International Multidisciplinary

ENVIRONMENT AND HEMP CONGRESS

20-22 / MAY / 2024 / ANKARA

OSTİM TECHNICAL UNIVERSITY
A N K A R A

IKSAD INSTITUTE

Proceedings Book

EDITOR

Prof. Dr. Ahmet Karadağ

ISBN: 978-625-367-740-4

INTERNATIONAL MULTIDISCIPLINARY ENVIRONMENT AND HEMP CONGRESS

E-HEMP2024

20-22 May 2024 / Ankara TÜRKİYE

EDITOR

Prof. Dr. Ahmet KARADAĞ

Issued: 25.06.2024

PROCEEDINGS BOOK

ISBN: 978-625-367-740-4

CONGRESS ID

CONGRESS TITLE

INTERNATIONAL MULTIDISCIPLINARY ENVIRONMENT AND HEMP CONGRESS

E-HEMP2024

DATE AND PLACE

20-22 May 2024 / Ankara TÜRKİYE

ORGANIZATION

IKSAD INSTITUTE

OSTİM TECHNICAL UNIVERSITY

EDITOR

Prof. Dr. Ahmet KARADAĞ

PARTICIPANTS COUNTRY (14 countries)

TÜRKİYE, PAKISTAN, AZERBAIJAN, ROMANIA, IRAN, NIGERIA, INDIA, SERBIA, ALGERIA, MOROCCO, FRANCE, BANGLADESH, SPAIN, PORTUGAL

Total Accepted Article: 74

Total Rejected Papers: 39

Accepted Article (Türkiye): 32

Accepted Article (Other Countries): 42

ISBN: 978-625-367-740-4

International Multidisciplinary

ENVIRONMENT AND HEMP

Congress

OSTİM TECHNICAL UNIVERSITY ANKARA

IKSAD INSTITUTE
Institute of Economic Development and Social Research

25.06.2024

REF: Akademik Teşvik

İlgili makama;

Uluslararası Multidisipliner Çevre Ve Kenevir Kongresi, 20-22 Mayıs 2024 tarihleri arasında Ankara'da 14 farklı ülkenin (Türkiye 32 bildiri- Diğer ülkeler 42 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,

Saygılarımla

Prof. Dr. Ahmet KARADAĞ
HEAD OF CONGRESS

T.C.
OSTİM TEKNİK ÜNİVERSİTESİ
Rektörlük

TÜRKİYE CUMHURİYETİ'NİN YÜZÜNCÜ YILI

Sayı : E-99650833-100-27400 03.02.2024
Konu : Uluslararası Multidisipliner Kenevir Araştırmaları Kongresi Hk.

İKTİSADİ KALKINMA VE SOSYAL ARAŞTIRMALAR ENSTİTÜSÜ BAŞKANLIĞI'NA

Üniversitemiz Teknoloji Transfer Ofisi ile İKSAD (İktisadi Kalkınma ve Sosyal Araştırmalar Enstitüsü) iş birliğinde 21-22 Mayıs 2024 tarihlerinde Prof. Dr. Ahmet KARADAĞ Başkanlığında "Uluslararası Multidisipliner Kenevir Araştırmaları Kongresi (International Multidisciplinary Environment and Hemp Congress) " adıyla düzenlenmesi planlanan kongre 18.01.2024 tarih ve E-99650833-051-26778 sayılı Rektörlük Oluru ile uygun görülmüştür.

İlgili kongrede OSTİM Teknik Üniversitesi'ni Düzenleme Kurulu ve Bilim Kurulu içerisinde temsil etmek üzere aşağıda isimleri yazılı akademik personelimizin görevlendirilmesi uygundur.

Gereğini bilgilerinize rica ederim.

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Rektör

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Bilgi İçin :Ali Osman KARCI
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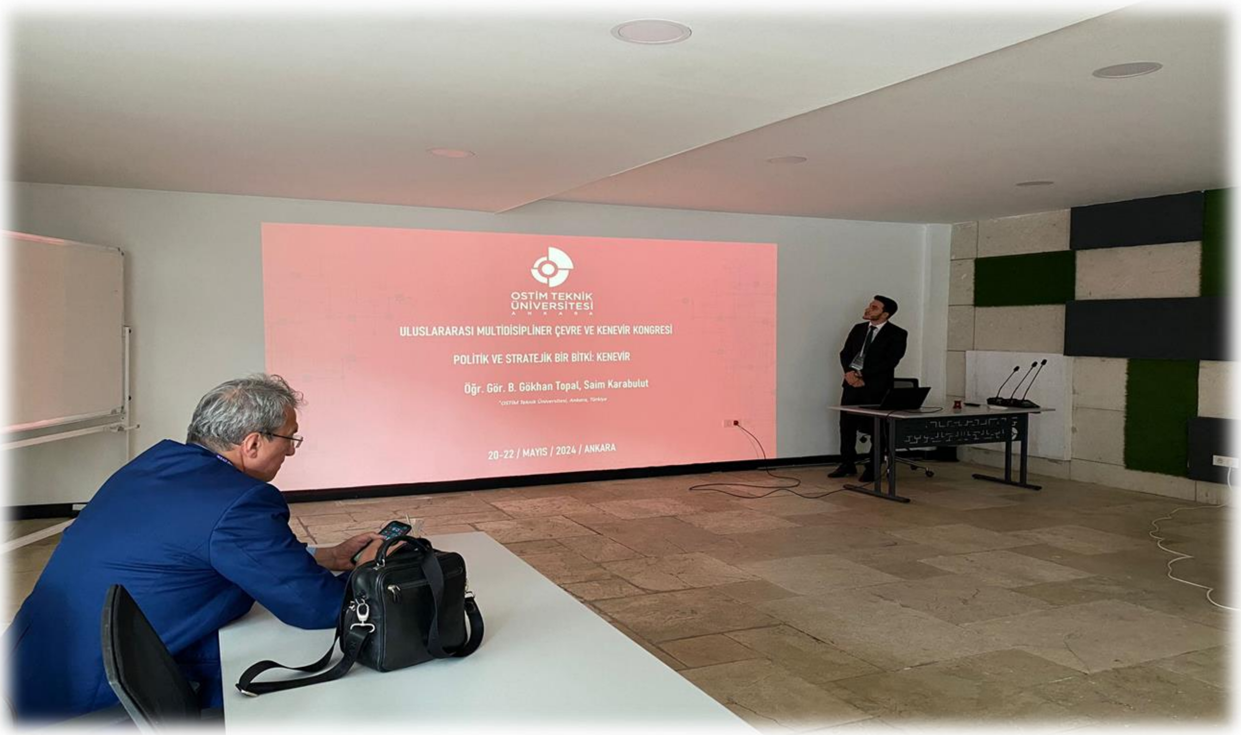

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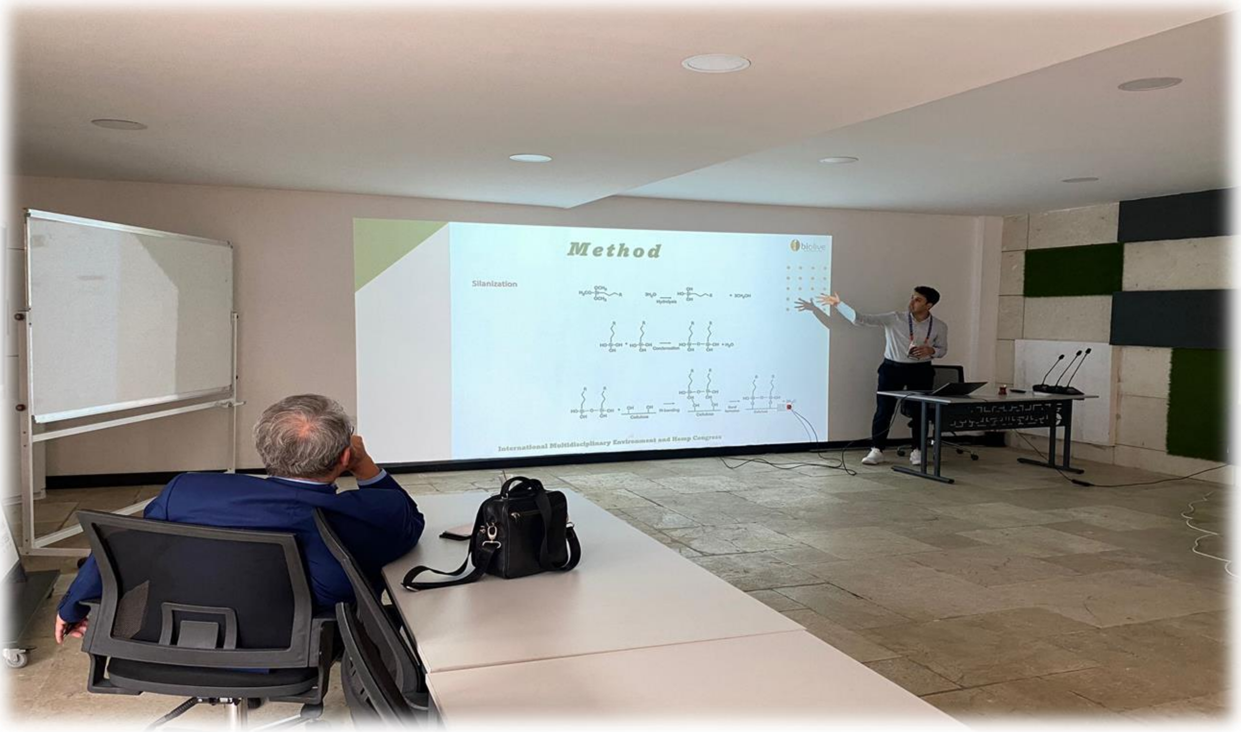

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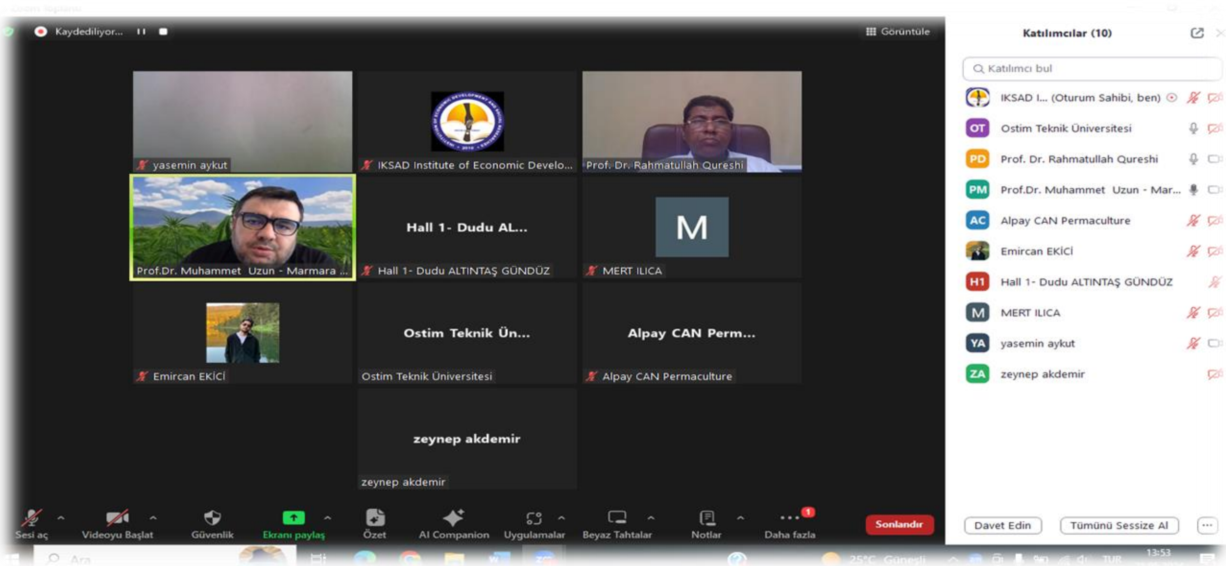

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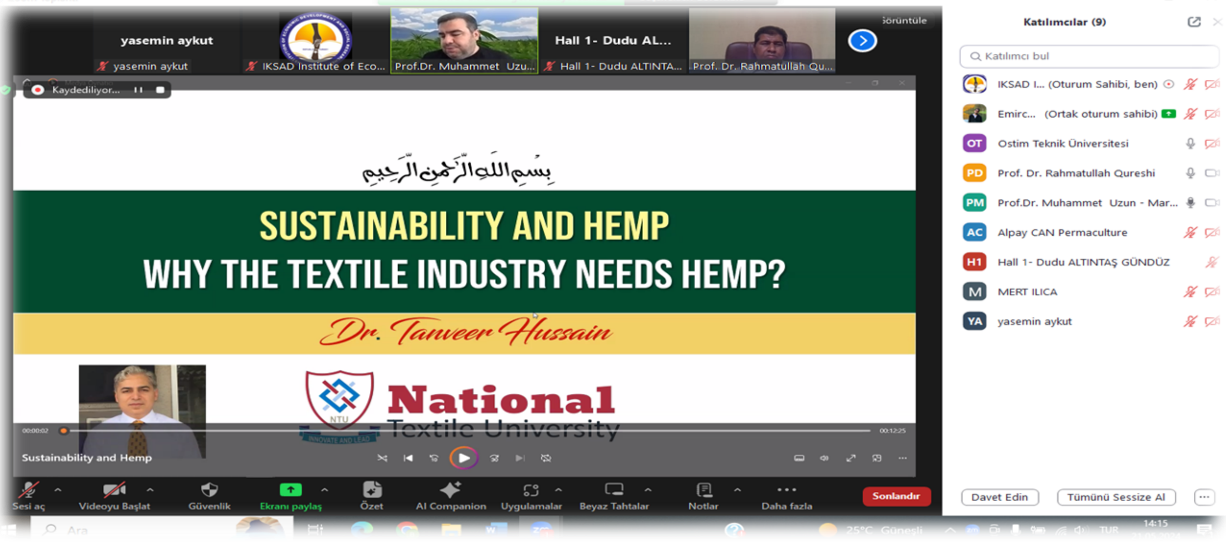

