have persisted for centuries. The intricate interplay between caste and agriculture continues to shape land ownership patterns and socio-economic hierarchies. The caste system, historically embedded in the agrarian structure, remains a critical factor in accessing resources like credit, extension services and technology. Despite the numerous land reform initiatives since Independence, marginalized communities like Dalits and Adivasis have largely been left out of meaningful land redistribution. Dalits, Scheduled Castes (SCs), and Scheduled Tribes (STs) are disproportionately marginalized in terms of land ownership and economic opportunities. While successive national governments have taken initiatives like the Green Revolution with the aim to modernize agriculture, reduce inequalities and alleviate poverty, the benefits have been disproportionately captured by the upper and dominant castes. Despite the attention given to the agricultural sector since Independence, caste continues to influence who benefits from state policies, technologies, and economic opportunities.

The case study of rural Maharashtra highlighted significant variations in the agricultural information needs of farmers based on caste, emphasizing that their priorities are shaped by their geographical, social and economic positions within the villages. These differences can be explained by their caste-related access to social capital. Overall, the study highlighted that agricultural information needs are not uniform but vary significantly by caste and landholding, with caste influencing the farmers' access to critical resources and information. It is important to note that the increasing fragmentation of operational holdings, emphasizes the challenge of ensuring equitable development within the agrarian sector. The small and marginal farmers must be given importance in the process of development and poverty reduction because they account for about 86% per cent of this sector.

Circling back to the political manifestos announcing their agenda of doubling farmers' income and to become a developed country by 2047, this paper underscores the importance of formulating inclusive policies and special strategy to address the challenges faced by Dalits, and small and marginal farmers. Overall, this study provides valuable insights for policymakers, researchers, and agricultural economists who seek to understand and address the barriers to agricultural growth and social justice in India's agrarian sector. Advocating for transformative changes addresses the socio-economic gaps in rural India and contributes to the broader discourse on inclusive growth.

CONCLUSION:

Agrarian policy in the 21st century must be driven by the twin concerns of raising farmers' incomes and ensuring the long-term sustainability of their livelihoods. Efforts to double farmers' income and other policy initiatives must go beyond economic growth and address the structural inequalities rooted in caste and land distribution. Without concerted efforts to reform land ownership patterns and provide marginalized communities with equitable access to resources, the cycle of poverty and exclusion will continue to persist. Effective policy solutions must, therefore, integrate social justice with agricultural development, ensuring that all farmers, regardless of caste, can benefit from the country's progress. Indian agriculture must incorporate a more inclusive approach that addresses the structural impediments rooted in caste and land inequality to ensure that historically marginalized groups are not left behind. True agrarian reform in India will require the dismantling of deeply entrenched caste hierarchies that continue to shape the country's rural economy.

References:

Aker, C. J. (2011). Dial "A" for agriculture: A review of information and communication technologies for agricultural extension in developing countries. *Agricultural Economics, 42*(6), 631-647.

Ambedkar, B. R. (1948). *The untouchables: Who were they and why they became untouchables?* Amrit Book Company.

Government of India. (2017a). *Agricultural statistics at a glance 2017.* Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare.
Thorat, S. (1996). *Ambedkar's role in economic planning and water policy.* Shipra Publications.
Thorat, S. (2009). *Dalits in India: Search for a common destiny.* SAGE Publications India.
Shah, A. (2001). Globalization and social inequalities. *Journal of Development Studies, 37*(4), 15-29. https://doi.org/xxxxx
Jodhka, S. S. (2012). *Caste*. Oxford University Press.
White, H. (2003). Social funds: A review of the issues. *World Bank Research Observer, 18*(1), 103-123.
Vasavi, A. R. (2012). *Shadow space: Suicides and the predicament of rural India*. Three Essays Collective.
Harris, J. (2006). *Power matters: Essays on institutions, politics, and society in India.* Oxford University Press.
Government of India. (2014). *Agricultural Census 2010-11: All India report on number and area of operational holdings.* Ministry of Agriculture, Department of Agriculture and Cooperation.
Office of the Registrar General & Census Commissioner, India. (2011). *Census of India 2011: Population and workforce statistics*. Ministry of Home Affairs, Government of India. Retrieved from https://censusindia.gov.in
Ghosh, J., & Chakrabarty, A. (2000). Inequalities in land ownership: A study of scheduled caste households in India. *Economic and Political Weekly, 35*(14), 1231-1241.
Dantwala, M. L. (1991). *Agrarian structure and land reforms in India*. Indian Society of Agricultural Economics.
Diwakar, D. M. (1999). Agrarian crisis and labour in India: A study of scheduled castes and scheduled tribes. *Journal of Rural Development, 18*(2), 201-230.
Mungekar, B. L. (1999). Scheduled castes and scheduled tribes in India: Problems of land, agriculture, and rural development. *Economic and Political Weekly, 34*(42), 2995-3003.
Government of Maharashtra. (2014). *Agricultural statistics of Maharashtra: 2014-15*. Department of Agriculture, Government of Maharashtra.
Government of Maharashtra. (2016). *Economic survey of Maharashtra: 2015-16*. Directorate of Economics and Statistics, Planning Department, Government of Maharashtra.