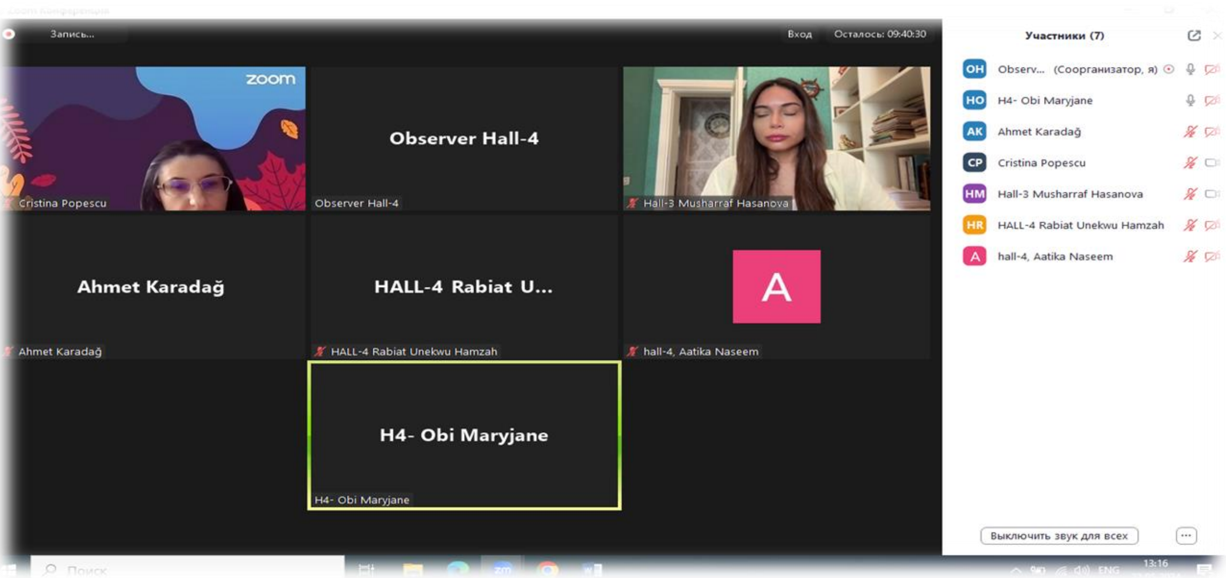

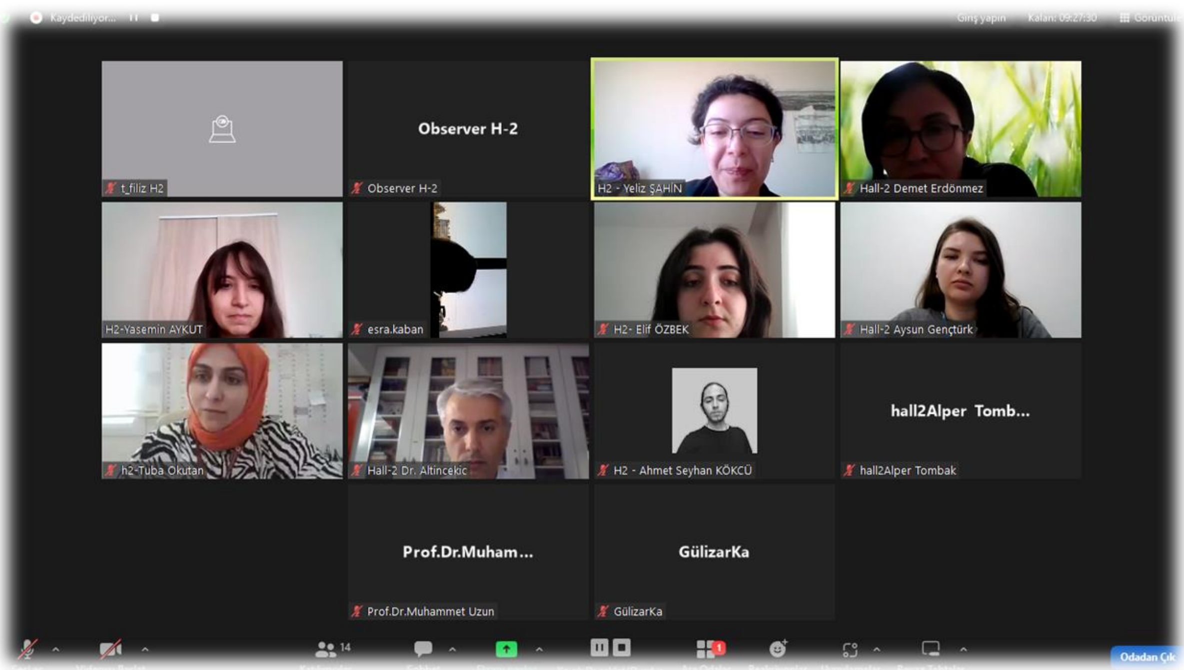

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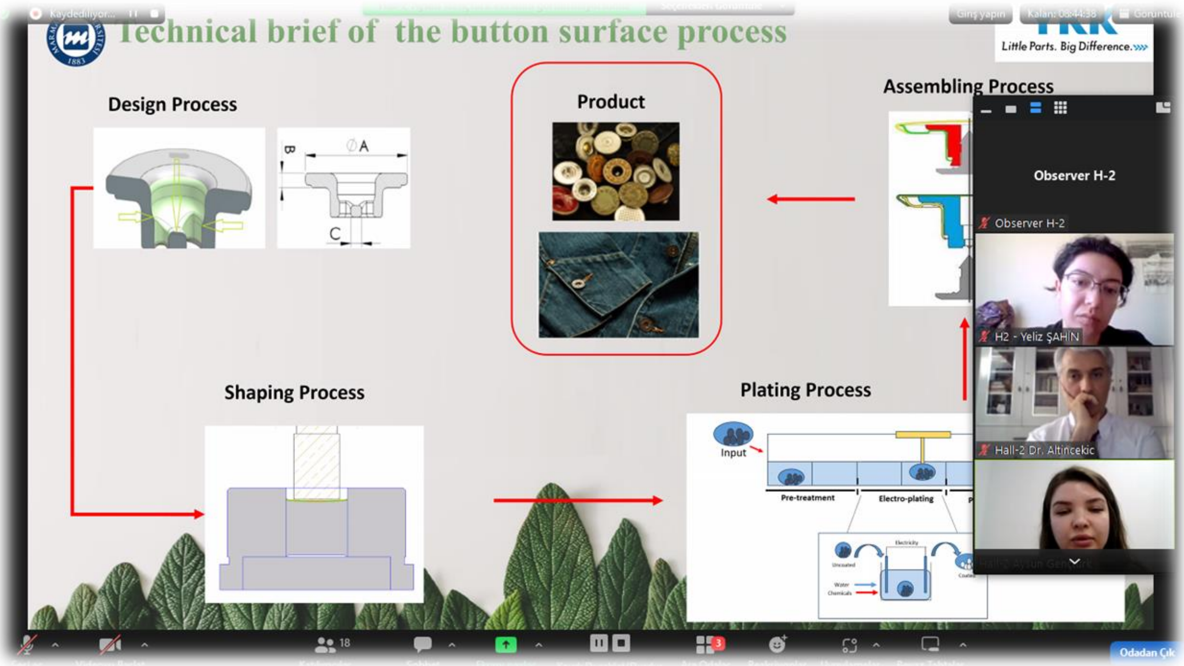

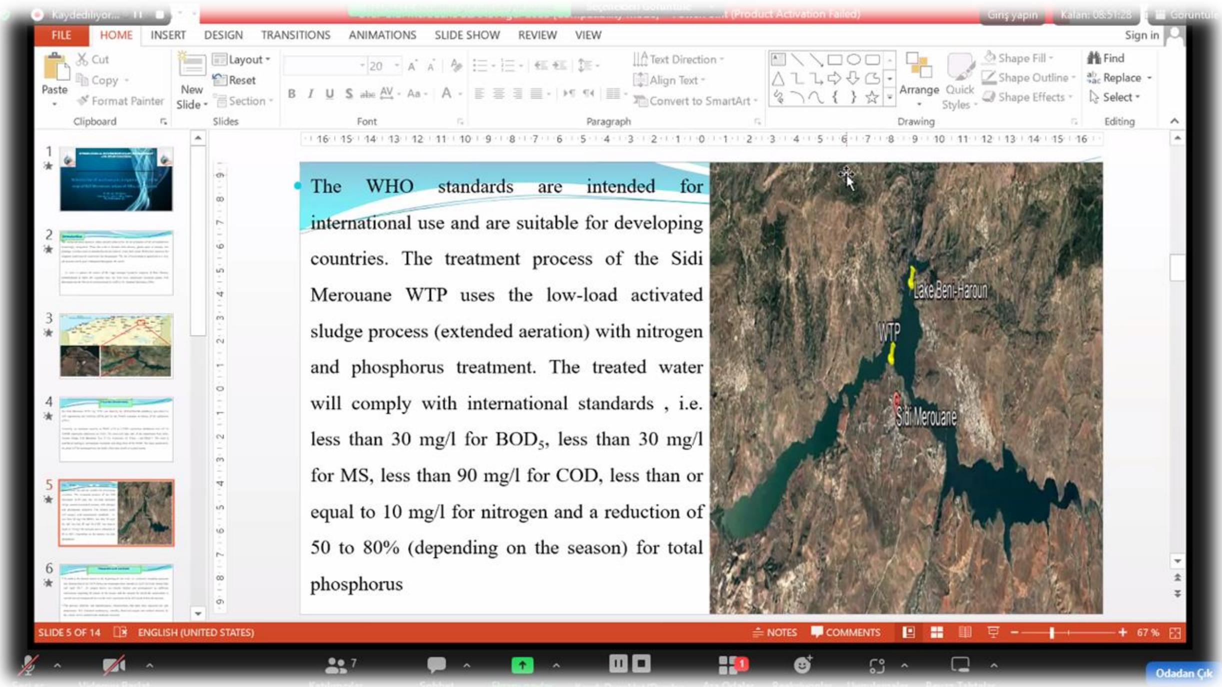

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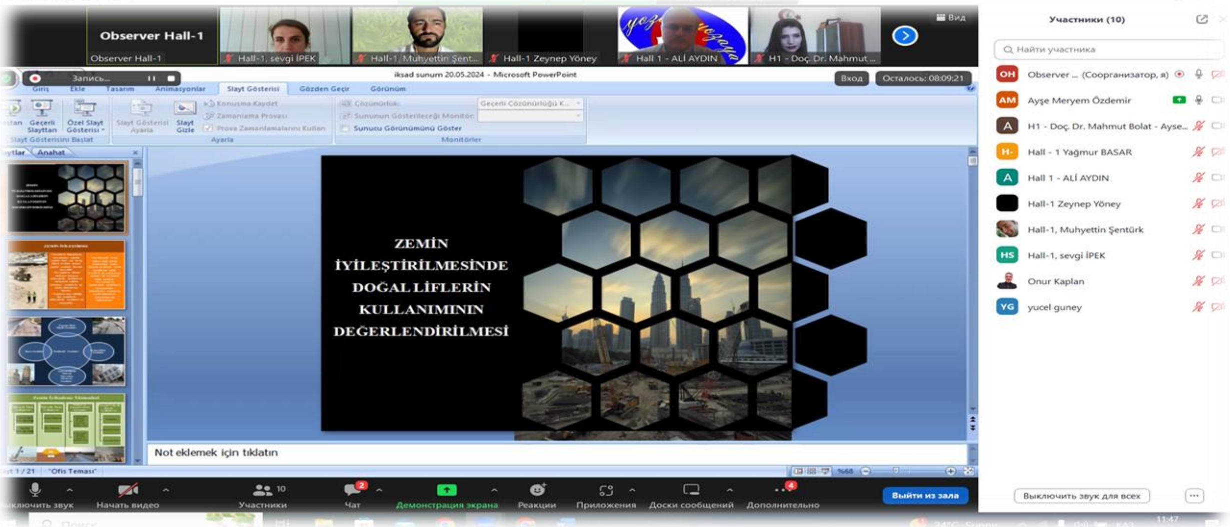

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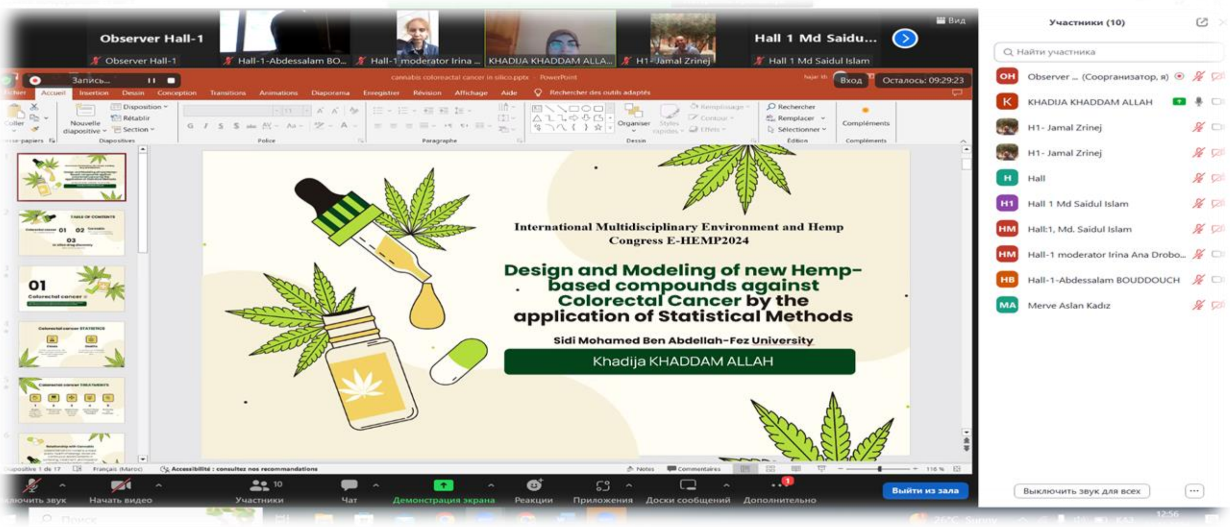

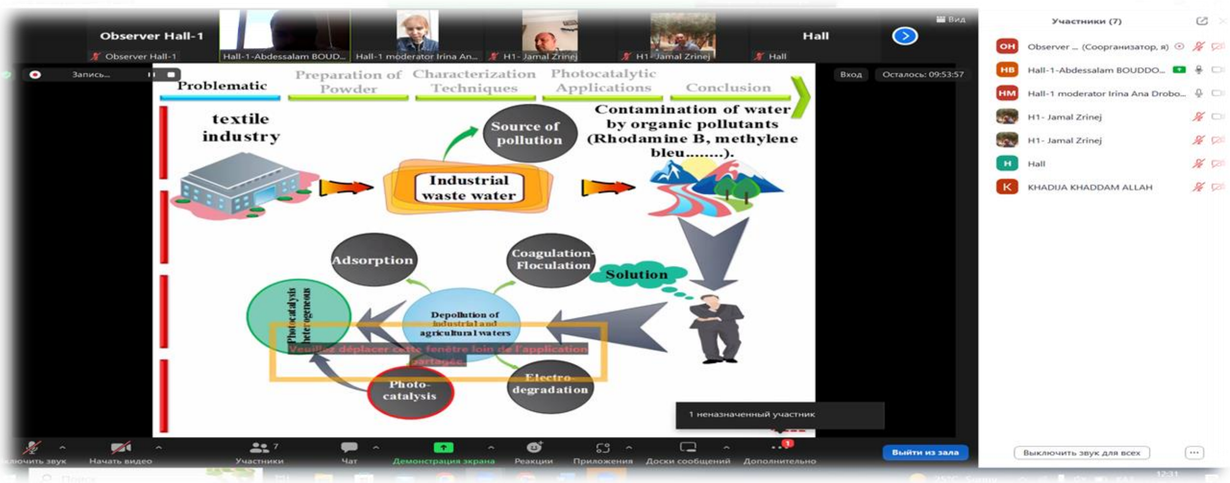

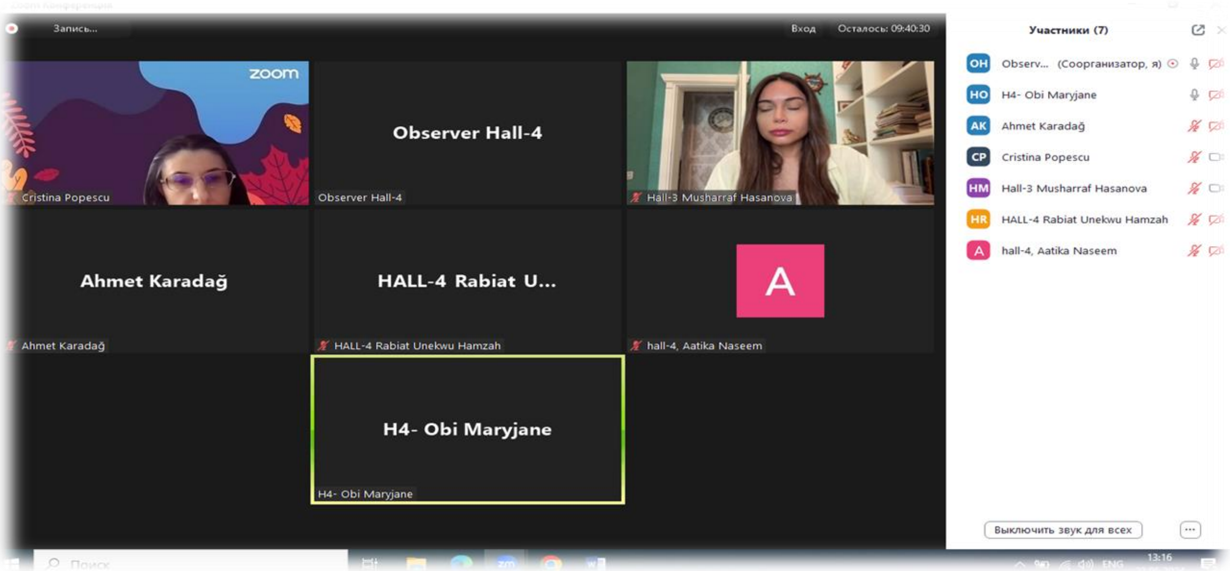

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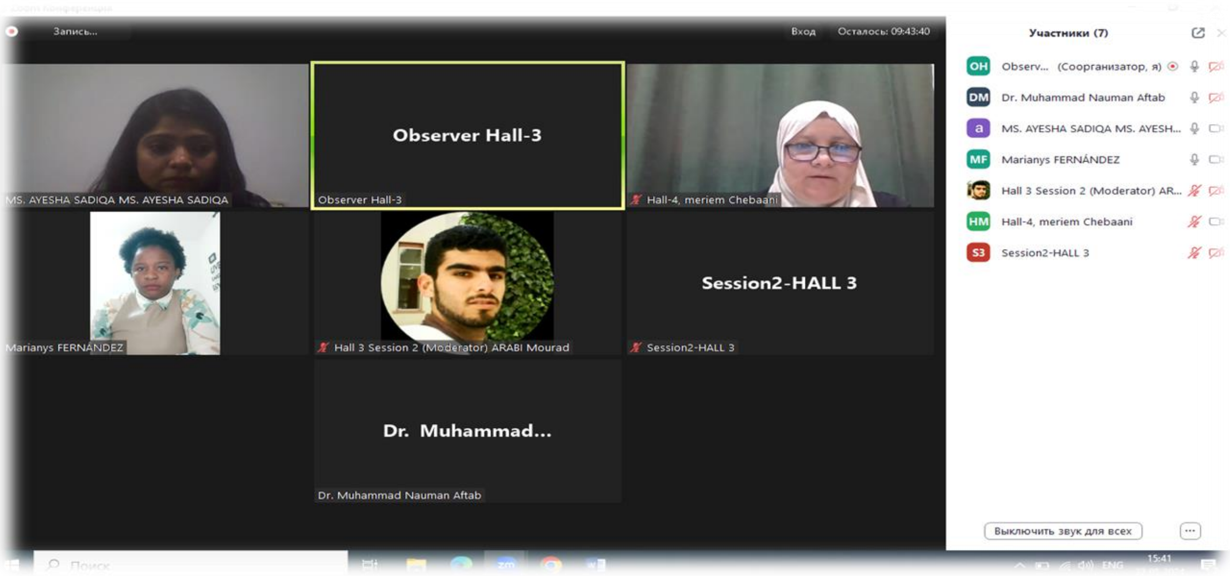

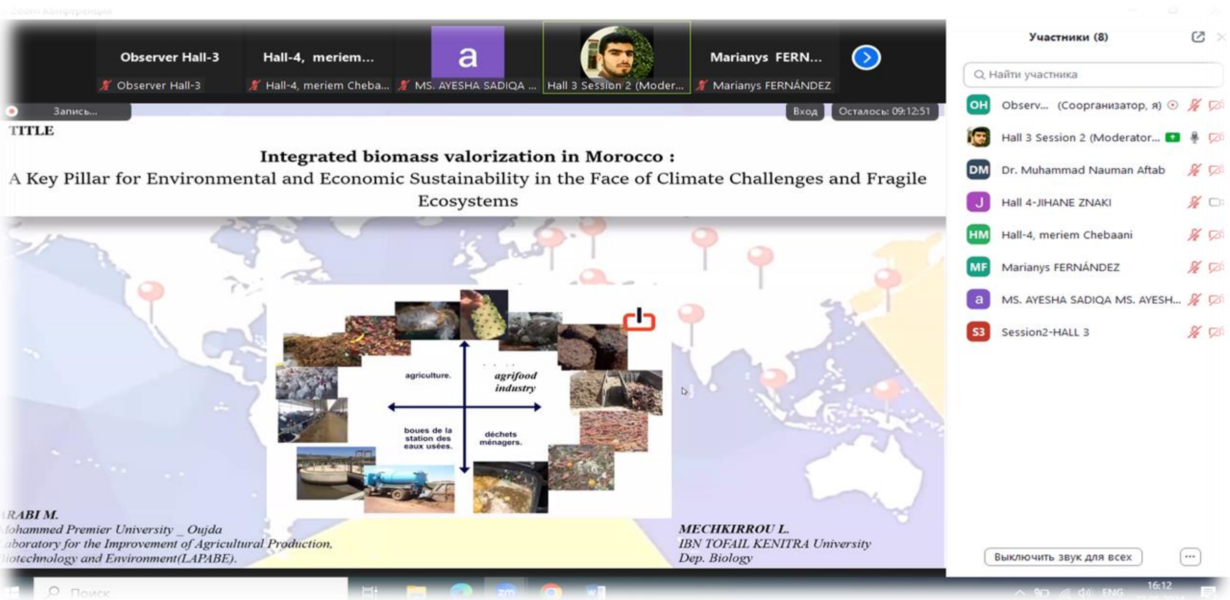

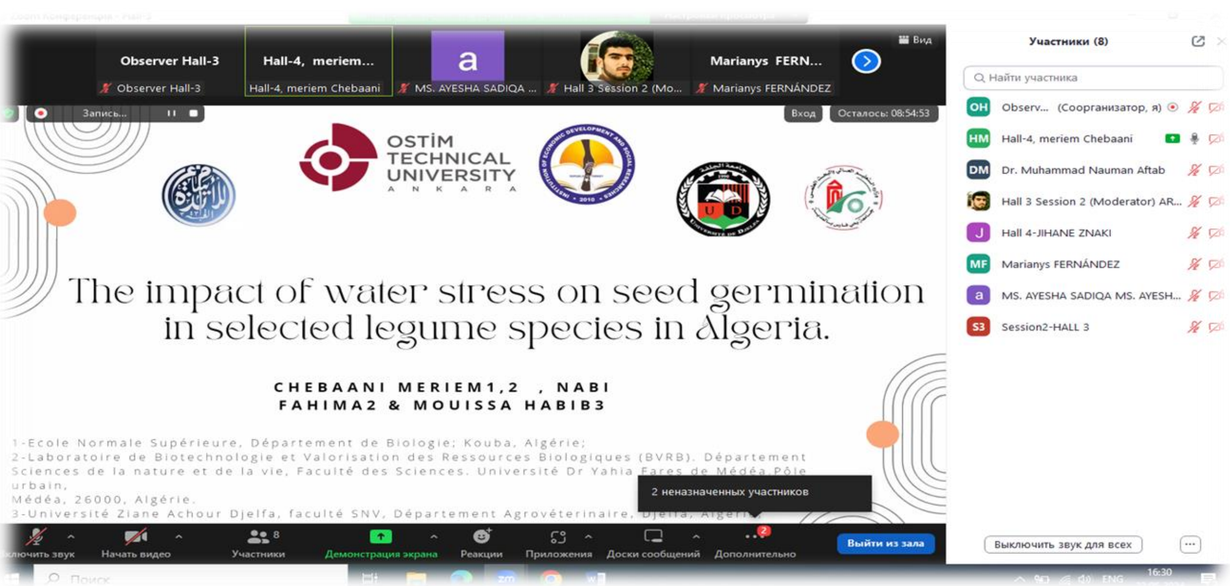

INTERNATIONAL MULTIDISCIPLINARY ENVIRONMENT AND HEMP CONGRESS

May 20-22, 2024
Ankara, Türkiye

CONGRESS PROGRAM

Zoom Meeting ID: 814 6814 3456
Zoom Passcode: 478972

https://us02web.zoom.us/j/81468143456?pwd=dkdEbHJNVVRwMkNMQWUwU0JTTkpZZz09

Participant Countries (14):

TÜRKİYE, PAKISTAN, AZERBAIJAN, ROMANIA, IRAN, NIGERIA, INDIA, SERBIA, ALGERIA, MOROCCO, FRANCE, BANGLADESH, SPAIN, PORTUGAL

ÖNEMLİ, DİKKATLE OKUYUNUZ LÜTFEN / IMPORTANT, PLEASE READ CAREFULLY

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 15 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 özelliğine 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 15 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.

Before you login to Zoom please indicate your name_surname and HALL number,

exp. Hall-1, Merve KIDIRYUZ

OSTİMTECH
KENEVİR
FORUMU

OSTİMTECH KENEVİR FORUMU

20 MAYIS 2024

09.30 - 16.30

3. Kat Konferans Salonu

Kenevir Forumu, Türkiye'de kenevir endüstrisi ve kenevirle ilgili konuları ele alarak, üreticilerden araştırmacılara, işletmecilerden politika yapıcılara kadar geniş bir katılımcı kitlesini bir araya getiriyor.

Program Akışı

09.30- 10.00	**Kayıt ve Açılış**
10.10- 10.50	I. Oturum Anadolu'da Kenevir: Günümüz Türkiye'sinde Kenevir Algısı
10.50- 11.00	Ara
11.00- 11.40	II. Oturum Türkiye'de Kenevir Tarımı: Toprak ve Çevre
12.00- 13.30	Öğle Yemeği
13.30- 14.10	III. Oturum Endüstride Kenevir: Biyokütlenin Sürdürülebilir Malzeme Çeşitliliği ile Ekonomiye Kazandırılması
14.10- 14.20	Ara
14.20- 15.00	IV. Oturum Endüstride Kenevir: Sağlık, Kozmetik ve Gıda Endüstrisi
15.00- 15.10	Ara
15.10- 15.50	V. Oturum Kenevirin Mucizesi: Kannabinoidler

ÖSTİM

OSTİM TEKNİK ÜNİVERSİTESİ
A N K A R A

OSTİM TEKNİK ÜNİVERSİTESİ TEKNOLOJİ TRANSFER OFİSİ

Opening Ceremony

Ostim Technical University
Date: 21.05.2024
Ankara Time: 13:30

MODERATOR

Prof. Dr. Muhammet UZUN
Marmara University (TÜRKİYE)

***

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Prof. Dr. Muhammad Nauman Aftab
Government College University (PAKISTAN)

Prof. Dr. Rahmatullah Qureshi
Pir Mehr Ali Shah Arid Agriculture University (PAKISTAN)

***

21.05.2024

Ankara Local Time: 13^{30}-15^{00}

FACE TO FACE OSTİM TECHNICAL UNIVERSITY
Moderator: Prof. Dr. Yücel GÜNEY

Title	Author(s)	Affiliation
EFFICIENT UTILIZATION OF LIGNOCELLULOSIC HEMP: PRETREATMENT	Lect. Özgenur DİNÇER ŞAHAN Prof. Dr. Ahmet KARADAĞ Attia HAMİD	Yozgat Bozok University TÜRKİYE Government College University PAKISTAN
PRODUCTION PROCESS OF BIOETHANOL AND BIOBUTANOL FROM INDUSTRIAL HEMP	Lect. Özgenur DİNÇER ŞAHAN Prof. Dr. Ahmet KARADAĞ Attia HAMİD	Yozgat Bozok University TÜRKİYE Government College University PAKISTAN
DEVELOPMENT OF THERMAL STABILITY OF HEMP FIBER AND HURD WITH SURFACE MODIFICATION METHODS AND COMPOUNDING WITH ACRYLONITRILE-BUTADIENE-STYRENE COPOLYMER	Anıl KARTAL Duygu YILMAZ Mehmet Emin ÖZ Ahmet Fatih AYAŞ Buse KAYMAZ	İstanbul University Cerrahpaşa TÜRKİYE Biolive Biological ve Chemical Technologies Inc. TÜRKİYE
A POLITICAL AND STRATEGIC PLANT: HEMP	Bahattin Gökhan TOPAL Saim KARABULUT	OSTİM Technical University TÜRKİYE

21.05.2024

Ankara Local Time: 13^{30}-15^{0}

FACE TO FACE OSTİM TECHNICAL UNIVERSITY
Moderator: Ufuk KOCA CALIŞKAN

Title	Author(s)	Affiliation
FROM A NATIONAL PHARMACEUTICAL STRATEGY PERSPECTIVE: MEDICAL CANNABIS	Yavuz Gökalp YILDIZ	Istanbul University TÜRKİYE
THE INHIBITION OF LIPID DROPLET FORMATION BY CANNABINOIDS: A NEW APPROACH IN CANCER THERAPY	Seher ŞAHİN Deniz ATAKOL Özen ÖZENSOY GÜLER Asuman SUNGUROĞLU Mustafa Emre ERCİN Ender ŞİMŞEK	Ankara Yıldırım Beyazıt University TÜRKİYE
INVESTIGATING THE THERAPEUTIC EFFECTS OF CANNABIDIOL ON SPORTS PERFORMANCE AND RECOVERY	Gokhan CALISKAN Ufuk KOCA CALIŞKAN	Igdir University TÜRKİYE Gazi University TÜRKİYE
ECO-FRIENDLY INDUSTRIAL HEMP SUPPORTING THE CIRCULAR ECONOMY	Gülizar Kurtoğlu AKKAYA İbrahim ERDAL	Necmettin Erbakan University TÜRKİYE
THE ROLE OF HEMP-BASED MATERIALS IN BUSINESS STRATEGIES: ENVIRONMENTAL AND ECONOMIC IMPACTS	Nida Nisanur GÖZETLİK Zehra YILDIZ Ayşe Asel BİNER	OSTİM Technical University TÜRKİYE

21.05.2024

Ankara Local Time: 13^{30}-15^{00}

FACE TO FACE OSTİM TECHNICAL UNIVERSITY
Moderator: Prof. Dr. Ahmet KARADAĞ

Title	Author(s)	Affiliation
USE OF HEMP IN EXISTING BRANCHES OF INDUSTRIES IN ORDER TO DEVELOP THE HEMP INDUSTRY, TO COMPENSATE THE LOST TIME AND TO REACH THE HEMP INDUSTRY WHERE IT NEEDS TO BE AS SOON AS POSSIBLE	Fahri AKMANSOY	Independent Researcher İstanbul TÜRKİYE
ENHANCING FABRIC STRUCTURES DERIVED FROM TURKISH HEMP FIBERS WITH ECO-FRIENDLY NATURAL DYE APPLICATIONS	Iraz ÇINAR Başak EROL Melike Oya KADER Bekir BOYACI	Sun Textile Industry and Trade A.S. Torbalı, İzmir TÜRKİYE
INTERACTION OF CHITOSAN MONOMER WITH Ti+2, Al+2, Pb+2 And As+3 Ions: A COMPUTATIONAL STUDY	Uday HACHÜSEYİN Ergün KASAP	Gazi University TÜRKİYE
GREEN SYNTHESIS OF SILVER NANOPARTICLES AND PRODUCTION OF NANOFIBERS BY ELECTROSPINNING AS AA FUNCTIONAL MATERIAL	Çağatay SAĞIR İrem CAN Assoc. Prof. Dr. Fatih ERCİ Prof. Dr. Erdal KOCABAŞ	Necmettin Erbakan University TÜRKİYE

22.05.2024 | HALL-1 | SESSION-1

Ankara Local Time: 10^{00}-12^{00}

Meeting ID: 814 6814 3456 / Passcode: 478972

Moderator: Observer

Title	Author(s)	Affiliation
EXAMINATION OF HEMP-BASED GARMENT FABRICS AS FORENSIC EVIDENCE AND COMPARISON WITH OTHER TYPE FABRIC	Zeynep Yoney Soner Kizil	Uskudar University TURKİYE
TAXONOMY OF CANNABIS	Muhyettin ŞENTÜRK	Mersin University TÜRKİYE
CANNABIDIOL INTERACTS SYNERGISTICALLY WITH CISPLATIN IN VARIOUS BONE CELL LINES	Ali AYDIN Prof. Dr. Ahmet KARADAĞ	Yozgat Bozok University TÜRKİYE
AN INDUSTRIALISATION MOVE IN THE ATATURK ERA: "KENDİR VE KETEN SANAYİ TÜRK ANONİM ŞİRKETİ"	Assoc. Prof. Dr. Mahmut Bolat Aysel Çakan	Kırşehir Ahi Evran University TÜRKİYE
ANALYSIS OF METALS ADSORPTION ON CHITOSAN DIMER BY USING DENSITY FUNCTIONAL THEORY	Sevgi IPEK Ergün KASAP	Gazi University TÜRKİYE
THE OIL CONTENT AND POTENTIAL HEALTH EFFECT OF HEMP OIL	Dudu Altıntaş Gündüz Ufuk KOCA CALIŞKAN	Gazi University TÜRKİYE
EFFECT OF WASTE HEMP FIBER USE ON SOME CEMENTITIOUS SYSTEM PROPERTIES	Yağmur Başar Yahya KAYA Ali MARDANİ	Bursa Uludağ University TÜRKİYE
GEOSYNTHETICS PRODUCED FROM NATURAL FIBERS: PAST TO FUTURE	Eren BAYRAKCI Dr. Eren BALABAN Mehmet İnanç ONUR Yücel GÜNEY	Eskisehir Technical University TÜRKİYE
EFFECTIVE UTILIZATION OF HEMP SEED MEAL (CANNABIS SATIVA) IN POULTRY FEEDS (BROILERS AND LAYING HENS)	Attia HAMİD Özgenur DİNÇER ŞAHAN Prof. Dr. Ahmet KARADAĞ	Government College University PAKISTAN Yozgat Bozok University TÜRKİYE
HEMP-BASED FIBER-REINFORCED POLYMER COMPOSITES IN SEISMIC RETROFITTING OF EXISTING BUILDINGS	Onur KAPLAN	Eskisehir Technical University TÜRKİYE
EVALUATION OF THE USE OF NATURAL FIBERS IN SOIL IMPROVEMENT	Ayşe Meryem ÖZDEMİR Eren BAYRAKCI Yücel GÜNEY	Independent Researcher TÜRKİYE Eskisehir Technical University TÜRKİYE
THE PLACE OF NATURAL COMPOSITE HEMP FIBERS IN THE CONSTRUCTION SECTOR AND ITS IMPORTANCE IN TERMS OF SUSTAINABILITY	Assist. Prof. Dr. Özlem ÖZKAN ÖNÜR Dr. Ethem İLHAN ŞAHİN Assist. Prof. Dr. Mihriban EMEK	Nişantaşı University TÜRKİYE Adana Alparslan Türkeş Science and Technology University TÜRKİYE University of Adıyaman, Gölbaşı Vocational School, TÜRKİYE

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22.05.2024 | HALL-2 | SESSION-1

Ankara Local Time: 10^{00}-12^{00}

Meeting ID: 814 6814 3456 / Passcode: 478972
Moderator: Assist. Prof. Dr. Yeliz ŞAHİN

Title	Author(s)	Affiliation
A DECISION SUPPORT SYSTEM THAT DETECTS CHANGES IN AGRICULTURAL PLANTING AREAS DUE TO CLIMATE CHANGE AND MAKES ECOMMENDATIONS FOR NEW AGRICULTURAL PLANTING AREAS (ADAPT-AG)	Mehmet Emre Ali Cengiz Rüstemli Ahmet Seyhan Kökçü Ferid Baran Hancı Elif Özbek	OSTİM Technical University TÜRKİYE
SYNTHESIS OF ACTIVATED CARBON FROM HEMP STALK	Yasemin Aykut Assoc. Prof. Dr. Ayşe Bayrakçeken	Atatürk University TÜRKİYE
THE ROLE OF HEMP IN ELECTROCHEMICAL STUDIES	Yasemin Aykut Assoc. Prof. Dr. Ayşe Bayrakçeken	Atatürk University TÜRKİYE
EVALUATION THE POTENTIAL OF INDUSTRIAL HEMP (CANNABIS SATIVA L.) AS A FORAGE SOURCE IN RUMINANT NUTRITION	Dr. Erdinç ALTINÇEKİÇ Dr. Ömer ÖZBEK	Central Research Institute of Food and Feed Control, Bursa TÜRKİYE Bati Akdeniz Agricultural Research Institute, Antalya TÜRKİYE
A CASE STUDY ON WET-SPUN HEMP YARN PROPERTIES FOR SUSTAINABLE FASHION APPLICATIONS	Aysun Gençtürk Bahar Aşılıoğlu Türkan Özger Muhammet Uzun	YKK Metal and Plastic Products Industry and Trade Inc. R&D Design Center, Tekirdag TÜRKİYE Marmara University TÜRKİYE
A CLINICAL PHARMACY PERSPECTIVE ON MEDICAL CANNABIS	Assist. Prof. Dr. Yeliz ŞAHİN	Ağrı İbrahim Çeçen University TÜRKİYE
DIFFERENT CYTOKINE CONCENTRATIONS IN CANNABIS INDICA LAM. EFFECT ON CANNABIDIOL (CBD) VALUES IN CALLUS CULTURES	Lect. Tuba OKUTAN Prof. Dr. Ökkeş YILMAZ Assoc. Dr. Aykut TOPDEMIR	Fırat University TÜRKİYE
POTENTIAL EFFECT OF Cannabis sativa L. FOR THE TREATMENT OF DENTAL AND ORAL DISEASE	Demet Erdonmez Ufuk Koca Çalışkan	Düzce University TÜRKİYE
EMERGING VALUE CREATION AT OSTIM INDUSTRIAL ZONE; THE ECONOMIC IMPORTANCE AND STRATEGIC ROLE OF 'INDUSTRIAL AND INSTITUTIONAL GREEN CAMPUSES IN PRACTICE'	Assist. Prof. Dr. Zeliha ŞAHİN ÇAĞLI	OSTİM Technical University TÜRKİYE

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22.05.2024 | HALL-3 | SESSION-1

Ankara Local Time: 10^{00}-12^{00}

Meeting ID: 814 6814 3456 / Passcode: 478972

Moderator: Full-Professor PhD. Habil. Cristina Raluca Gh. Popescu

Title	Author(s)	Affiliation
LOW COST BIOETHANOL PRODUCTION FROM VARIOUS PLANT BIOMASS INCLUDING HEMP BY NANO-COUPLED RECOMBINANT Β-GLUCOSIDASE FROM CLOSTRIDIUM CLARIFLAVUM	Muhammad Nauman Aftab	Government College Universit PAKISTAN
HEMP–A KEY ELEMENT OF ANCIENT RELIGIOUS RITUALS	Musharraf HASANOVA	ANAS Institute of History and Ethnology named after A. A. Bakikhanov AZERBAIJAN
INDUSTRIAL HEMP AGRONOMY AND FIBRE VALUE CHAIN IN PAKISTAN: CURRENT PROGRESS, CHALLENGES, AND PROSPECTS	Dr. Saddam Hussain	Dr. Saddam Hussain
EXTENSIVE POWER OF COMMON AGRICULTURAL POLICY AND HEMP PRODUCTION IN EUROPEAN UNION: CASE OF FRANCE AND MAKING A CONTRIBUTION TO THE EUROPEAN GREEN DEAL OBJECTIVES	Full-Professor PhD. Habil. Cristina Raluca Gh. Popescu	Bucharest University ROMANIA
THE HEALTH-ENVIRONMENT NEXUS: TACKLING VITAL HEMP POLICIES, ADDRESSING CUTTING-EDGE RESEARCH FOR SUSTAINABLE DEVELOPMENT, AND MANAGING DECISIVE HUMAN RIGHTS	Full-Professor PhD. Habil. Cristina Raluca Gh. Popescu Emeritus Full-Professor PhD. Gheorghe N. Popescu	Bucharest University ROMANIA
SALT STRESS AFFECTED SEEDLING ESTABLISHMENT AND FORAGE PRODUCTION OF SOME HALO-FORAGE SPECIES	M.H. Banakar M.J. Babaei-Zarch Amir Parnian	National Salinity Research Center, Agricultural Research, Education and Extension Organization IRAN
INFERENCE ON SOME ENVIRONMENTAL FACTORS ON ANNUAL RAINFALL IN NIGERIA	David, I. J. Mathew, S. Ikwuoche, P. O.	Kwararafa University NIGERIA

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22.05.2024 | HALL-4 | SESSION-1

Ankara Local Time: 10^{00}-12^{00}

Meeting ID: 814 6814 3456 / Passcode: 478972
Moderator: Obi, Maryjane A.