EFFECT OF DRIED TIGERNUT (*Cyperus esculentus L.)* SUPPLEMENTARY DIET IN FORMULATED FEED ON *Clarias gariepinus* FECUNDITY, FERTILIZATION, HATCHABILITY OF EGGS AND SURVIVAL RATE OF THE HATCHLINGS

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ABSTRACT
Study was carried out in the demonstration farm of the Department of Aquaculture and Fisheries Management to evaluate the effect of tigernut (*Cyperus esculentus*) supplementary diet on fecundity, fertilization, and hatchability and survival rate of *Clarias gariepinus* hatchlings. Twenty female broodstock with average of 859g to 1kg were sourced and randomly distributed into ten concrete tanks. Nine experimental diet of 40% crude protein containing 0%, 5%, 10%, 15% and 20% of wet and dry tigernut respectively were included in the feed, formulated and fed to the female broodstock at 3% of body weight twice daily for 30 days. Data on fecundity, percentage fertilization, and hatchability and survival rate were collected and analysed using two-way ANOVA with Genstat. In the average weight of egg with egg sac, the dried tigernut treatment diet was significantly higher than that of wet. The fecundity of the fish result shows that there is significant difference between the wet and dry tigernut supplementary diet with TSD 15 showing the highest value for the wet and dry followed by TSD 05 and TSD 10. Which were significantly different from other treatments and the control. The result of the fertilization shows no significant difference between wet and dry control, TSD 5, TSD 10 respectively, but is significantly different for TSD 15 and TSD 20. The hatchability result shows the control with no significant difference between the wet and dry treatments of hatchability, TSD 20, TSD 15, TSD 10 also shows no significant difference between the wet and dry treatments except for TSD 5 which shows significant difference. TSD 10 of the dry treatment shows the highest value while TSD 15 has the lowest value. The survival rate result shows that there is a significant difference between wet and dry tigernut diet in TSD 00, TSD 05, TSD 10 and TSD 15. TSD 15 have the highest significant value in survival rate more than any other treatments in wet experimental diet This study has shown that inclusion of tigernut in the feed of fish enhance fecundity, fertilization, hatchability and survival of *C. gariepinus* fry. This study established the efficacy of tigernut seed meal as fertility enhancer and hatchling survival in *C. gariepinus* broodstock and should be encouraged as it will minimize the dependence on synthetic drugs as fertility enhancing agents.
Keywords: Tigernut, Fecundity, Fertilization, Hatchability, *Clarias gariepinus.*

INTRODUCTION
Tigernut are edible tubers with a sweet nutty flavor (Akuoma *et al.*, 2000). When they are dried, they are quite hard and are generally soaked in water before consumption for those that want the soft. Tigernut has several varieties (black, brown and yellow and they have been described as an important food of high nutritional and economic values (Oguntona and Akinyele, 1995) and a good source of starch for human consumption and industrial use (Barko and Smart, 1979). It yields more milk upon extraction and contains lower fat and more protein (Okafor and Okolo,

2003). It has considerably high levels of fibre, protein, carbohydrates especially natural sugars (Soluble Glucose), Potassium and Phosphorus. The very high fibre content combined with a delicious taste make it ideal for children, older and sports men (Annon, 2005). Although, tigernut is gluten and cholesterol free, it is rich in essential amino acids (lysine, threonine and cysteine), oil, oleic acids, Vitamins C and E and very low in sodium content. Medically, it is regarded as a digestive tonic, having a heating effect on the digestive system and alleviating flatulence. The nut is used in the treatment of Boil, Cold, Polio, Ulcers (Chevalier, 1990).

Among the culturable fish in Nigeria includes *C. gariepinus,* which is a major tropical aquaculture species in Africa (Ayinla and Akande, 1988) and it has a very good commercial value in Nigerian markets (Ayinla *et al.,* 1994). Fish seed production is an important aspect of aquaculture that has witnessed continuous research and innovation for increased fish production. Artificial propagation methods constitute the major practicable means of providing enough quality seed for rearing in confined fish enclosure waters such a fish ponds, reservoirs and lakes (FAO, 2006).