Title	Author(s)	Affiliation
EXPLORING STRUCTURAL, ELECTRONIC, AND OPTICAL PROPERTIES OF LEAD-FREE PEROVSKITE CH3NH3SNBR3 UNDER COMPRESSIVE STRAIN	Khalid Said Souad Elkhattabi	Sidi Mohamed Ben Abdellah-Fez University MOROCCO
SYNERGISTIC EFFECT OF GARLIC EXTRACT AND FOLIAR APPLICATION OF ASCORBIC ACID ON THE GROWTH OF OKRA (ABELMOSCHUS ESCULENTUS L.) UNDER DROUGHT STRESS	Aatika Naseem Dr. Sammina MAHMOOD Rabiya Izhar	University of Education PAKISTAN
AGROECOLOGICAL CONDITIONS FOR OPTIMAL CULTIVATION OF INDUSTRIAL HEMP (Cannabis sativa L.) IN THE TERRITORY OF THE REPUBLIC OF SERBIA	Radmila Pivić Vladan Ugrenović Aleksandra Stanojković-Sebić	Institute of Soil Science SERBIA
EVALUATING THE SENSORY ATTRIBUTES AND CONSUMER ACCEPTANCE OF COCOA-TIGERNUT-DATE BEVERAGE POWDER BLENDS COMPARED TO A COMMERCIAL COCOA POWDER PRODUCT (MILO)	Obi, Maryjane A.	Obi, Maryjane A.
THE EFFECT OF DIFFERENT AMOUNTS OF PALM LEAF ASH ON INDICATORS RELATED TO GERMINATION OF WHEAT	Mohammad Javad Babaie-Zarch Mohammad Hossein Banakar Amir Parnian	National Salinity Research Center, Agricultural Research IRAN
PHYTOCHEMICAL CONSTITUENTS AND EFFECTS OF METHANOL EXTRACT OF CALOTROPIS PROCERA FLOWER ON HEMATOLOGICAL PARAMETERS IN ALLOXAN-INDUCED DIABETES IN WISTAR RATS	HAMZAH R. U. BUSARI M. B. YUSUF R. S. NWOYE G. N. IGHO O.	Federal University NIGERIA Federal University NIGERIA Bauchi State University NIGERIA Federal University NIGERIA Federal University NIGERIA
THE IMPORTANCE OF HEMP AND CORK IN INNOVATIVE MATERIALS IN THE FIELD OF CIVIL ENGINEERING: ADDRESSING THE ISSUE OF DEPLETION AND PROPOSING SOLUTIONS THROUGH REPLACEMENT WITH PNEUMATIC WASTE OR RUBBER WASTE	Abdelmoutalib BENFRID Mohamed BACHIR BOUIADJRA	ATRST University ALGERIA

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22.05.2024 | HALL-1 | SESSION-2

Ankara Local Time: 12^{30}-14^{30}

Meeting ID: 814 6814 3456 / Passcode: 478972

Moderator: Lect. PhD Irina-Ana DROBOT

Title	Author(s)	Affiliation
DEVELOPMENT OF PHOSPHATE-BASED PHOTOCATALYSTS FOR THE DEGRADATION OF ORGANIC POLLUTANTS IN WASTEWATER	Abdessalam BOUDDOUCH Brahim AKHSASSI Bahcine BAKIZ Frédéric GUINNETON Sylvie VILLAIN Jean-Raymond GAVARRI Abdeljalil BENLHACHEMI	Chouaïb Doukkali University MOROCCO Ibn Zohr University MOROCCO Ibn Zohr University MOROCCO Toulon University FRANCE Toulon University FRANCE Toulon University FRANCE Ibn Zohr University MOROCCO
STUDY OF THE CHEMICAL INHIBITION OF SCALING PHENOMENON IN TREATED WASTEWATER PIPES	Mustapha Nassiri Sara Darbal Ilham Karmal Mohamed El house Said ben-aazza M'barek belattar Abdallah Hadfi Ali Driouiche	Ibn Zohr University MOROCCO
IN SILICO INVESTIGATION ON THE BENEFICIAL EFFECTS OF THE PLANT PLUMBAGO ZEYLANICA AGAINST PROSTATE CANCER: MOLECULAR DOCKING, MOLECULAR DYNAMICS SIMULATION, AND ADMET STUDIES	Jamal Zrinej Ouabane Mohamed Larbi El Mchichi Abdelhamid Qara Chakib Sekkate Tahar Lakhlifi Mohammed Bouachrine	Moulay Ismail University MOROCCO
DESIGN AND MODELING OF NEW HEMP-BASED COMPOUNDS AGAINST COLORECTAL CANCER BY THE APPLICATION OF STATISTICAL METHODS	Khadija KHADDAM ALLAH Rachid HALOUI Amine BALLARI Mustapha ERREBBANE Abdelmoula EL ABBOUCHI Samir CHTITA Souad EL KHATTABI	Sidi Mohamed Ben Abdellah-Fez University MOROCCO Sidi Mohamed Ben Abdellah-Fez University MOROCCO
PROMOTION OF CONCERN FOR THE ENVIRONMENT	Lect. PhD Irina-Ana DROBOT	Technical University of Civil Engineering Bucharest ROMANIA
IMPACT OF VARIETIES ON GROWTH AND YIELD OF TOMATO THROUGH THE MANAGEMENT OF ORGANIC MANURE	Mosa. Murshida Khatun Md. Abdul Baree Md. Saidul Islam Md. Abdul Kaium Md. Sharif Ahmed	Rajshahi University BANGLADESH
GREEN ARCHITECTURE: DESIGNING ZERO-CARBON BUILDINGS FOR ENHANCED PUBLIC HEALTH	Melik Sami Khelil Sara Tallal Abdel Karim Bouzir	Mohamed Khider Biskra University ALGERIA Blida University ALGERIA

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22.05.2024 | HALL-2 | SESSION-2

Ankara Local Time: 12^{30}-14^{30}

Meeting ID: 814 6814 3456 / Passcode: 478972
Moderator: Assist. Prof. Dr. V.S. Angulakshmi

Title	Author(s)	Affiliation
VALORIZATION OF USED WATER IN IRRIGATION, CASE OF THE STEP OF SIDI MEROUANE, WILAYA OF MILA, EAST ALGERIA	Belalite Halima Athamena Ali	Mila University Centre ALGERIA Batna 2 University ALGERIA
WATER AND SUSTAINABLE DEVELOPMENT A COMBINED RELATIONSHIP. IMPACT OF THE MOBILIZATION OF SURFACE WATER RESOURCES IN SEMI-ARID AREAS: CASE OF THE FOUM TOUB REGION, NORTHEAST OF ALGERIA	ATHAMENA Ali BELALITE Halima GAAGAI Aissam AOUISSI Hani Amir	Batna 2 University ALGERIA Mila University Centre ALGERIA CRSTRA University ALGERIA CRE Annaba University ALGERIA
SYNTHESIS OF COPPER NANOPARTICLES FROM BIODEGRADABLE WASTE	Assist. Prof. Dr. V.S. Angulakshmi Assoc. Prof. Dr. S. Kalaiselvan	PSGR Krishnammal Colllege for Women INDIA M. Kumarasamy College of Engineering INDIA
IN VITRO A-AMYLASE AND HEMOGLOBIN GLYCATION INHIBITORY POTENTIAL OF NIGELLA SATIVA ESSENTIAL OIL, AND MOLECULAR DOCKING STUDIES OF ITS PRINCIPAL COMPONENTS	Prof. Mohammed Dalli Prof. Nour Elhouda Daoudi Prof. Salah-eddine Azizi Prof. Ilyass Alami Merrouni Dr. Mohammed Roubi Prof. Nadia Gseyra	Higher Institute of Nursing Professions and Health Techniques MOROCCO Mohammed First University MOROCCO
BIO-PLASTIC ADOPTION: THE INTERPLAY OF ALTRUISM, INNOVATIVENESS, AND ENVIRONMENTAL MOTIVATION AMONG YOUNG CONSUMERS	Muhammad Imran Musarrat Parveen	University of Veterinary and Animal Sciences PAKISTAN
RECYCLING OF WASTE COMPOSITE MATERIALS FOR USE AS FILLER IN GLASS-POLYESTER COMPOSITES FOR NAVAL USE	Moncef BRINIS Younès MENAIL Djaber BOUHAFARA Farouk MESRAFET	Badji Mokhtar Annaba University ALGERIA Badji Mokhtar Annaba University ALGERIA Annaba Graduate School of Industrial Technologies Plaine Ouest ALGERIA Badji Mokhtar Annaba University ALGERIA

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22.05.2024 | HALL-3 | SESSION-2

Ankara Local Time: 12^{30}-14^{30}

Meeting ID: 814 6814 3456 / Passcode: 478972

Moderator: Mourad ARABI

Title	Author(s)	Affiliation
FABRICATION OF HYDROGELS USING COMMIPHORA WIGHTII RESIN, EVALUATION OF THEIR MICROBIAL AND HEMOLYTIC PROPERTIES	Ayesha Sadiqa Noreen Sajjad	Lahore University PAKISTAN
SNAIL SHELL CARBON ADSORPTIVITY IN HEAVY METAL DIMINUTION FROM INDUSTRIAL PAINT WASTEWATER	Adedipe, J.O Aderemi, A.M	Federal College of Forestry NIGERIA
PRESERVING INDIGENOUS CATTLE: SAFEGUARDING BIODIVERSITY AND ENHANCING FOOD SECURITY	Madalina Alexandra DAVIDESCU Claudia PANZARU Bogdan Iosif DOBOS Bianca Maria MADESCU Daniel SIMEANU Cristina SIMEANU Alexandru USTUROI	"Ion Ionescu de la Brad" University of Life Sciences ROMANIA Gheorghe Asachi Technical University of Iaşi ROMANIA
EVALUATION OF ANALGESIC ACTIVITY OF METHANOLIC EXTRACT OF TRICHODESMA AFRICANUM PLANT IN MICE	Aliyu Ahmad Firdausi Yusuf Nasiru Salihu Sadiq Bashir Babuga Zulaihat Lawan Muhammad Nuhu	Aliko Dangote University of Science and Technology NIGERIA Kaduna State University NIGERIA Dutse Medical Science Federal University NIGERIA Sheikh Isyaka Rabiu University NIGERIA Bayero University NIGARIA
INVESTIGATION OF THERAPEUTIC POTENTIAL OF METHANOL EXTRACT OF EUCALYPTUS GLOBULUS LEAF IN MITIGATING ETHANOL-INDUCED INFERTILITY IN ALBINO RATS	Obiora Celestine Ugwu Chidimma Lilian Asadu Ugochinyere Florence Amadi Chukwuebuka Kingsley Nwokedi Uchenna Emmanuel Obasi	Enugu State University NIGERIA
OPTIMIZING THE CIRCULAR BIOECONOMY: INNOVATIVE UTILIZATION OF FOOD RESIDUES AS HIGH-QUALITY LIVESTOCK FEED	Mourad ARABI Latifa MECHKIRROU Mohammed Ouhssine	Mohamed Premier University MOROCCO Ibn Tofail University MOROCCO
VALORIZATION OF USED WATER IN IRRIGATION, CASE OF THE STEP OF SIDI MEROUANE, WILAYA OF MILA, EAST ALGERIA	Belalite Halima Athamena Ali	Mila Center University ALGERIA Batna 2 University ALGERIA

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22.05.2024 | HALL-4 | SESSION-2

Ankara Local Time: 12^{30}-14^{30}

Meeting ID: 814 6814 3456 / Passcode: 478972

Moderator: Abubakar Muhammad Sani

Title	Author(s)	Affiliation
THE IMPACT OF WATER STRESS ON SEED GERMINATION IN SELECTED LEGUME SPECIES IN ALGERIA	Chebaanı Meriem Nabı Fahıma Mouıssa Habıb	Département De Science Naturelle Ecole Normale Supérieure Kouba ALGERIA Science De La Nature Et De La Vie University ALGERIA Djelfa University ALGERIA
ANTIBIOTIC SENSITIVITY PROFILE OF COLIFORM ISOLATED FROM DIFFERENT WATER SOURCES IN ALIERO METROPOLIS, KEBBI STATE, NIGERIA	Abubakar Muhammad Sani Salmanu Shu, aibu	Kebbi State University NIGERIA
TRANSITION TO A SUSTAINABLE ECONOMY: A SCOPING REVIEW OF LITERATURE FOCUSED ON SUSTAINABLE GASTRONOMY	Marianys FERNÁNDEZ Prof. Nuno BAPTISTA Prof. Mário ANTÃO	Sevilla University SPAIN Polytechnic Institute of Lisbon PORTUGAL Lusíada University PORTUGAL
EXAMINING TWO BISKRA PLANTS FROM THE SAHARA TO DETERMINE WHETHER THEIR PHENOLIC COMPONENTS HAVE ANY POTENTIAL INSECTICIDAL	Djellouli Amir Berredjem Yamina Hattab Zhour Guesmia Hadjer Mehenni Mokthar Barbari Fateh	Mohammed Chérif Mesaadia University ALGERIA Badji Mokhtar-Annaba University ALGERIA CRSTRA University ALGERIA
TREATMENT OF TWO DYES: CRYSTAL VIOLET AND CONGO RED CONTAINED IN WASTEWATER USING THE ELECTROCOAGULATION/ELECTRO-FLOCCULATION TECHNIQUE	ALI Hamada Asmaa Benbiyi Mohamed El Guendouzi	Hassan II University of Casablanca MOROCCO
PURSUIT OF CLEAN ENERGY: PEROVSKITE-BASED SOLAR CELLS	Jihane ZNAKI Fatima Zahra ZNAKI Khalid SAID Mohamed ADADI Hassan MOUSTABCHIR Samir CHTITA Souad ELKHATTABI	Sidi Mohamed Ben Abdallah University MOROCCO Hassan II University of Casablanca MOROCCO
UNDERSTANDING THE CHALLENGES OF LEAD-BASED PEROVSKITE SOLAR CELLS AND PROSPECTS FOR SUSTAINABLE ALTERNATIVES	Fatima Zahra ZNAKI Jihane ZNAKI Khalid. SAID Mohamed ADADI Hassan MOUSTABCHIR Adil TOUIMI BENJELLOUN Souad ELKHATTABI	Sidi Mohamed Ben Abdallah University MOROCCO

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CONTENTS

AUTHOR	TITLE	No
Özlem ÖZKAN ÖNÜR Ethem İLHAN ŞAHİN Mihriban EMEK	THE PLACE OF NATURAL COMPOSITE HEMP FIBERS IN THE CONSTRUCTION SECTOR AND ITS IMPORTANCE IN TERMS OF SUSTAINABILITY	1
V. S. Angulakshmi S. Kalaiselvan	SYNTHESIS OF COPPER NANOPARTICLES FROM BIODEGRADABLE WASTE	10
Anıl KARTAL Duygu YILMAZ Mehmet Emin ÖZ Ahmet Fatih AYAŞ Buse KAYMAZ	DEVELOPMENT OF THERMAL STABILITY OF HEMP FIBER AND HURD WITH SURFACE MODIFICATION METHODS AND COMPOUNDING WITH ACRYLONITRILE-BUTADIENE-STYRENE COPOLYMER	11
Madalina Alexandra DAVIDESCU Claudia PANZARU Bogdan Iosif DOBOS Bianca Maria MADESCU Daniel SIMEANU Cristina SIMEANU Alexandru USTUROI	PRESERVING INDIGENOUS CATTLE: SAFEGUARDING BIODIVERSITY AND ENHANCING FOOD SECURITY	19
Bahattin Gökhan TOPAL Saim KARABULUT	A POLITICAL AND STRATEGIC PLANT: HEMP	22
Muhammad Nauman Aftab	LOW COST BIOETHANOL PRODUCTION FROM VARIOUS PLANT BIOMASS INCLUDING HEMP BY NANO-COUPLED RECOMBINANT Β-GLUCOSIDASE FROM *CLOSTRIDIUM CLARIFLAVUM*	24
Iraz ÇİNAR Başak EROL Melike Oya KADER Bekir BOYACI	ENHANCING FABRIC STRUCTURES DERIVED FROM TURKISH HEMP FIBERS WITH ECO-FRIENDLY NATURAL DYE APPLICATIONS	25
ALI Hamada Asmaa benbiyi Mohamed El Guendouzi	TREATMENT OF TWO DYES: CRYSTAL VIOLET AND CONGO RED CONTAINED IN WASTEWATER USING THE ELECTROCOAGULATION/ELECTRO-FLOCCULATION TECHNIQUE	27
Jihane ZNAKI Fatima Zahra ZNAKI Khalid SAID Mohamed ADADI Hassan MOUSTABCHIR Samir CHTITA Souad ELKHATTABI	PURSUIT OF CLEAN ENERGY: PEROVSKITE-BASED SOLAR CELLS	28
Moncef BRINIS Younès MENAIL Djaber BOUHAFARA Farouk MESRAFET	RECYCLING OF WASTE COMPOSITE MATERIALS FOR USE AS FILLER IN GLASS-POLYESTER COMPOSITES FOR NAVAL USE	30

Djellouli Amir Berredjem Yamina Hattab Zhour Guesmia Hadjer Mehenni mokthar Barbari Fateh	EXAMINING TWO BISKRA PLANTS FROM THE SAHARA TO DETERMINE WHETHER THEIR PHENOLIC COMPONENTS HAVE ANY POTENTIAL INSECTICIDAL	31
Mohammed Dalli Nour Elhouda Daoudi Salah-eddine Azizi Ilyass Alami Merrouni Mohammed Roubi Nadia Gseyra	IN VITRO A-AMYLASE AND HEMOGLOBIN GLYCATION INHIBITORY POTENTIAL OF NIGELLA SATIVA ESSENTIAL OIL, AND MOLECULAR DOCKING STUDIES OF ITS PRINCIPAL COMPONENTS	32
Khadija KHADDAM ALLAH Rachid HALOUI Amine BALLARI Mustapha ERREBBANE Abdelmoula EL ABBOUCHI Samir CHTITA Souad EL KHATTABI	DESIGN AND MODELING OF NEW HEMP-BASED COMPOUNDS AGAINST COLORECTAL CANCER BY THE APPLICATION OF STATISTICAL METHODS	33
Obiora Celestine Ugwu Chidimma Lilian Asadu Ugochinyere Florence Amadi Chukwuebuka Kingsley Nwokedi Uchenna Emmanuel Obasi	INVESTIGATION OF THERAPEUTIC POTENTIAL OF METHANOL EXTRACT OF *EUCALYPTUS GLOBULUS* LEAF IN MITIGATING ETHANOL-INDUCED INFERTILITY IN ALBINO RATS	35
Nida Nisanur GÖZETLİK Zehra YILDIZ Ayşe Asel BİNER	THE ROLE OF HEMP-BASED MATERIALS IN BUSINESS STRATEGIES: ENVIRONMENTAL AND ECONOMIC IMPACTS	36
Mehmet Emre Ali Cengiz Rüstemli Ahmet Seyhan Kökçü Ferid Baran Hancı Elif Özbek	A DECISION SUPPORT SYSTEM THAT DETECTS CHANGES IN AGRICULTURAL PLANTING AREAS DUE TO CLIMATE CHANGE AND MAKES RECOMMENDATIONS FOR NEW AGRICULTURAL PLANTING AREAS (ADAPT-AG)	37
Fatima Zahra ZNAKI Jihane ZNAKI Khalid. SAID Mohamed ADADI Hassan MOUSTABCHIR Adil TOUIMI BENJELLOUN	UNDERSTANDING THE CHALLENGES OF LEAD-BASED PEROVSKITE SOLAR CELLS AND PROSPECTS FOR SUSTAINABLE ALTERNATIVES	38
Radmila Pivić Vladan Ugrenović Aleksandra Stanojković-Sebić	AGROECOLOGICAL CONDITIONS FOR OPTIMAL CULTIVATION OF INDUSTRIAL HEMP (*Cannabis sativa* L.) IN THE TERRITORY OF THE REPUBLIC OF SERBIA	40
Ali AYDIN Ahmet KARADAĞ	CANNABIDIOL INTERACTS SYNERGISTICALLY WITH CISPLATIN IN VARIOUS BONE CELL LINES	41
ATHAMENA Ali BELALITE Halima GAAGAI Aissam AOUISSI Hani Amir	WATER AND SUSTAINABLE DEVELOPMENT A COMBINED RELATIONSHIP. IMPACT OF THE MOBILIZATION OF SURFACE WATER RESOURCES IN SEMI-ARID AREAS: CASE OF THE FOUM TOUB REGION, NORTHEAST OF ALGERIA	51

Ayesha Sadiqa Noreen Sajjad	FABRICATION OF HYDROGELS USING *COMMIPHORA WIGHTII* RESIN, EVALUATION OF THEIR MICROBIAL AND HEMOLYTIC PROPERTIES	52
Yavuz Gökalp Yıldız	FROM A NATIONAL PHARMACEUTICAL STRATEGY PERSPECTIVE: MEDICAL CANNABIS	53
Mahmut Bolat Aysel Çakan	AN INDUSTRIALISATION MOVE IN THE ATATURK ERA: “KENDİR VE KETEN SANAYİ TÜRK ANONİM ŞİRKETİ”	62
Abdessalam BOUDDOUCH Brahim AKHSASSI Bahcine BAKIZ Frédéric GUINNETON Sylvie VILLAIN Jean-Raymond GAVARRI Abdeljalil BENLHACHEMI	DEVELOPMENT OF PHOSPHATE-BASED PHOTOCATALYSTS FOR THE DEGRADATION OF ORGANIC POLLUTANTS IN WASTEWATER	64
HAMZAH R. U. BUSARI M. B. YUSUF R. S. NWOYE G. N. IGHO O.	PHYTOCHEMICAL CONSTITUENTS AND EFFECTS OF METHANOL EXTRACT OF *CALOTROPIS PROCERA* FLOWER ON HEMATOLOGICAL PARAMETERS IN ALLOXAN-INDUCED DIABETES IN WISTAR RATS	66
Tuba OKUTAN Ökkeş YILMAZ Aykut TOPDEMIR	DIFFERENT CYTOKINE CONCENTRATIONS IN *Cannabis indica* LAM. EFFECT ON CANNABIDIOL (CBD) VALUES IN CALLUS CULTURES	73
Chebaanı Meriem Nabı Fahıma Mouıssa Habıb	THE IMPACT OF WATER STRESS ON SEED GERMINATION IN SELECTED LEGUME SPECIES IN ALGERIA	82
Aatika Naseem Sammina MAHMOOD Rabiya Izhar	SYNERGISTIC EFFECT OF GARLIC EXTRACT AND FOLIAR APPLICATION OF ASCORBIC ACID ON THE GROWTH OF OKRA (ABELMOSCHUS ESCULENTUS L.) UNDER DROUGHT STRESS	83
İrına-Ana DROBOT	PROMOTION OF CONCERN FOR THE ENVIRONMENT	84
O. Kaplan	HEMP-BASED FIBER-REINFORCED POLYMER COMPOSITES IN SEISMIC RETROFITTING OF EXISTING BUILDINGS	91
Özgenur DİNÇER ŞAHAN Ahmet KARADAĞ Attia HAMİD	EFFICIENT UTILIZATION OF LIGNOCELLULOSIC HEMP: PRETREATMENT	92
Muhammad Imran Musarrat Parveen	BIO-PLASTIC ADOPTION: THE INTERPLAY OF ALTRUISM, INNOVATIVENESS, AND ENVIRONMENTAL MOTIVATION AMONG YOUNG CONSUMERS	99
David, I. J. Mathew, S. Ikwuoche, P. O.	INFERENCE ON SOME ENVIRONMENTAL FACTORS ON ANNUAL RAINFALL IN NIGERIA	100
Abubakar Muhammad Sani Salmanu Shu’aibu	ANTIBIOTIC SENSITIVITY PROFILE OF COLIFORM ISOLATED FROM DIFFERENT WATER SOURCES IN ALIERO METROPOLIS, KEBBI STATE, NIGERIA	101

Fahri AKMANSOY	USE OF HEMP IN EXISTING BRANCHES OF INDUSTRIES IN ORDER TO DEVELOP THE HEMP INDUSTRY, TO COMPENSATE THE LOST TIME AND TO REACH THE HEMP INDUSTRY WHERE IT NEEDS TO BE AS SOON AS POSSIBLE	102
Aliyu Ahmad Firdausi Yusuf Nasiru Salihu Sadiq Bashir Babuga Zulaihat Lawan Muhammad Nuhu	EVALUATION OF ANALGESIC ACTIVITY OF METHANOLIC EXTRACT OF *TRICHODESMA AFRICANUM* PLANT IN MICE	111
Eren BAYRAKCI Eren BALABAN Mehmet İnanç ONUR Yücel GÜNEY	GEOSYNTHETICS PRODUCED FROM NATURAL FIBERS: PAST TO FUTURE	122
Habil. Cristina Raluca Gh. POPESCU	EXTENSIVE POWER OF COMMON AGRICULTURAL POLICY AND HEMP PRODUCTION IN EUROPEAN UNION: CASE OF FRANCE AND MAKING A CONTRIBUTION TO THE EUROPEAN GREEN DEAL OBJECTIVES	137
Habil. Cristina Raluca Gh. POPESCU Gheorghe N. POPESCU	THE HEALTH-ENVIRONMENT NEXUS: TACKLING VITAL HEMP POLICIES, ADDRESSING CUTTING-EDGE RESEARCH FOR SUSTAINABLE DEVELOPMENT, AND MANAGING DECISIVE HUMAN RIGHTS	157
Melik Sami Khelil Sara Tallal Abdel Karim Bouzir	GREEN ARCHITECTURE: DESIGNING ZERO-CARBON BUILDINGS FOR ENHANCED PUBLIC HEALTH	172
Zeynep Yoney Soner Kizil	EXAMINATION OF HEMP-BASED GARMENT FABRICS AS FORENSIC EVIDENCE AND COMPARISON WITH OTHER TYPE FABRIC	174
Gülizar Kurtoğlu Akkaya İbrahim Erdal	ECO-FRIENDLY INDUSTRIAL HEMP SUPPORTING THE CIRCULAR ECONOMY	175
Erdinç ALTINÇEKİÇ Ömer ÖZBEK	EVALUATION THE POTENTIAL OF INDUSTRIAL HEMP (*CANNABIS SATIVA* L.) AS A FORAGE SOURCE IN RUMINANT NUTRITION	176
Ayşe Meryem ÖZDEMİR Eren BAYRAKCI Yücel GÜNEY	EVALUATION OF THE USE OF NATURAL FIBERS IN SOIL IMPROVEMENT	177
Saddam Hussain	INDUSTRIAL HEMP AGRONOMY AND FIBRE VALUE CHAIN IN PAKISTAN: CURRENT PROGRESS, CHALLENGES, AND PROSPECTS	186
Gökhan ÇALIŞKAN Ufuk KOCA ÇALIŞKAN	INVESTIGATING THE THERAPEUTIC EFFECTS OF CANNABIDIOL ON SPORTS PERFORMANCE AND RECOVERY	187
Jamal Zrinej Ouabane Mohamed Larbi El Mchichi Abdelhamid Qara Chakib Sekkate Tahar Lakhlifi Mohammed Bouachrine	IN SILICO INVESTIGATION ON THE BENEFICIAL EFFECTS OF THE PLANT PLUMBAGO ZEYLANICA AGAINST PROSTATE CANCER: MOLECULAR DOCKING, MOLECULAR DYNAMICS SIMULATION, AND ADMET STUDIES	195

Erdonmez, D. Ufuk Koca Çalışkan	POTENTIAL EFFECT OF *Cannabis sativa* L. FOR THE TREATMENT OF DENTAL AND ORAL DISEASE	196
Dudu Altıntaş Gündüz Ufuk Koca Çalışkan	THE OIL CONTENT AND POTENTIAL HEALTH EFFECT OF HEMP OIL	205
Abdelmoutalib BENFRID Mohamed BACHIR BOUIADJRA	THE IMPORTANCE OF HEMP AND CORK IN INNOVATIVE MATERIALS IN THE FIELD OF CIVIL ENGINEERING: ADDRESSING THE ISSUE OF DEPLETION AND PROPOSING SOLUTIONS THROUGH REPLACEMENT WITH PNEUMATIC WASTE OR RUBBER WASTE	211
Sevgi IPEK Ergün KASAP	ANALYSIS OF METALS ADSORPTION ON CHITOSAN DIMER BY USING DENSITY FUNCTIONAL THEORY	212
Obi, Maryjane A.	EVALUATING THE SENSORY ATTRIBUTES AND CONSUMER ACCEPTANCE OF COCOA-TIGERNUT-DATE BEVERAGE POWDER BLENDS COMPARED TO A COMMERCIAL COCOA POWDER PRODUCT (MILO)	219
Mustapha Nassiri Sara Darbal Ilham Karmal Mohamed El house Said Ben-aazza M'Barek Belattar Abdallah Hadfi Ali Driouiche	STUDY OF THE CHEMICAL INHIBITION OF SCALING PHENOMENON IN TREATED WASTEWATER PIPES	220
Mourad ARABI Latifa MECHKIRROU Mohammed Ouhssine	OPTIMIZING THE CIRCULAR BIOECONOMY: INNOVATIVE UTILIZATION OF FOOD RESIDUES AS HIGH-QUALITY LIVESTOCK FEED	221
Müşərrəf HƏSƏNOVA	HEMP – A KEY ELEMENT OF ANCIENT RELIGIOUS RITUALS	222
Çağatay SAĞIR İrem CAN Fatih ERCİ Erdal KOCABAŞ	GREEN SYNTHESIS OF SILVER NANOPARTICLES AND PRODUCTION OF NANOFIBERS BY ELECTROSPINNING AS AA FUNCTIONAL MATERIAL	224
Attia HAMİD Özgenur DİNÇER ŞAHAN Ahmet KARADAĞ	EFFECTIVE UTILIZATION OF HEMP SEED MEAL (*CANNABIS SATIVA*) IN POULTRY FEEDS (BROILERS AND LAYING HENS)	226
Özgenur DİNÇER ŞAHAN Ahmet KARADAĞ Attia HAMİD	PRODUCTION PROCESS OF BIOETHANOL AND BIOBUTANOL FROM INDUSTRIAL HEMP	232
Khalid Said Souad Elkhattabi	EXPLORING STRUCTURAL, ELECTRONIC, AND OPTICAL PROPERTIES OF LEAD-FREE PEROVSKITE CH3NH3SNBR3 UNDER COMPRESSIVE STRAIN	241
Adedipe, J.O Aderemi, A.M	SNAIL SHELL CARBON ADSORPTIVITY IN HEAVY METAL DIMINUTION FROM INDUSTRIAL PAINT WASTEWATER	242
Yağmur BAŞAR Yahya KAYA Ali MARDANİ	EFFECT OF WASTE HEMP FIBER USE ON SOME CEMENTITIOUS SYSTEM PROPERTIES	247
Muhyettin ŞENTÜRK	TAXONOMY OF CANNABIS	254

Mohammad Javad Babaie-Zarch Mohammad Hossein Banakar Amir Parnian	THE EFFECT OF DIFFERENT AMOUNTS OF PALM LEAF ASH ON INDICATORS RELATED TO GERMINATION OF WHEAT	255
Seher ŞAHİN Deniz ATAKOL Özen ÖZENSOY GÜLER Asuman SUNGUROĞLU Mustafa Emre ERCİN Ender ŞİMŞEK	THE INHIBITION OF LIPID DROPLET FORMATION BY CANNABINOIDS: A NEW APPROACH IN CANCER THERAPY	256
Murshida Khatun Abdul Baree Saidul Islam Abdul Kaium Sharif Ahmed	IMPACT OF VARIETIES ON GROWTH AND YIELD OF TOMATO THROUGH THE MANAGEMENT OF ORGANIC MANURE	258
Marianys FERNÁNDEZ Nuno BAPTISTA Mário ANTÃO	TRANSITION TO A SUSTAINABLE ECONOMY: A SCOPING REVIEW OF LITERATURE FOCUSED ON SUSTAINABLE GASTRONOMY	259
M.H. Banakar M.J. Babaei-Zarch Amir Parnian	SALT STRESS AFFECTED SEEDLING ESTABLISHMENT AND FORAGE PRODUCTION OF SOME HALO-FORAGE SPECIES	260
Uday HACHÜSEYİN Ergün KASAP	INTERACION OF CHITOSAN MONOMER WITH Ti^{+2}, Al^{+2}, Pb^{+2} AND As^{+3} IONS: A COMPUTATIONAL STUDY	261
Belalite Halima Athamena Ali	VALORIZATION OF USED WATER IN IRRIGATION, CASE OF THE STEP OF SIDI MEROUANE, WILAYA OF MILA, EAST ALGERIA	272
Yasemin Aykut Ayşe Bayrakçeken	SYNTHESIS OF ACTIVATED CARBON FROM HEMP STALK	273
Yasemin Aykut Ayşe Bayrakçeken	THE ROLE OF HEMP IN ELECTROCHEMICAL STUDIES	278
Yeliz Şahin	A CLINICAL PHARMACY PERSPECTIVE ON MEDICAL CANNABIS	284
Aysun Gençtürk Bahar Aşılıoğlu Türkan Özger Muhammet Uzun	A CASE STUDY ON WET-SPUN HEMP YARN PROPERTIES FOR SUSTAINABLE FASHION APPLICATIONS	286
Zeliha ŞAHİN ÇAĞLI	EMERGING VALUE CREATION AT OSTIM INDUSTRIAL ZONE; THE ECONOMIC IMPORTANCE AND STRATEGIC ROLE OF ‘INDUSTRIAL GREEN CAMPUSES IN PRACTICE’	287

ÖNSÖZ

M.Ö. 8000'li yıllara dayanan kenevirden üretilmiş kumaş kalıntıları kenevirin insanlık tarihi kadar eski, ötesi kadim coğrafyamızın bir bitkisi olarak kenevir (kendir) öncelikle tohumu ve lifleri için yetiştirilen ilk kültür bitkilerinden biri olma kimliği taşımaktadır. Kenevir lifleri tarih boyunca ülke ekonomilerini etkileyecek boyutu ile tekstil üretiminde çok önemli yer tutarak 19. yy. sonlarına kadar dünya üzerindeki tüm tekstil ürünlerinin %80'inin hammaddesini oluşturmuştur. 20. yy. başlarında gelişen teknoloji ile birlikte pamuk lifinin kullanılmaya başlanmasıyla daha ince iplikler üretilmiş, daha hafif elbiselerin üretimi mümkün hale gelmiştir. 1930'lu yıllarda çıkarılan esrar karşıtı yasalarla kenevir tarımı büyük sekteye uğramış, üstelik savaş sanayisine paralel olarak kapital dünyanın geliştirdiği sentetik liflerle beraber kenevir tekstili eski önemini kaybetmeye başlamıştır.

Bununla birlikte, kenevir (*Cannabis*), Hıristiyanlıktan önce ilk olarak Asya'da, özellikle Hindistan'da tıbbi amaçlarla kullanılmış bir bitki olarak bilinirdi. 19. yüzyılın son on yılında yaygın olarak bulunan *Cannabis* ekstraktlarının veya tentürlerinin kullanımı, kenevirin batı tıbbına girişinin doruk noktasına ulaştığı son nokta olmuştur. Ancak, batı tıbbında *Cannabis* kullanımı, farklı bitki materyallerinden tutarlı sonuçların tam alınamaması nedeniyle 20. yüzyılın ilk on yılında önemli ölçüde etkisini kaybetmiştir. Ancak, Batı tıbbında kenevir kullanımı, 1965 yılından bu yana, *Cannabis* bileşenlerinin kimyasal yapılarının belirlenebilmesi ve ayrıştırma tekniklerinin gelişimine bağlı olarak saf bileşiklerinin elde edilmesi ile sağlık için bu bitkiye yönelik bilimsel araştırmalarda önemli derecede bir artış gözlemlenmiştir. Bu araştırmalarla birlikte, batı tıbbında kenevir kullanımına ilgi 1990'lı yıllarda beyindeki endojen bir kannabinoid sisteminin ve kannabinoid reseptörlerinin tanımlanmasıyla yeniden canlanmaya başlamıştır. Sonuçta, tedavi, etkinlik ve güvenlik faktörleri bilimsel olarak belirlenmeye başladığından beri, *Cannabis* türevlerinin ilaç olarak kullanılmasına yönelik yeni ve daha düzenli bir döngü gözlemlenmektedir.