Common practices in hatcheries such as transportation, handling, cleaning, use of chemicals, overstocking, water quality problems are not the only factors that may negatively influence fish reproduction (Adeparusi *et al.*, 2010) but quality of eggs is also suspected. These common factors affect fertilization success in both artificial and natural reproduction. As a result of these factors, low quality fish seeds are produced (Adeparusi *et al*., 2010). The need for acceptability and affordability pro-fertility agents in fish for quality fish seeds availability informed the study of tigernut in female *C. gariepinus* broodstock and its medicinal properties for adequate fish seed production.

MATERIALS AND METHODS

Research Area

The research was carried out at the Department of Aquaculture and Fisheries Management Fish Farm, Shabu-Lafia Campus. Nasarawa State University, Keffi. Lafia is located on latitude $8^0 35^0$N, longitude $8^0 32^0$E and altitude 181.53m above sea level with mean temperature of 34^0C, relative humidity of 40-86% and average day light of 9-12hours. (NIMET, 2011)

Collection and Acclimation of Experimental Fish

Twenty (20) female experimental *C. gariepinus* broodstock of mean weight between 650g-1kg were sourced from a commercial farm in Lafia, Nasarawa State. The broodstocks was acclimated for one weeks in concrete holding tanks at the Department of Aquaculture and Fisheries Management Fish Farm, Nasarawa State University, Keffi Nigeria. During this period, they were fed with commercial diets of 40% crude protein twice daily at 3% of their body weight.

Experimental Diet Preparation

The feedstuff and tigernut was obtained from various market in Nasarawa State, Nigeria. Part of the tigernut was sun dried and then grounded into fine powder. Treatment diet was formulated to provide 40% crude protein.

The ingredients was milled to small particles size and graded level of tigernut meal was added at 0% (control diet), 5%, 10%, 15% and 20% inclusion level. Ingredients including vitamin premix and tigernut meal (dry) were thoroughly mixed to obtain a homogenous mass. The feed was pelletized using extruder machine and the pellets were sun-dried immediately to required minimum moisture level for storage.

Table 1: Composition of experimental diet.

Experimental Setup

Two (2) females broodstocks were randomly selected and kept into five different concrete ponds (1m by 1m by 1.5m) in three replicates (i.e. tigernut inclusion level of 0%, 5%, 10%, 15% and 20%) dried tigernut. The experimental broodstocks were starved 24 hours to the commencement of the experiment. The experimental broodstocks were fed with the varying inclusion level of the experimental diet twice daily at 3% of their body weight per day for a period of seven weeks. The quantity of feed was adjusted based on the weight attained by the fish fortnightly throughout the feeding trial. The water quality standard was strictly adhered while the water in each tank was completely changed twice a week and tanks were washed regularly to ensure optimum quality of the culture medium and healthy condition of the fish according to (Adewole and Owolabi, 2007).

Sampling and data collection

Initial and final mean weight at the beginning and at the end of the period of this study of randomly distributed fish were done using sensitive weighing balance respectively. Data collected were processed and used to compute parameters for weight of the fish and feed utilisation.

Growth Assessment

The following indices was used to determine the biological evaluation of growth performance of the experimental fish according to methods described by Jobling (1983).

Mean Weight Gain (MWG)

The weight gains of fish in each treatment group was taken. All fish per treatment was individually weighed on a spring weighing balance and the respective means was recorded.

Percentage Mean Weight Gain (PMWG)

This was calculated using the formula:

$$\text{Percentage mean weight gain} = \frac{W_f - W_i}{W_i} \times 100$$

Where, W_f is final mean weight and W_i is initial mean weight

Reproductive performance

At the end of the feeding trial, six females randomly selected per dietary treatment were weighed, killed and dissected to remove the egg sac. Fecundity estimation was done using volumetric sub-sampling (wet method) as described by Okaeme, *et al*. (2013). The egg sac were carefully weighed

S/N	COMPONENTS	TREATMENTS				
		FTSD/ DTSD 0% (ctrl)	**FTSD/ DTSD 5%**	**FTSD/ DTSD 10%**	**FTSD/ DTSD 15%**	**FTSD/ DTSD 20%**
1	Fish meal (kg)	16.06	16.06	16.06	16.06	16.06
2	Soybean meal (kg)	18.98	18.98	18.98	18.98	18.98
3	Groundnut cake (kg)	20.44	20.44	20.44	20.44	20.44
4	Millet (kg)	14.60	14.60	14.60	14.60	14.60
5	Wheat offal (kg)	16.06	16.06	16.06	16.06	16.06
6	Cassava flour (kg)	11.20	11.20	11.20	11.20	11.20
7	Vitalyte premix (kg)	0.37	0.37	0.37	0.37	0.37
8	Lysine (kg)	1.07	1.07	1.07	1.07	1.07
9	Methionine (kg)	0.61	0.61	0.61	0.61	0.61
10	Salt (kg)	0.61	0.61	0.61	0.61	0.61
10	**TOTAL**	**100**	**100**	**100**	**100**	**100**
Additives	Dried Tigernut meal (%)	0.00	0.50	1.00	1.50	2.00

after cleaning the blood stain and removing attached tissues. The egg sac is then placed in 100ml of diluted water in a measuring cylinder and the volume (V) recoded. A small sample of the eggs was gotten from the egg sac and placed in 5ml of dilute water in a measuring cylinder and the volume (v) was recorded. The egg sample was counted and recorded as (n) and was calculated using the formulae below:

$$X/n=V/v$$

Where, X= Unknown number of eggs in the total sample collected, n= Number of eggs counted in sample,

V= Total displaced volume, v= Volume of the sample

Egg Quality Assessment and Larval Production

After seven weeks of feeding trial, two females were randomly selected per dietary treatment, weighed and injected with ovaprim hormone according to manufacturer’s recommended dosage of 0.5/kg body weight. The Fish was kept in a bowl for 12 hours (twelve hours) as latency period and eggs was collected by manual stripping of the sexually gravid females while milt from the male fish prepared for the experiment was used for the fertilization of eggs. The incubators was kept well oxygenated with aerators while the ambient temperature (hatchery) was kept within 28^{0}C and eggs hatched after approximately 24 hours of incubation in plastic tanks.

The percentage of egg fertilized as well as the percentage number of egg hatched and percentage survival was computed according to the methods described by Ayinla (1988):

% Egg Fertilized = No. of eggs incubated − No. of opaque eggs / Total no. of eggs incubated × 100.

% Egg Hatching = No. of whitish broken eggs / No. of eggs fertilized × 100

% Survival = No. of hatchling alive up to larvae stage / Total number of hatchlings × 100, which was determined after 10th day of hatching.

Statistical Analysis

Data obtained were analysed by two-way Analysis of variance (ANOVA) and significant mean differences was separated at 0.05 probability level as described by Steel *et al*. (1997).

RESULTS

Analysis of feed and inclusion rate of tiger nut in percentage

Result of proximate analysis of formulated diet of the experiment is presented in table 4. Result of moisture, ash and crude protein show that DTSD 10, 15 and 20 were significantly the same but they were significantly higher than the control.

Result shows that Ether extract and Nitrogen free extract of treatment DTSD 20 was significantly higher than other treatments.

Table 2: Proximate composition of the experimental diet (Dry tigernut)

Treatments	**Moisture**	**Ash**	**Crude protein**	**Ether extract**	**Crude fibre**	**Nitrogen Free extract**
DTSD 00	11.58500^{b} (0.0071)	14.2150^{b} (0.0071)	39.3500^{b} (0.0707)	14.0550^{e} (0.0071)	2.2750^{d} (0.0354)	18.4650^{e} (0.0071)
DTSD 05	11.58985^{b} (0.0029)	14.2193^{b} (0.0059)	39.4277^{ab} (0.0047)	14.1619^{d} (0.0037)	2.3169^{cd} (0.0062)	36.6342^{d} (0.0075)
DTSD 10	11.61830^{a} (0.0205)	14.2425^{a} (0.0083)	39.4437^{a} (0.0070)	14.2638^{c} (0.0067)	2.3370^{bc} (0.0078)	36.2821^{c} (0.0043)
DTSD 15	11.62150^{a} (0.0082)	14.2553^{a} (0.0069)	39.4766^{a} (0.0051)	14.3715^{b} (0.0087)	2.3605^{ab} (0.0048)	35.9071^{b} (0.0163)
DTSD 20	11.63155^{a} (0.0056)	14.2593^{a} (0.0066)	39.4918^{a} (0.0077)	14.4819^{a} (0.0071)	2.3877^{a} (0.0037)	35.5597^{a} (0.0022)

DTSD 00= Dry Tigernut supplemented diet 0% (control), DTSD 05= Dry Tigernut supplemented diet 5%, DTSD 10= Dry Tigernut supplemented diet 10%, DTSD 15= Dry Tigernut supplemented diet 15% , DTSD 20= Dry Tigernut supplemented diet 20%

Average Weight of the Fish

The result for the average weight of fish treated with dry tigernut supplementary diet is shown in Figure 1. Result shows that there is no significant difference between the value obtained for the average weight of fish treated with dry and wet tigernut supplementary diet. However, treatment TSD 10 and TSD 15 were each significantly higher than other treatments. The control treatment had the lowest value recorded for average weight of the fish treated with experimental diet.