Ülkemizde, kenevir 1961 yılında 20.800 ha alanda 10.700 ton lif ve 5.000 ton tohum amaçlı üretimi gerçekleştirilmiştir. 1988 yılında 1200 ton olan kenevir tohumu üretimimiz, 2015 yılında 1 tona düşmüştür. 2017 yılında toplam 12 hektar alanda ekim alanı sadece 10 hektar lif ve 2 hektar tohum amaçlı kenevir üretilirken, 2023 itibarıyla da toplam kenevir ekim alanı 5600 dekar olarak gerçekleşmiştir. Ancak, tüm dünyada olduğu gibi, ülkemizde de; yüksek iş gücü, mekanizasyonun eksikliği, pamuk bitkisiyle rekabet edememe, sentetik lif ve elyafın daha ucuz olması, dahası psikoaktif THC içeriği nedeni ile üretiminde birçok zorluklarla karşılaşılması kenevir tarımını nerde ise bitme noktasına getirmiştir.

Kenevirle ilgili olumsuz, olumsuz olduğu kadar da kasıtlı ve yanlı sergilenen tutuma rağmen onun insanlık için ne ifade ettiğini göz ardı etmek, dahası yok saymak pek mümkün gözükememiştir. ŞÖYLE Kİ;

Kenevir, bütün biyokütlesi çok çeşitli alanlarda ve çok çeşitli amaçlarda kullanma potansiyeli oldukça yüksek olan bir bitki çeşididir. Kenevirin tıptan eczacılığa, kozmetikten temizlik ürünlerine, tarımdan gıdaya, tekstilden kâğıda ve her çeşitte biyomalzemeden kaportaya varan yelpazede nitelikli ve sürdürülebilir yüzlerce ürününden bahsetmek mümkündür. Aynı zamanda kenevir; makul su ayak-izine sahip, ekildiği toprağı onaran ve yenileyen, yetiştirilmesinde ilaç kullanımı gerekmeyen, dolayısıyla da ekildiği toprağı ve yeraltı sularının kirlenmesine neden olmadığı gibi bulunduğu ortamın oksijen kalitesini oldukça yükselten ve radyosyonu tutan eşsiz bir bitkidir. Dahası, kenevirin nerde ise bütün biyokütlesinin sağlık ve gıda kullanımları için çok önemli bileşenlere sahip olması onu mucize bir bitki haline getirmektedir.

Kenevirde bulunan birçok faydalı bileşenin yanında esas olarak glandüler trikomlarda bulunan kannabinoidlerin birçok yararları, bu bitkiyi daha sağlık yaşam için hem gıda takviyesi, hem de tıpta, eczacılıkta ve kozmetikte kullanımı ile insanların odağı haline getirmiştir. Aynı zamanda, kenevir tohumunun, özellikle doymamış yağ asitleri başta olmak üzere protein, vitamin ve karbonhidrat içeriklerinin zenginliği sayesinde insanları daha çok kenevir ürünlerini kullanmaya sevk etmiştir.

Bunların yanında, kenevirin en genel psikoaktif bileşeni olan delta-9-tetrahidrokanabinolden (δ^9-THC) dolayı bir uyuşturucu hammaddesi olarak nitelendirilmesi, hiç de hak etmediği bir kimliktir. Çünkü δ^9-THC'nin özellikle antikanser aktiviteleri de dâhil tıptaki çeşitli kullanımları başta olmak üzere diğer kannabinoidlerin birçok önemli ve faydalı özellikleri dahil, biyokütlenin diğer oldukça önemli bileşenleri uyuşturucu algısının yersizliğinin en net resmidir. Üstelik, psikoaktif δ^9-THC'nin karasız bir kimyasal olması, kimyasal olarak daha kararlı ancak psikoaktivitesi daha düşük izomeri δ^8-THC'ye kolaylıkla dönüşmesi, kenevirin "esrar" algısıyla ön plana çıkmasını hiç hak etmediğinin açık bir diğer göstergesidir.

Özetle, kenevir dünyada 25.000'den fazla üründe hammadde olarak kullanılmakta, 2017 yılında 4 milyar doları bulan dünya endüstriyel kenevir pazarının, 2025 yılında 11 milyar doları bulması beklenmektedir (*bu verilere tıbbi kenevirden elde edilen-edilmesi muhtemel dünya Pazar payı dâhil değil!*). Dolayısıyla da, Ülke olarak, tarım kültürünü iyi bildiğimiz kenevire, akılcı ve dinamik yaklaşımlarla bu alanda ülkemize kazandıracağımız yeni ve yenilikçi sektörlerle kenevirin ülke ekonomisine katma değerini en üst seviyeye çıkartmak pekala mümkün gözükmektedir.

Ülkemizde ilk kez Ostim Üniversitesi evsahipliği ve İKSAD organizatörlüğünde yapılan "*I. Mültidisipliner Çevre ve Kenevir Kongresi*"ne "*Kenevir Forumu*" özelinde 20'si konuşmacı 50'nin üzerinde katılımcı, "Akademik" olarak da 113 bildiriden kabul edilen 74 bildirinin 42'sinin 14 farklı ülkeden bilim insanlarının çalışmalarının sunumları damgasını vurmuştur. Bu çerçevede, bu kongrenin hem "*Kenevir Forum*" oturumları, hem de "*Akademik*" sunumlarla kenevire yönelik politik yada apolitik duruş sergileyen Entelektüellerimiz ve yatırımları olan Sanayicilerimizle bilimsel çalışmalarıyla katılım sağlayan Akademisyenlerin birlikte ve birarada olduğu önemli bir toplantı hüviyeti kazandığını düşünmekteyiz. Bu vesile ile "*Kenevir Forum*"una ve "*Bilimsel Çalışmaları*" ile kongremize değer katan tüm Katılımcılara en kalbi teşekkürlerimizi sunuyoruz. Özellikle de, Ostim Üniversitemiz Rektörü Sayın Murat Yülek ve İKSAD Başkanı Mustafa Latif Emek'in şahsında kongremize bugüne kadar büyük emek ve çabaları ile katkı sunan tüm kongre ekibine çok teşekkür ediyoruz. Ayrıca, Kongre Düzenleme Kurulu ve Bilim Kurulundaki tüm Akademisyenlere de katkılarından ötürü şükranlarımızı iletiyoruz.

Prof. Dr. Ahmet KARADAĞ
Kongre Başkanı

FOREWORD

Residues of hemp fabric dating back to around 8000 BC indicate that hemp, as an ancient plant of our geography, is as old as human history itself. Hemp (*Cannabis*), primarily cultivated for its seeds and fibers, is one of the first cultivated plants in history. Throughout history, hemp fibers played a crucial role in textile production, constituting up to 80% of all textiles worldwide until the late 19th century. With advancements in technology in the early 20th century, the use of cotton fibers began, enabling the production of finer yarns and lighter fabrics. In the 1930s, anti-marijuana laws significantly disrupted hemp cultivation, and alongside the synthetic fibers developed by the capitalist world parallel to the war industry, hemp textiles began to lose their former importance.

However, hemp (*Cannabis*) was known primarily in Asia, especially in India, before Christianity, as a plant used for medicinal purposes. The widespread use of *Cannabis* extracts or tinctures in the last decade of the 19th century marked the peak of hemp's introduction to Western medicine. Nevertheless, the use of *Cannabis* in Western medicine declined significantly in the early 20th century due to inconsistent results from different plant materials. However, interest in hemp use in Western medicine was revived in the 1990s with the identification of an endogenous cannabinoid system in the brain and cannabinoid receptors. Subsequently, a new and more systematic cycle has been observed in scientific research for the use of *Cannabis* derivatives as medicines, as treatment efficacy and safety factors began to be scientifically determined.

In our country, hemp was cultivated on 20,800 hectares producing 10,700 tons of fiber and 5,000 tons of seeds in 1961. By 1988, our hemp seed production had decreased to 1,200 tons, dropping further to 1 ton by 2015. In 2017, hemp was cultivated on a total area of 12 hectares, consisting of 10 hectares for fiber and 2 hectares for seed production, while as of 2023, the total hemp cultivation area reached 5,600 hectares. However, as in the rest of the world, hemp cultivation in our country has been brought almost to the brink due to various difficulties, including high labor costs, lack of mechanization, inability to compete with cotton, cheaper synthetic fibers, and challenges in cultivation due to the psychoactive THC content.

Despite the negative and sometimes intentionally biased portrayal of hemp, it is hardly possible to ignore or disregard what it means for humanity. Hemp is a plant with high potential for use in a wide range of fields and purposes with its entire biomass. Hemp can be utilized in medicine, pharmacy, cosmetics, agriculture, food, textiles, paper, and a variety of biomaterials, contributing to hundreds of sustainable and high-quality products. Moreover, hemp has a reasonable water footprint, repairs and replenishes the soil it is grown in, requires no pesticide use, thus does not pollute the soil and groundwater, significantly improves oxygen quality in its environment, and absorbs radiation, making it a unique plant.

Furthermore, the many benefits of cannabinoids, primarily found in glandular trichomes in hemp, have made this plant a focus of attention for health and dietary supplements, as well as for use in medicine, pharmacy, and cosmetics. In addition, the classification of hemp primarily as a drug raw material due to delta-9-tetrahydrocannabinol (δ^9-THC), its most general psychoactive component, is an undeserved identity. This is because the chemical instability of psychoactive δ^9-THC and its easy conversion to the chemically more stable but less psychoactive isomer δ^8-THC, along with many other important and beneficial properties of cannabinoids, clearly illustrate the unjustifiability of the drug perception associated with hemp.

In summary, hemp is used as a raw material in over 25,000 products worldwide, and the global industrial hemp market, which reached $4 billion in 2017, is expected to reach $11 billion by

2025 (*excluding the potential market share derived from medical hemp!*). Therefore, it is quite possible for our country, with its well-known agricultural culture, to maximize the added value of hemp to the national economy through rational and dynamic approaches and innovative sectors that we can introduce in this field.

The "*I. Multidisciplinary Environment and Hemp Congress*," held for the first time in our country under the auspices of Ostim University and organized by İKSAD, left its mark with over 50 participants, including 20 speakers in the "*Hemp Forum*" specifically, and 74 out of 113 papers accepted academically, presented by researchers from 14 different countries. In this context, we believe that this congress has gained importance as a significant meeting where our Intellectuals and Industrialists who adopt a political or apolitical stance towards hemp, and Academicians contributing with scientific studies in both "*Hemp Forum*" sessions and "*Academic*" presentations, gathered together. On this occasion, we extend our heartfelt thanks to all Participants who contributed value to our "*Hemp Forum*" and "*Scientific Studies*" at the congress. We particularly thank Ostim University Rector Mr. Murat Yülek and İKSAD President Mustafa Latif Emek, and through them, all members of the congress team who have contributed greatly to our congress with their efforts and endeavors. Additionally, we express our gratitude to all Academicians in the Congress Organization Committee and Scientific Committee for their contributions.

Professor Ahmet KARADAĞ, PhD
HEAD OF CONGRESS

THE PLACE OF NATURAL COMPOSITE HEMP FIBERS IN THE CONSTRUCTION SECTOR AND ITS IMPORTANCE IN TERMS OF SUSTAINABILITY

DOĞAL KOMPOZİT KENEVİR LİFLERİNİN İNŞAAT SEKTÖRÜNDEKİ YERİ VE SÜRDÜRÜLEBİLİRLİK AÇISINDAN ÖNEMİ

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Abstract

Introduction and Purpose: Sustainable building materials, while helping to alleviate the environmental crisis with the durability and recycling opportunities they provide throughout their life cycle, also offer long-term solutions. Simultaneously, they support economic and social sustainability by providing economic advantages such as energy efficiency and low maintenance costs, as well as social opportunities like healthy living conditions and local employment opportunities. In this context, sustainable building materials play a significant role in both protecting the environment and promoting economic and social development. This study aims to demonstrate how the hemp plant, known for its environmentally friendly and sustainable approach, can play a role in improving the overall efficiency and sustainability of the construction industry, by extensively addressing its potential use areas in the sector.

Materials and Methods: In line with the literature, the physical and chemical features of the hemp plant, which can be used as a construction material, has been researched. Its areas of use in the construction sector have been identified, evaluations have been made in the context of sustainable materials, and suggestions have been made.

Findings: Hemp, thanks to its high isolation properties, preserves the indoor temperature as a natural insulation material and provides energy savings. It is resistant to fire and thanks to its non-flammable features, it also offers fire safety advantage. In addition, with its moisture absorption feature, it prevents rot and mold formation, and with its flexible design features, it demonstrates the characteristics of an ideal material that adapts to different architectural styles.

Discussion and Conclusion: With today's technology, the sustainable building materials used reduce negative environmental impacts and prevent depletion of natural resources. It can contribute by representing significant progress with efforts to build a sustainable future for the preservation of environmental balance.

Key Words: Natural composite, Hemp, Sustainability, Building material.

Özet

Giriş ve Amaç: Sürdürülebilir yapı malzemeleri, yaşam döngüsü boyunca sağladıkları dayanıklılık ve geri dönüşüm olanaklarıyla çevre krizinin hafifletilmesine yardımcı olurken, uzun vadeli çözümler de sunmaktadır. Aynı zamanda, enerji verimliliği ve düşük bakım maliyeti gibi ekonomik avantajlar ile sağlıklı yaşam koşulları ve yerel istihdam olanakları gibi sosyal imkanlar da sağlayarak ekonomik ve sosyal sürdürülebilirliği desteklemektedir. Bu bağlamda, sürdürülebilir yapı malzemeleri hem çevreyi koruma hem de ekonomik ve sosyal gelişmeyi teşvik etme konusunda önemli bir role sahiptir. Bu çalışma, çevreye duyarlı ve sürdürülebilir bir yaklaşım olan kenevir bitkisinin inşaat sektöründeki potansiyel kullanım alanları kapsamlı bir şekilde ele alınarak, bu sektörün genel verimliliğini ve sürdürülebilirliğini artırmada nasıl bir rol oynayabileceğini göstermeyi amaçlamaktadır.

Gereç ve Yöntem: Literatür kapsamı doğrultusunda, yapı malzemeleri olarak kullanılabilen kenevir bitkisinin fiziksel ve kimyasal özellikleri araştırılmıştır. İnşaat sektöründeki kullanım alanları tespit edilip sürdürülebilir malzemeler bağlamında değerlendirmeler yapılarak öneriler getirilmiştir.

Bulgular: Kenevir, yüksek izolasyon özellikleri sayesinde doğal bir yalıtım malzemesi olarak iç ortamın sıcaklığını korur ve enerji tasarrufu sağlamaktadır. Yangına karşı dirençlidir ve alev almayan özellikleri sayesinde yangın güvenliği avantajı da sunmaktadır. Ayrıca, rutubet emme özelliğiyle çürüme ve küf oluşumunu önlerken, esnek tasarım özellikleri ile farklı mimari tarzlara uyum sağlayan ideal bir malzeme özelliği gösterir.

Tartışma ve Sonuç: Günümüz teknolojisiyle birlikte kullanılan sürdürülebilir yapı malzemeleri, çevresel olumsuz etkileri azaltıp doğal kaynakların tükenmesini önler. Çevresel dengenin korunması için sürdürülebilir bir gelecek inşa etme çabalarıyla önemli bir ilerlemeyi temsil ederek katkı sağlayabilir.

Anahtar Kelimeler: Doğal kompozit, Kenevir, Sürdürülebilirlik, Yapı malzemeleri.

INTRODUCTION

Sustainability is the understanding of using natural resources to meet today's needs while considering the needs of future generations and maintaining environmental, economic, and social balance. This understanding is based on the principle of preventing the consumption of tomorrow's resources while using today's resources, and ensuring future generations have access to the same resources. This approach, which protects the environment and includes economic progress, ensures the well-being of both current and future generations [1].

Today, while the consumable parts of many plants, trees, and fruits are used, the fibrous parts are often left as waste in nature. This not only pollutes the environment, but also overlooks potential uses of the fibrous parts. The other resources used as alternatives to such materials are causing an increase in costs and the depletion of our natural resources. It is necessary to investigate how waste suitable for a sustainable environment can be utilized more efficiently [2].

Various wastes can be transformed into a completely new substance different from their original forms. This process, called recycling, prevents resource waste and also supports efforts to raise living standards. Advanced countries facing global problems such as energy crisis, have researched and developed various methods for waste recovery and reuse. These methods have both enabled more efficient use of energy resources and provided the opportunity for increased environmental sustainability [3].

Hemp, which stands out as a sustainable building material, is seen as a renewable and environmentally friendly alternative, and its potential in the construction sector is quite large. It offers a unique environmental profile due to its rapid growth rate and carbon absorption capacity. Thus, it makes a significant contribution to the construction industry, especially the green building movement that encourages the use of sustainable materials. The use of hemp can help reduce the environmental footprint of the construction sector. It can also be an important step in combating climate change, helping the construction industry move towards a more sustainable future.

MATERIALS AND METHODS:

HEMP

Hemp is a plant used by various civilizations throughout history to meet different needs. Hemp is a species usually annual, belonging to the Cannabaceae family. It is a dicotyledonous and herbaceous plant genus. The plants can grow from 50 cm to 3m. The plant genus is dioecious and the plants are divided into male and female. The male plant produces pollen while the female plant flowers [4]. Figure 1 shows a) Flowered hemp male plant, b) Flowered hemp female plant appearances.

a) *b)*

Figure 1. *a) Flowered hemp male plant, b) Flowered hemp female plant [5]*

With the start of the use of female hemp plants as marijuana, cultivation areas have been restricted over time. The leaves are used for pleasure, the stems as a source of fiber, and the seeds as a source of oil, bird feed, and snacks. Marijuana is secreted from the silver-colored glands in the leaves and flower perigon leaves at the tips of female hemp plants. About 15%-20% of the hemp stem is fiber. The fibers are generally yellow and brown in color. The unique structure of hemp consists of an outer layer of bast fibers surrounded by a woody core fiber called shive, and an inner layer called pith [5].

Just like in Turkey, the cultivation of hemp has been banned in various countries around the world due to its use for drug purposes. However, in Turkey, the production of its fiber, stalk, and seeds has never been banned, it is only stated that the production should be under control and licensed. The banned part is cultivation for marijuana or drug purposes. Therefore, the production, cultivation, use, and trade of leaves and especially flowers suitable for use as drugs have been banned in any way [6].