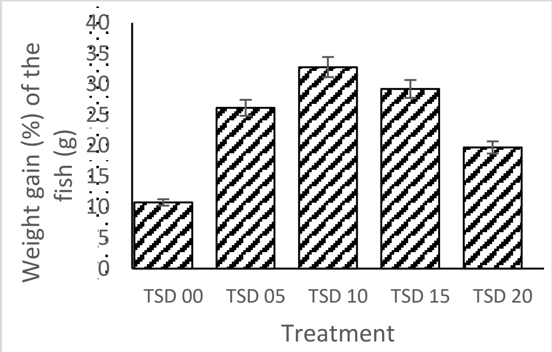

Figure 1: Average weight (%) of *C. gariepinus* female fed experimental diet for 30days

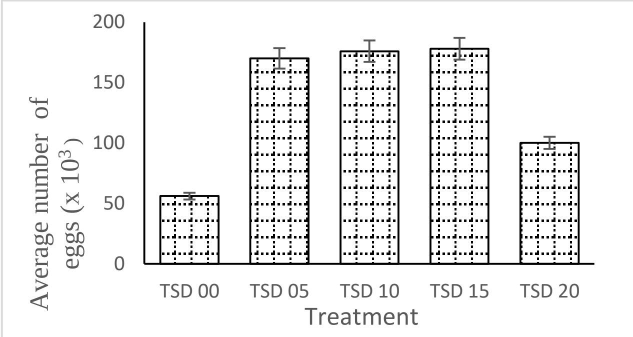

Figure 2: Average number of egg of *C. gariepinus* female fed experimental diet for 30days

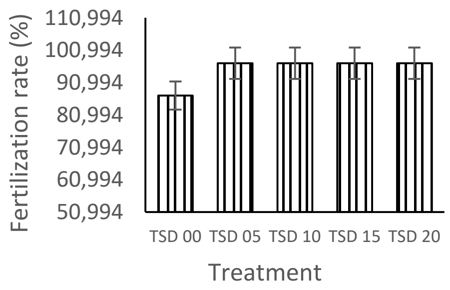

Figure 3: Effect of tigernut experimental diet on Fertilization rate of *C. gariepinus* eggs

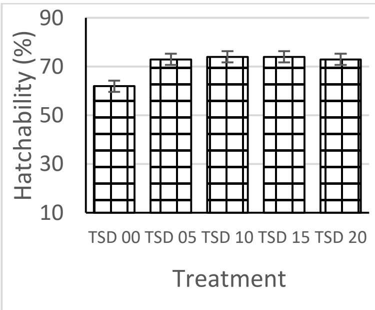

Figure 4: Effect of tigernut experimental diet on the Hatchability Rate of *C. gariepinus* fry

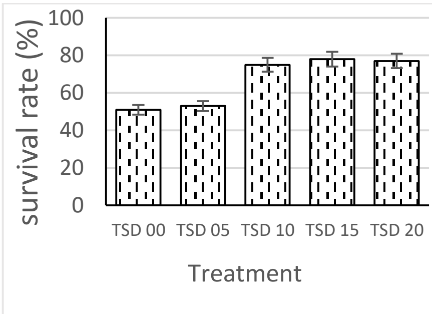

Figure 5: Effect of tigernut supplementary diet on Survival Rate of *C. gariepinus* hatchlings

TSD 00= Tigernut supplementary diet 0% (Control) TSD 05= Tigernut supplementary diet 5% inclusion level

TSD 10= Tigernut supplementary diet 10% inclusion level TSD 00= Tigernut supplementary diet 15% inclusion level

TSD 00= Tigernut supplementary diet 20% inclusion level

Average weight of egg with egg sac of *C. gariepinus* treatment with tigernut supplementary diet

The average weight of egg with egg sac is presented in figure 2. Result of ANOVA show that there is significant difference between the treatments. The dried tigernut treatment diet was significantly higher than that of wet. Treatment TSD 10 value recorded were significantly higher than that of other treatments. Treatment TSD 20 for wet tigernut treatment had the lowest recorded value for weight of egg with egg sac.

Average number of egg of *C. gariepinus* female treated with dry and wet tigernut supplementary diet (Fecundity)

The result of the average number of eggs in female fish treated with dry and wet supplementary diet is presented in figure 3. The result for the average number of eggs in fish shows that there is significant difference between the wet and dry tigernut supplementary diet. TSD 15 shows the highest value for the wet and dry followed by TSD 05 and TSD 10. There is no significant difference between TSD 05 and TSD 10 but are significantly different from other treatments and the control. TSD 15 also shows the highest value for the wet and it is significantly different from the control and other treatment. TSD 05 and TSD 10 are not significantly different from each other in the experimental diet. TSD 15 also showed highest value for the dry and it is significantly different from the control and other treatments among the dry tigernut experimental diet.

Effect of tigernut supplementary diet on the Fertilization rate of *C. gariepinus* eggs.

The result of the effects of tigernut supplementary diet on fertilization rate of *C. gariepinus* eggs is shown in figure 3. The result of the fertilization shows no significant difference between wet and dry control, TSD 5, TSD 10 respectively, but is significantly different for TSD 15 and TSD 20. There is no significant difference between the control, TSD 5 and TSD 10 respectively for the dry treatment but there is significant difference for TSD 15 and TSD 20 record the lowest value for dry treatment. The wet treatment only shows significant difference for TSD 15, while control, TSD 5 TSD 10 and TSD 20 shows no significant difference.

Effect of tigernut supplementary diet on the Hatchability Rate of *C. gariepinus* fry

The effect of tigernut supplementary diet on *C. gariepinus* hatchability rate is presented in figure 4.

The control shows no significant difference between the wet and dry treatments of hatchability, TSD 20, TSD 15, TSD 10 also shows no significant difference between the wet and dry treatments except for TSD 5 which shows significant difference. TSD 10 of the dry treatment shows the highest value while TSD 15 has the lowest value. TSD 5, TSD 20 and control has no significant difference, between them, but are significantly different from TSD 15 and TSD 5, while TSD 5 records the lowest value.

Effect of tigernut supplementary diet on Survival Rate of *C. gariepinus* fry

The effect of tigernut supplementary diet on survival rate of *C. gariepinus* hatchling is presented in figure 5.

The result shows that there is a significant difference between wet and dry tigernut diet in TSD 00, TSD 05, TSD 10 and TSD 15. TSD 15 have the highest significant value in survival rate more than any other treatments in wet experimental diet while TSD 05 of the dry tiger nut experimental diet has the significant value for survival rate.

DISCUSSION

The general increase in body weights of the experimental fish in all the treatments in this study indicated that the diets were adequate in dietary protein and other nutrients required by female catfish. Similar results were obtained when tilapia fingerlings fed on different grains and *Clarias gariepinus* fed cocoyam based diets respectively (Solomon *et al.,* 2007; Aderolu and Sogbesan, 2010). The increase in body weight might be attributed to the nutrient rich of the tigernut which might have allowed proper absorption of the nutrients which have allowed proper utilization of the nutrients.

The result of this study shows that tigernut supplementary diet affects the fecundity, hatching rate and percentage survival of *C. gariepinus* larval. Similar result was reported for using ethanol extract of *Gacinia kola* seed as fertility-promoting agent for *C. gariepinus* (Dada and Ajilore, 2001). Adesanya *et al*., (2007) reported an increase in the sperm count of wistar rats after treatment with ethanol extract of *G .kola* seed for 6 weeks.

This might be attributed to the seeds of *Cyperus esculentus* established as a very nutritious (Paigen *et al*., 1987), rich mineral content especially vitamin E, phosphorus and potassium, oil resistance to peroxidation and fatty acid (palmitic acid, stearic acid, oleic acid and linoleic acid), alkaloids that prolonging the action of camp, they also affect glucagons and thyroid stimulating hormones, saponins and tannins are known to have antimicrobial activity, as well as other physiological activities (Sofoworo, 1993; Evans, 2005). The extract play an important role in enhancement fertility so it may improve reproductive system maturity (Almashhadani and Alessawe, 2010)

In this study, the larval of the broodstocks fed on diets 5% and 15% tigernut supplementary diet survived well than the ones placed on other diets. Since most of the losses in hatchery are recorded at the critical transitional period of moving from endogenous feeding to exogenous feeding, any effort made to improve the quality of the egg will surely increase the survival of the larval (Davy and Chouinard, 1980). The significantly higher ($p<0.05$) percentage fertilization and hatchability observed in the fish fed the diet 5% tigernut supplementary diet agrees with Adewumi *et al*. (2005) who reported that *C. gariepinus* broodstock fed differentially heated soybean-based diets had smaller eggs and produced lower hatching rates and larval survives than the control fish which were fed on fish meal – based diet.

Conclusion

Tigernut supplementary diet improved the reproductive performance of cultured African catfish, *C. gariepinus* and was useful and reliable ingredient for propagating seedling production and rearing strategy of hatchlings.