Although hemp fiber is a natural cellulose fiber, it contains significant amounts of non-cellulosic substances in its structure. The properties and behaviors of hemp fibers are shaped by the components they contain and also affect the production process. Knowing the properties and functions of the components that make up the hemp fibers well is extremely important in order to be able to predict more accurately and effectively under which conditions and in which applications they can be used best [7].

In addition to the consumption of hemp seeds and oil as food, it has rapidly spread geographically thanks to its use in textiles, shipping, and paper production. Today, there are different uses for the hemp plant in various industries. Hemp oil is used in the food, cosmetic, pharmaceutical industries, as well as for bioplastics, varnish, paint; hemp seeds are used in the food and livestock sectors. In other sectors, hemp fibers are used as reinforcing elements in composite materials, insulation materials, textile products, paper production, floor coverings such as carpets, linoleum, or hemp particles are used as compressed boards in structures [4], [8]. Hemp seeds are given in Figure 2, hemp fibers in Figure 3, and hemp wood and stalks in Figure 4.

Şekil 2. *Hemp Seed*

Şekil 3. *Hemp Fiber*

Şekil 4. *Hemp wood and stems*

In accordance with the literature, the physical and chemical structure of the hemp plant, which can be used as construction materials, has been researched and its areas of use in the construction sector have been determined. Suggestions have been made through evaluations in the context of sustainable materials.

FINDINGS

Physical Structure of the Hemp Fiber

Hemp fibers are high-strength natural fibers that increase in strength as they age, are not greatly affected by temperature, and are resistant to high temperatures [8],[9].

Table1. Physical Properties of Hemp Fiber

Hemp Fiber	*Length (mm)*	*Intensity (g/cm^3)*	*Tensile strength (Mpa)*	*Young Modulus (Gpa)*	*Moisture (%)*
	5-55	1,4	550-1110	30-70	8

Chemical Structure of the Hemp Fiber

The chemical composition of hemp fibers contains 70-74% cellulose, 15-20% hemicellulose, 3.5-5% lignin, and 0.8% pectin [10].

Table 2. Chemical Properties of Hemp Fiber

Hemp Fiber	*Cellulose (%)*	*Lignin (%)*	*Hemicellulese (%)*	*Pectin (%)*
	70-74	3.5-5,7	15-20	0.8

Use of Hemp Plant in the Construction Sector

Hemp is a versatile industrial plant, its usage is gradually increasing in various fields due to its wide range of applications. The importance and usage of hemp worldwide have significantly increased, especially lately. This situation has expanded the diversity of hemp usage and created many new product and service categories based on hemp in the industry. Hemp plays a significant role in various industrial sectors such as food, construction, textiles, pharmaceuticals, composite materials, and cosmetics. Hemp, with its various uses, has brought a significant increase in its cultivation and planting areas by encouraging the expansion of its cultivation areas. [7].

Hemp, as a construction material, offers solutions to various problems faced by current construction standards, bringing hemp products to the forefront in use due to properties such as lightness, mold resistance, and breathability due to its porosity [6]. Since hemp has the ability to absorb and release moisture without degradation, it gains fire-resistant properties when mixed with lime and can be applied in areas such as walls and roofs in buildings due to its lightness [11].

In the construction industry, the stalk, fiber, and shives of hemp are used. Fibers are obtained from hemp stalks and a material called hemp concrete is obtained by fusing with cement and lime obtained in the form of particles of a certain size. The fibers used in the concrete are usually 50-80 mm long. From the stalk, fiber, and shives of hemp, hemp-based interior and exterior insulation materials, bricks, and briquettes are produced. At the same time, boutique houses and some organic boards, highland houses in tourist areas, and structures for special camping areas are made from hemp-added materials.

Hemp building material is obtained by blending the inner woody seed of the hemp plant with a lime-based binder and water. This building material is shaped into blocks and left to cure, and then loaded onto pallets and delivered to the construction site [12].

In Europe and America, instead of ytong or perforated bricks, hemp bricks with much higher insulation are used. In addition, these bricks can be preferred often as they have very high fire resistance. Apart from bricks, insulation materials that can be laid and mounted as an alternative to glass wool material are produced. The insulation values of these types of materials are quite high and the use of hemp-based products is rapidly expanding in the construction sector. Innovative manufacturers and researchers are discovering the potential of hemp and developing new products and applications [13].

It performs better in many ways compared to traditional building materials. Hemp absorbs a large amount of carbon dioxide from the atmosphere as it grows. The carbon content of hemp is higher than most traditional building materials. Hemp prevents bacteria breeding by preventing mold formation and maintaining proper levels of humidity. There is no need for a ventilation system to achieve this effect. The building material made from hemp can be used as a material that provides indoor thermal comfort because it has very good thermal properties. When used as a building material in architecture, it has a good design flexibility and is more aesthetically pleasing than traditional architecture. In concrete houses made using hemp, winters are warm and summers are cool. The production and use of hemp products are very low and effective processes. It has a very high efficiency in waste recycling, and it has better fire resistance than traditional houses [14].

It is known that hemp fiber, when used in high proportions, allows for the production of low-density composites, providing high strength and hardness performance. Also, due to its flexible feature, it is resistant to breakage during processing [15, 16, 17]. Thanks to its biodegradability, which allows for longer use time, and its low heat transfer coefficient, hemp fiber displays high performance as a thermal insulation material compared to other plant fibers [18]. Indeed, because of this superior feature, hemp fiber is chosen as an insulation material in the construction industry. Hemp is easily applied in structural framing systems as a useful insulation material. During the assembly process, due to its flexibility and durability, it can be easily adjusted in different sizes and shapes that can be comfortably cut, with the ability to not create gaps requiring little maintenance, and is used in various areas including insulation material in flooring, wall and roof coverings due to its lightness. Without losing any structural features, it allows up to 20% of air and moisture to penetrate into its structure due to its porous structure. It facilitates the extraction of moisture from the wall structure by allowing air circulation. Also, in terms of sound insulation, it weakens the sound waves in the air passing through it [19].

DISCUSSION AND CONCLUSION

Hemp, which demonstrates high thermal insulation performance, is a plant with a low density fibrous structure. It can be used in many different areas as a construction element. It is used in many architectures as a construction element in walls, roofs, floors, panels and boards, as a filler and reinforcement element. When used in walls, attics and floors, it increases the thermal insulation of buildings, when used in the form of panels and boards, it increases the durability of structures, and when used as a filler and reinforcement element, it is widely used in many different architectural designs by increasing the overall safety and durability of structures.

Insulation materials that have high insulation performance and require low production energy play an important role in creating healthy living conditions, thanks to their ability to provide thermal and acoustic comfort [20]. The environmentally friendly features and sustainable qualities of these materials make them a priority among local insulation options. Therefore, efforts to research, develop, and produce such local and sustainable insulation materials should be increased. The widespread use of these materials both saves energy and helps contribute to the overall welfare of our society by improving the quality of life. Studies to be conducted on this subject will have the potential to revitalize the local economy and make significant contributions to environmental protection efforts.

In conclusion; the use of sustainable building materials is an important step towards enhancing environmental and economic sustainability in the construction sector. The adoption of these alternative materials carries great importance in terms of effectively managing natural resources while meeting the needs of future generations and preserving the environmental balance. The building sector offers a great opportunity for a greener and longer-lasting future with the use of sustainable materials. The use of these materials reduces the amount of waste and carbon emissions by increasing energy efficiency. Therefore, the use of sustainable building materials helps to create a healthier and more livable world for both today's and future generations.

REFERENCES

[1] Sılay Emir, H.N., Yıldırım, E. (2024). Sürdürülebilirlik perspektifinden golf sahaları, Mimarlık Alanında Akademik İzler, Yaz Yayınları.

[2] Serin, S., Macit, M. E., Çınar, E.C., Çelik, S. (2018). Doğal kenevir lifi kullanımının asfalt beton karışımlara etkisi, *Düzce Üniversitesi Bilim ve Teknoloji Dergisi,* 6, 732-744.

[3] Gürer, C., Akbulut, H., Kürklü G. (2004). İnşaat endüstrisinde geri dönüşüm ve bir hammadde kaynağı olarak yapı malzemelerinin yeniden değerlendirilmesi, Endüstriyel Hammeddeler Sempozyumu, Türkiye,

[4] *Hardenack, L., Grant, S., Sarah R. (1997).* Genetics of sex determination in flowering plants, *Trends in Plant Science. 2 (4). 130-136.*

[5] Online Erişim: https://tr.wikipedia.org/wiki/Kenevir. 27/05/2024

[6] Yılmaz, F. ve Yazıcı, L., 2022, Dünya'da Yükselen Değer; Endüstriyel Kenevir (Cannabis sativa L.), *Bozok Tarım ve Doğa Bilimleri Dergisi.,* 1 (1), 54-61.

[7] Gedik, G., Avinç, O.O., Yavaş, A. (2010). Kenevir Lifinin Özellikleri ve Tekstil Endüstrisinde Kullanımıyla Sağladığı Avantajlar, *Tekstil Teknolojileri Elektronik Dergisi,* 4(3), 39-48.

[8] Holzmann, G., Wangelin, M. ve Bruns, R. (2012). Natürliche und pflanzliche baustoffe. Wiesbaden: Vieweg+Teubner Verlag.

[9] Özdemir, S., Tekoğlu, O. (2012). Ekolojik Tekstil Ürünlerinde Kullanılan Hammaddeler, *Akdeniz Sanat Dergisi*, 27-30.

[10] Manaia, J., Manaia, A.T., Rodriges, L. (2019). Industrial Hemp Fibers: An Overview. *Fibers,* 7(106), 1-16.

[11] Diary. (2023). Eco Friendly Building Materials – 20 Examples of the Latest Trend. Online Erişim: https://thearchitectsdiary.com/eco-friendly-buildingmaterials-20-examples-of-the-latest-trend/

[12] Online Erişim: https://emsal.com/insaatta-sifir-karbon-hedefinde-kenevirin-onemi/ (28/05/2024)

[13] Jian Zuo, J., ZhaoGreen, Z. (2014). Building research–current status and future agenda: A review, *Renewable and Sustainable Energy Reviews,* 30, 271-281.

[14] Vantreese, V.L. (2002). Hemp support: evolution in EU regulation. Journal of International Hemp Association, 7 (12), 1-23.

[15] Santos, P.A., et al., Natural fibers plastic composites in automotive applications, 2008. SPE Automotive Composites Conference & Exhibition, Troy, MI, USA.

[16] Spoljaric, S., A. Genovese, R.A. Shanks, (2009). Polypropylene-microcrystalline cellulose composites with enhanced compatibility and properties. Composite Part A:Applied Science and Manufacturing, 40, 791-799.

[17] Kymäläinen, H.R., A.M. Sjöberg, (2008). Flax and hemp fibres as raw materials for thermal insulations. *Building and Environment,* 43, 1261–1269.

[18] Nováková, P. (2017). Use of technical hemp in the construction industry, *MATEC Web of Conferences, 146, 1-8.*

[19]https://web.archive.org/web/20210510095059/https://www.asbportal.cz/stavebnictvi/zatepleni/vyuziti-konopi-ve-stavebnictvi

[20] The Hempcrete Book: Designing and Building with Hemp-Lime. Cambridge: Green Books. 2014.

SYNTHESIS OF COPPER NANOPARTICLES FROM BIODEGRADABLE WASTE

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Abstract

Nanoparticles of Copper oxide were prepared by eco-friendly synthesis using sugarcane bagasse extract. SEM analysis of nanoparticles was demonstrated with an average diameter of about 63nm. Further characterization was done with X- Ray diffraction. XRD studies used to find the crystalline size of the nanoparticles. FTIR Spectroscopy was used to understand the functional group. Antibacterial activities of the synthesized copper oxide nanoparticles were evaluated against *E.coli* and *Staphylococcus aureus.*

Key Words: Copper nanoparticle, Sugarcane bagasse, Antibacterial activity.

DEVELOPMENT OF THERMAL STABILITY OF HEMP FIBER AND HURD WITH SURFACE MODIFICATION METHODS AND COMPOUNDING WITH ACRYLONITRILE-BUTADIENE-STYRENE COPOLYMER

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Abstract

Although the use of biological resources together with petroleum-derived plastics is increasing, one of the obstacles to the widespread use of applications in this field is the low thermal resistance of bio-sourced materials. Additionally, there are not enough studies on the use of these materials together with engineering plastics processed at high temperatures. Besides, the hemp plant is a plant that grows quickly and has a strong fibre structure and thus has the potential to be used in the industrial field. In this study, it was aimed to increase the thermal resistance of hemp fibres and fibre waste defined as scrap by modifying them with various methods. For this purpose, the study was conducted on applying alkaline and silanization processes to hemp fibers and fiber wastes and then evaluating them with FTIR, TGA and SEM analyses. Finally, a mixture was created with acrylonitrile-butadiene-styrene (ABS) polymer, an engineering plastic, and examined its mechanical properties. The cellulose, hemicellulose and lignin ratios in the structure of hemp fibres and fibre waste were determined by the Klason lignin method. Then, grinding, alkalization and silanization processes were applied to these structures, and dried in an oven at 80 ºC. SEM, TGA and FTIR analyses were performed for morphological and thermal examination of the modified structures. In addition, modified hemp structures were mixed with ABS processed at high temperatures and examined its mechanical properties by applying a tensile test. After the modification processes, it was observed in the SEM images of hemp fibre and fibre waste that surface roughness was eliminated, impurities were removed and a stable fibre structure was obtained for both hemp structures. According to TGA results, thermal stability was improved and in the FTIR results, the changes in the densities of C-C, C-H, and C-O single and double bonds in the aromatic and aliphatic chain structure at various wavelengths was shown. Then, compared to the pure ABS polymer in terms of elastic modulus and tensile strength, the blend with hemp fibre resulted in increased properties, while the structure containing fibre waste resulted in lower mechanical value. In the mixture with ABS, while the hemp fibre structure gives relatively higher mechanical value, it was found that the structure containing fibre waste is more advantageous in terms of cost and is suitable for use in applications where high mechanical properties are not required.

Keywords: Bioplastic, Hemp Fiber, Silane, Thermal Improvement.

INTRODUCTION

Concerns about petroleum-derived materials such as resource depletion and environmental problems are increasing, and this increases the importance of alternative resources. Although the use of biological resources together with petroleum-derived plastics is increasing, one of the obstacles to the widespread use of applications in this field is the low thermal resistance of bio-sourced materials (Kaddouri et al., 2024). Additionally, there are not enough studies on the use of these materials together with engineering plastics processed at high temperatures. Besides, the hemp plant is a plant that grows quickly and has a strong fibre structure and thus has the potential to be used in the industrial field. (Keller, 2013)

In this study, it was aimed to increase the thermal resistance of hemp fibres (HF) and fibre waste (FW) defined as scrap by modifying them with various methods. For this purpose, the study was conducted on applying alkaline and silanization processes to hemp fibers and fiber wastes and then evaluating them with FTIR, TGA and SEM analyses. Finally, a mixture was created with acrylonitrile-butadiene-styrene (ABS) polymer, an engineering plastic, and examined its mechanical properties.

MATERIALS AND METHODS

Materials

Hemp fiber and hemp fiber waste were utilized as primary bio-sources and reinforcement materials. Sodium hydroxide (NaOH) and aminopropyltrimethoxy silane were employed during the modification steps to enhance the properties of the hemp structures. The modified hemp structures were then compounded with acrylonitrile-butadiene-styrene (ABS) copolymer to form composite materials. A pin mill was used for the grinding process to ensure a consistent particle size of the bio-sources. Additionally, sulfuric acid (H_2SO_4) was used for the Klason lignin determination, aiding in the chemical analysis of the lignin content in the fibers. These materials and methods were selected to improve the thermal stability, mechanical properties, and overall performance of the hemp-based composites.

Methods

The cellulose, hemicellulose and lignin ratios in the structure of hemp fibres and fibre waste were determined by the Klason lignin method. Then, grinding to under 200 microns size, alkalization with 1M NaOH and silanization with 0.75 M amino silane were applied to these structures, and dried in an oven at 80 ^{o}C. After these processes, material properties were examined with SEM, FTIR and TGA. After that, modified materials were compounded with ABS at 210 ºC temperature using an extrusion machine. The resulting composites were then subjected to mechanical testing to evaluate their performance characteristics.

The properties of the modified hemp structures were analyzed using Scanning Electron Microscopy (SEM), Fourier Transform Infrared Spectroscopy (FTIR), and Thermogravimetric Analysis (TGA). SEM provided insights into the surface morphology and structural changes, FTIR was used to identify functional groups and confirm the chemical modifications, and TGA assessed the thermal stability of the hemp structures.

Characterization

A small piece of the modified and unmodified hemp structures was examined with a Zeiss EVO LS 10 scanning electron microscopy (SEM). The test pieces were coated with thin layer gold on the surface to provide electrical conductivity. Perkin Elmer Spectrum 100 FTIR device was used for FTIR analysis. The absorption peaks in the FTIR spectrum show the functional groups of the components of lignocellulosic materials such as cellulose, hemicellulose, lignin. TGA analysis was performed to examine the thermal properties of the modified hemp structures. In the study, SII Nanotechnology SII6000 Exstar TG/DTA 6300 TG/DTA device was used. In this analysis carried out in a nitrogen atmosphere, the device was operated with a temperature increase rate of 10 ºC/min and the percentage change in sample weight depending on temperature was calculated in the temperature range of 30-600 ºC.

RESULTS

As a result of the Klason lignin method, hemp fibre contains 72% cellulose, 18% hemicellulose, 8% lignin, and 2% ash content and fibre waste contains 48% cellulose, 18% hemicellulose, 30% lignin and 4% ash content.

The effect of the modification process on the surfaces of hemp structures is shown in the SEM images given in Figure 1. As seen in Figure 1, there are significant amounts of impurities on the surfaces of unmodified hemp structures. It has been shown that the applied modification methods play an effective role in removing surface impurities. In addition, it was clearly observed that the fibril bundles of the modified structures are separated from each other as a result of fibrillation. This situation can be observed effectively in hemp fiber. The reason for this may be that the modification processes were more efficient for the hemp fiber and thus caused the fiber to fibrillate. In addition, it is thought that after the applied modification process, surface impurities and rough surface are removed, and functional groups were formed on the fiber structures. In this way, the modified surface can interact with the polymer, and it is predicted that this situation may increase the bond formation between hemp structures and the polymer matrix. The similar situations have been shown in other studies and reported in other biosourced structures (Cai et al., 2015; Williams et al., 2011; Asim et al., 2016; Ikramullah et al., 2018; Reddy et al., 2013; Srinivasa and Bharath 2013; Tenazoa et al., 2021).). In these studies, it is stated that similar structures undergo fibrillation with the modification processes applied. These changes can increase the interaction of hemp structures with the polymer matrix, it is thought that they will contribute positively to the polymeric composites to be produced.