This study has shown that inclusion of tigernut in the feed of fish enhance Fecundity, fertilization, hatchability and survival of *C. gariepinus* fry.

Recommendations

This study established the efficacy of tigernut seed meal as fertility enhancer and hatchling survival in *C. gariepinus* broodstock and should be encouraged as it will minimize the dependence on synthetic drugs as fertility enhancing agents. Therefore, future research should focus on the improvement of fresh seed production technology of different fish by tigernut meal.

REFERENCES

Adeparusi, E. O., Dada, A. A., and Alale, O. V. (2010). Effects of Medicinal Plant (*Kigelia Africana*) on Sperm Quality of African Catfish *Clarias Gariepinus* (Burchell, 1822) Broodstock *Journal of Agricultural science* 2 (1): 791-795.

Aderolu, A. Z. and Sogbesan, A. O. (2010). Evaluation and potential of Cocoyam as carbohydrate source in catfish (*C. gariepinus*; Burchell, 1822) juvenile diets. *African Journal of Agric. Research,* 5(6); 453 – 457.

Adesanya, O. A., Oluyemi, K. A., Omotuyi, I. O., Saalu, C.L. and Josiah, S. J. (2007). Erythropoietic and Anti-Obesity effects of *Garcinia cambogia* (Bitter Kola) in Wistar rats. *Biotechnol. Appl. Biochem* 2007; 46: 69 – 72.

Adewumi, A. A., Olaleye V. F. and Adesulu, E.A. (2005). Egg and Sperm Quality of the African Catfish, *Clarias gariepinus* Broodstock Fed Differently Heated soybean – base Agric. And *Journal Bio of North America*. 2151-7517.Diets. *Research Journal of Agriculture and Biological Sciences* 2005; 1(1): 17 – 22.

Agbabiaka, L. A., Madubuike F. N., Ekenyem, B. U. and Esonu, B. O. (2013). Effect of tigernut based diets on haematology and serum biochemistry of broiler finisher.

Akoma, O., Elekwa, U. A., Afodunrinbi, A. T. and Onyeukwu, G. C. (2000). Yogurt from Coconut and Tiger nut. T J Fd Tech. Africa.; 5:132-134

Almashhadani A. A. M. and Al-Essawe E. M. A. (2010). The Effect of *Cyperus esculentus* on sperm function parameters in prepubertal mice as a model for Human. *Journal of Baghdad for Science* 7: 389-393

Ayinla, O.A. and Akande, G.R. (1988). Growth response of *Clarias gariepinus* (Burchell 1822) on silage-based diets.

Ayinla, O.A., Kayode, O, Idoniboye-Obu, O.I.E., Oresegun, A. and Adidu, V.E. (1994). Use of tadpole meal as Substitute for fish meal in the diet of *H bidorsalis* (Geoffrey St Hillarie 1809). *J. Aqua. Trop*., 9(I): 25-33.

Bamgbose, A.M., Eruvbetine, D. and Dada, W. (2003). Utilization of Tigernut (*Cyperus esculentus*) In the Diets for Cockerel.

Belewu M. A, and Abodunrin A. O. (2006). Preparation of kunnu from unexploited rich food source: Tigernut (*Cyperus esculentus*). *World Journal of Dairy and Food Sciences*. 1: 19-21.
Brookes, P. A. Lovett, D.A. and MacWilliams I. C. (1976). The Steeping of Barley: A Review of the Metabolic Consequences of Water Uptake and their Practical Implications. *J. Inst. Brew.*; 82: 14-26
Chevalier, G.E. (1990). The Nut as a Medicinal Plant. *J. Agric. Sci*., 17: 188 – 201.
Coban, D., Kamacı, H. O., Cuneyt, S., Yıldırım, S., Arda, G., Korkut, A.Y., Saka, S. and Fırat, K. (2011). Effect of Some Morphometric Characteristics on Egg Quality in Common Dentex, Dentex dentex (Linnaeus, 1758). *Turkish Journal of Fisheries and Aquatic Sciences* 11: 425-431
Dada, A.A. and Ajilore V. (2009). Use of Ethanol extracts of *Garcinia Kola* seed as fertility enhancer in female catfish *clarias gariepinus*. *International Journal of fisheries and Aquaculture* 2009; 1[1]: 005-010.
Dalziel, J. M. (1937). The useful plants of the West tropical Africa. Crown Agents UK. Pp.612
Davy F.B. and Chouinard A. (1980). Induced Breeding in S.E. Asia. The International Development Research Centre. Ottawa, Canada1980: 1277 – 1285.
Eteshola, E. and Oraedu A.C. (1996). Fatty acids composition of Tiger nut tubers (*Cyperus esculentus* L.), baobab seeds (Adansonia digitata L.) and their mixtures. *J American Oil Chem Soc*. 1996; 73: 255–257.
Evans, N. S. (2005). Trease and evans. Pharmocognosy, 15th Ed., Elsevier, India, pp: 1-24.
FAO (1998). Fermented Fruits and Vegetables: A Global Perspective; Edited by Battcock M. and Azam- Ali S. FAO Agricultural Services Bulletin No. 134. Rome
FAO (2006). United Nations Food and Agriculture Organization. The state of World Fisheries and Aquaculture 2006. FAO, Rome 2007. 142p.
FAO, (1990). Utilization of tropical food and animal product. FAO food and nutrition. Paper 47 FAO Rome 1990. Pp 8-21
Gabriel, V.U., Akinrotimi O.A., Bekibele D.O., Anyanwu P.E. and D.N. Onunkwo (2007). Economic benefit and ecological efficiency of integrated Fish farming in Nigeria. *Scientific Research and Essay* 2007; 2 (8): 302 - 308.
Moses, B. S. (2006). Fisheries and Ecotourism: A Tool for National Development. Proceedings of the Fisheries Society of Nigeria (FISON) (Enim, U.M., Chukwu, E.I., Ajah, P.O., Aina- Abasi D.A. and Nwowu, F.M. Ed.). 412.
National Research Council, (1993). National Academy Press. Nutrient Requirements of Fish Committee on Animal Nutrition Board on Agriculture Washington, dc books. Nap.edu/ open book .php?record_id=2115&page=R1
Nwokoye, C.O., Nwuba, L.A. and Eyo, J.E. (2007). Induced propagation of African clariid catfish, *Heterobranchus bidorsalis* (Geoffrey Saint Hillarie, 1809) using synthetic and homoplastic hormone. *African Journal of Biotechnolgy*, 6(23): 2687-2693
Oguntona, E. B. and Akinyele, I. O. (1995). Nutrient Composition of Commonly Eaten Food in Nigeria. Food Basket Foundation Publication Series. Obt Printing Ventures, Ibadan. Oyo State.
Okaeme A.N., Jude C. Nnaji, Samuel I., Olufeagba and Ilyasu A. (2013). Introduction to freshwater Fisheries. National Institute for Freshwater Fisheries Research. 1st Edn. 978-177-078-3. Pp 174-175
Okafor, J. C. and Okolo, H. C. (2003). Nutritive Value of a Mixture of Tigernut Tubers and *Baobab Seeds. J. Sc. Food Agric.*, 35: 437- 440.
Oladele, A.K., and. Aina, J.O. (2007). Chemical composition and Functional properties of Flour produced from two varieties of tiger nut. *African Journal of Biotechnology*, 6: 2473- 2476.
Omoniyi, I.T. Agbeti, O.T. and Olaoye, O.J. (2013). Fish Production and Management www.unaab.edu.ng/attachments/ 463_FIS501% 20by% 20ITO.pdf Retrieved on 21, May, 2013.
Paigen, B., Morrow, A., Holmes, P.A., Mitchell, D. and Williams, R.A. (1987). Quantitative assessment of atherosclerotic lesions in mice. Atherosclerosis. 68(3):231-40.
Purseglove, J.W. (1969). The tropical crops discotyledons 2nd Edn. Longmans, London, pp. 719

Simpson D.A. and. Inglis, C.A. (2001). Cyperacease of economics ethno botanical and horticultural importance. A check list. Kew Bull, 56:257-360

Sofowora, E.A. (1993). Medicinal plants and traditional medicine in Africa. Ibadan-Owerri Kaduna-Lagos Spectrum Books Limited, pp: 159-238.

Solomon, S.G., Tiamiyu, L. O. and Agaba, U.J. (2007). Effect of feeding different grains source on growth performance and body composition of Tilapia fingerlings fed in outdoor hapas. *Pakistan J. Nutr.* 6(3): 271275.

Sule, O. D. and Adikwu, I. A. (2004). Effect of broodstock size on egg and the African catfish, *Clarias gariepinus* under laboratory conditions. *Journal of Aquatic Science* 2004; 19(1): 1 – 4.

Umerie, S.C., Okafor E. P. and Uka, A.S. (1997). Evaluation of the tubers and oil of *Cyperus esculentus*. Bioresource Technology, 61: 171- 173.

World Fish Centre (2003). Fish: an issue for everyone. A concept paper for fish for all summit, 2003. 10p.