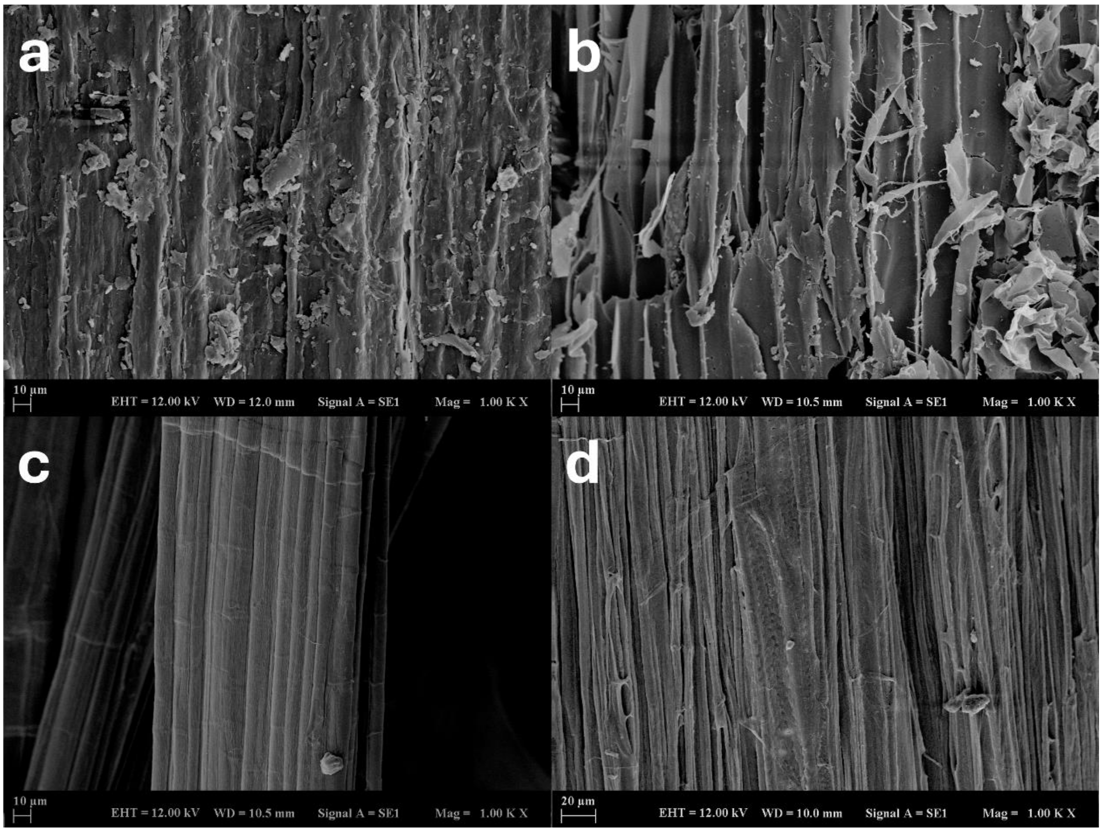

Figure 1 SEM images of a) fiber, b) hurd, c) modifed fiber, and d) modified hurd

FTIR results of hemp structures are shown in Figure 2. The signals in the spectrum of the main components such as cellulose, hemicellulose and lignin for hemp structures are comprehensively available in the studies in the literature (Sudha and Thilagavathi, 2016; Bakri et al., 2016; Sepe et al., 2018; Tenazoa et al., 2021; Bartos et al., 2021; Asim et al., 2016). When the signals for FTIR spectra are examined, the wide absorption band region between 3600 cm^{-1} and 3000 cm^{-1} indicates -H and -OH bond groups. These regions generally contain the main functions of phenol, alcohol and water. The signals in these regions decreased or disappeared as a result of the modification process. Changes in this region indicate the removal of phenolic and aliphatic hydroxyl groups in the fiber due to modification. The regions of 2900 cm^{-1} and 2850 cm^{-1} indicate the C-H and O-H bond structure in the functional alkane and carboxylic acid structure found in the cellulose and lignin structure. After the modification, the changes of the peaks at 1750 cm^{-1} and 1700 cm^{-1} for the fiber are attributed to the C=O bonds in the hemicellulose structure. The 1700 - 1600 cm^{-1} regions are defined as C=C, which are called the functional groups of alkenes. The regions 1420 - 1300 cm^{-1} represent C-H bends found in functional alkane groups. Functional alcohol groups are characterized as 1050 - 1000 cm^{-1} CO bonds, and decreases in the peaks in these regions were observed. Additionally, after the modification process, the color of the hemp structures changed. The change in color of these structures is due to the removal of lignin structures that act as natural dye within the structure. When the FTIR spectra of the modified structures are examined, it is known that the most intense regions in the spectrum of silane are the regions of approximately 1050 - 1000 cm^{-1} and 800 - 650 cm^{-1}, where the C–O, Si–O and Si–C bonds. These peaks are not visible in the spectra of silane-modified structures, probably because they overlap with the signals of the organic component of hemp fibers. Consequently, when it is evaluated in general, the changes in the intensities of FTIR spectra show that the modification of hemp structures was carried out successfully.

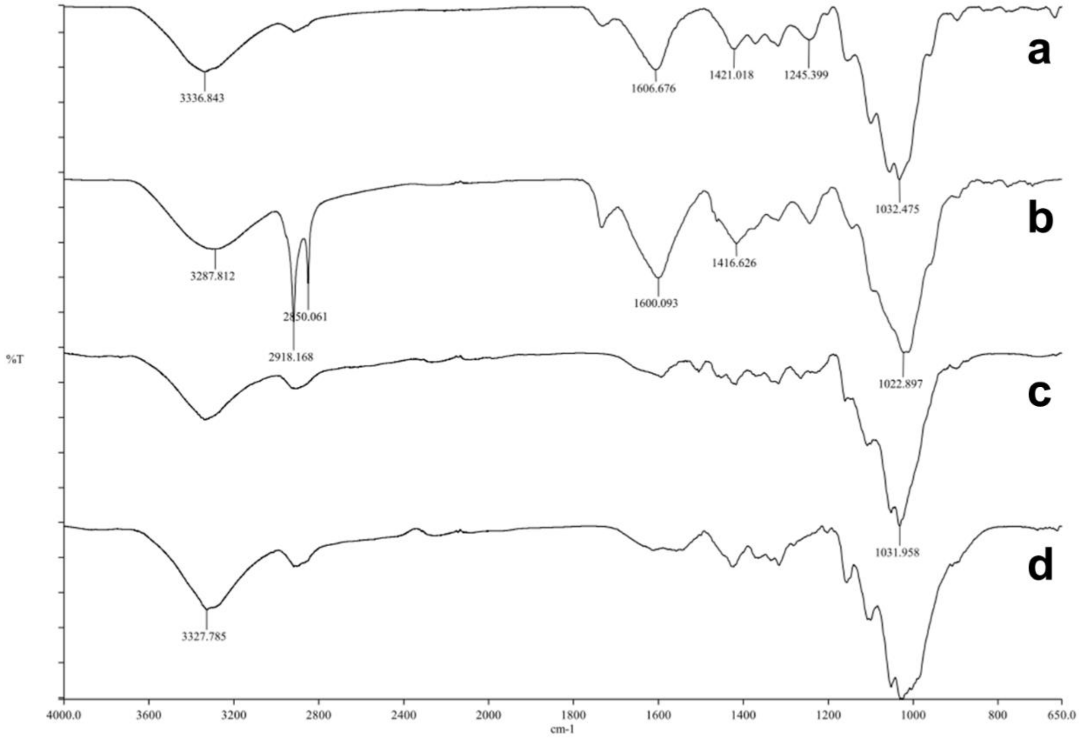

Figure 2 FTIR results of a) hurd, b) fiber, c) modifed hurd, and d) modified fiber

Figure 3 shows the TGA analysis curve for untreated hemp fiber, while Figure 4 shows the analysis curve of modified hemp fiber. The first curve that appears is due to the release of moisture contained in the structures. Afterwards, it is observed that the hemicellulose structure deteriorates in the temperature range of 200 - 320 °C, and the cellulose and lignin structure also decomposes in the temperature range of 260 - 350 °C. In Figure 4, it is concluded that there is an increase in the degradation temperature of the material and the modification developed the thermal properties. According to TGA results, the thermal stability and resistance were improved from 250 °C to 350 °C for hemp fiber and from 250 °C to 320 °C for fiber waste.

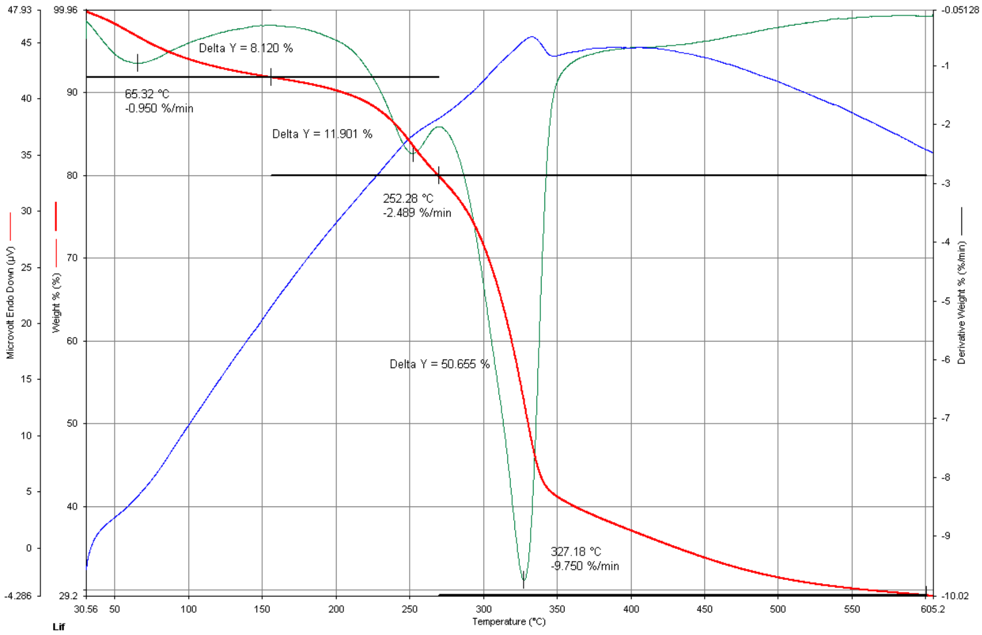

Figure 3 TGA graph of unmodified hemp fiber

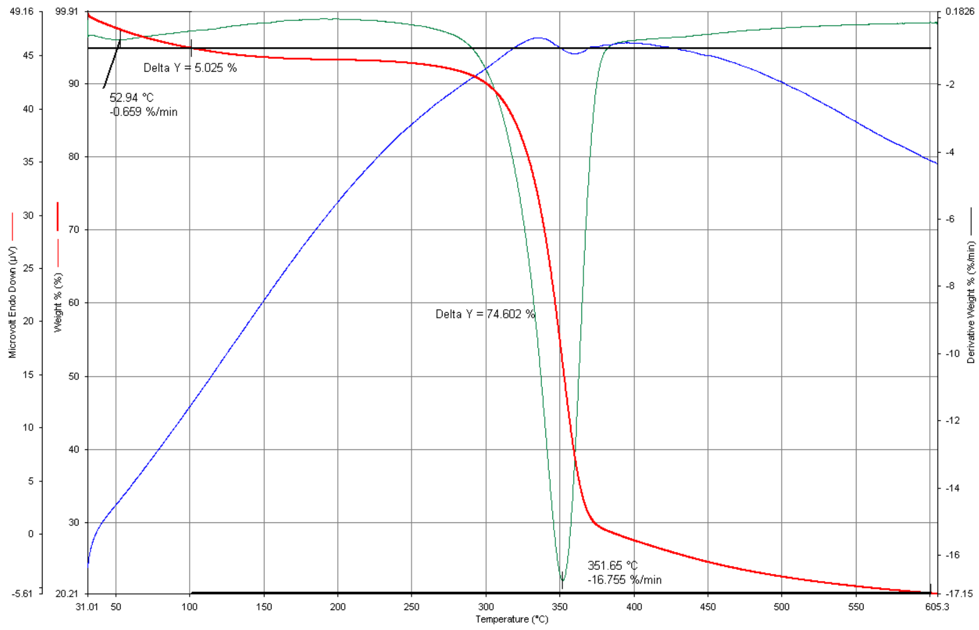

Figure 4 TGA graph of modifed hemp fiber

In this study, hemp structures were added with a 22% weight ratio as bio-sourced in the biocomposite formula and their properties were examined. After the compounding process, compared to the pure ABS polymer in terms of elastic modulus and tensile strength, the blend with hemp fibre resulted in increased properties, while the composite material containing fibre waste resulted in lower mechanical value. As a result, in terms of tensile strength, ABS copolymer showed 50.5 MPa, ABS/hemp fiber composite 74.1 MPa, and ABS/fiber waste composite 48.7 Mpa. Test results are shown in Table 1. Due to the strength provided by the fiber structures, the hemp fiber reinforced composite material exhibited higher tensile strength. The reason why the composite material containing fiber waste results in low mechanical value can be shown as the inability of fiber waste to create effective bonding interaction with the ABS copolymer.

Table 1 Mechanical properties of ABS and compounded materials

	ABS	**ABS/HF**	**ABS/FW**
Tensile Strength at Break (MPa)	50.5	74.1	48.7
Elastic Modulus (GPa)	2.7	4.18	3.8

In this study, various tests were applied to the modified hemp structures and the produced biocomposites and their properties were examined. Regarding this, it was concluded that the modification processes are effective and can be compounded with ABS polymer processed at high temperatures.

CONCLUSION AND DISCUSSION

As a result of the study, the fiber and fiber waste of hemp were analyzed and the efficiency of the modification process was evaluated. It is seen that the modified fiber and the fiber waste have superior properties to the unmodified structures in terms of surface properties and thermal resistance. In addition, it was determined that the modification process played an active role in the removal of non-cellulose structures. According to the improvement of surface properties and increase in thermal resistance, it is thought that the modification process improves the fibers and provides an advantage in processing with an extruder carried out at high temperatures to produce polymer-based composite materials. In terms of mechanical properties, the composite material containing hemp fiber resulted in higher mechanical properties. However, it has been shown that composite structures containing fiber waste can be used in applications requiring cost advantage.

REFERENCES

Asim et al., 2016. Asim, M., Jawaid, M., Abdan, K., & Ishak, M. R. (2016). Effect of alkali and silane treatments on mechanical and fibre-matrix bond strength of kenaf and pineapple leaf fibres. Journal of Bionic Engineering, 13(3), 426-435.

Bakri et al., 2016. Bakri, M. K. B., Jayamani, E., Hamdan, S., Rahman, M. R., Soon, K. H., & Kakar, A. (2016). Fundamental study on the effect of alkaline treatment on natural fibers structures and behaviors. Journal of Engineering and Applied Sciences, 11(14), 8759-63.

Bartos et al., 2021. Bartos, A., Anggono, J., Farkas, Á. E., Kun, D., Soetaredjo, F. E., & Móczó, J. (2020). Antoni; Purwaningsih, H.; Pukánszky, B. Alkali treatment of lignocellulosic fibers extracted from sugarcane bagasse: Composition, structure, properties. Polym. Test, 88, 106549.

Cai et al., 2015. Cai M., Takagi, H., Nakagaito, A. N., Katoh, M., Ueki, T., Waterhouse, G. I., & Li, Y. (2015). Influence of alkali treatment on internal microstructure and tensile properties of abaca fibers. Industrial Crops and Products, 65, 27-35.

Ikramullah et al., 2018. Ikramullah, I., S. Rizal, S. Thalib, and S. Huzni. 2018. Hemicellulose and lignin removal on typha fiber by alkali treatment. IOP Conference Series: Materials Science and Engineering 352 (1).

Kaddouri et al., 2024. Hicham Kaddouri, Abderrahim Abidouche, Mohamed Saidi Hassani Alaoui, Ismael Driouch, & Said Hamdaoui. (2024). Impact of Insulation using Bio-sourced Materials on the Thermal and Energy Performance of a Typical Residential Building in Morocco. Journal of Advanced Research in Fluid Mechanics and Thermal Sciences, 117(1), 43–59. https://doi.org/10.37934/arfmts.117.1.4359

Keller, 2013. Nicole M. Keller, The Legalization of Industrial Hemp and What it Could Mean for Indiana's Biofuel Industry, Indiana International & Comparative Law Review, 23 (3): 555, doi:10.18060/17887

Reddy et al., 2013. Reddy, K. O., K. N. Reddy, J. Zhang, and A. V. Rajulu. 2013. Effect of alkali treatment on the properties of century fiber. Journal of Natural Fibers 10:3. doi:10.1080/15440478.2013.800812.

Sepe et al., 2018. Sepe, R., Bollino, F., Boccarusso, L., & Caputo, F. (2018). Influence of chemical treatments on mechanical properties of hemp fiber reinforced composites. Composites Part B: Engineering, 133, 210-217.

Srinivasa and Bharath, 2013. Srinivasa, C. V., and K. N. Bharath. 2013. Effect of alkali treatment on impact behavior of areca fibers reinforced polymer composites. International Journal of Materials Engineering 7:4.

Sudha and Thilagavathi, 2016. Sudha, S., & Thilagavathi, G. (2016). Effect of alkali treatment on mechanical properties of woven jute composites. The Journal of The Textile Institute, 107(6), 691-701.

Tenazoa et al., 2021. Tenazoa, C., Savastano, H., Charca, S., Quintana, M., & Flores, E. (2021). The effect of alkali treatment on chemical and physical properties of ichu and cabuya fibers. Journal of Natural Fibers, 18(7), 923-936.

Williams et al., 2011. Williams, T., Hosur, M., Theodore, M., Netravali, A., Rangari, V., & Jeelani, S. (2011). Time effects on morphology and bonding ability in mercerized natural fibers for composite reinforcement. International Journal of Polymer Science, 2011.

PRESERVING INDIGENOUS CATTLE: SAFEGUARDING BIODIVERSITY AND ENHANCING FOOD SECURITY

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Abstract

Indigenous cattle breeds play a crucial role in maintaining biodiversity and enhancing food security worldwide. This paper explores the significance of indigenous cattle for biodiversity conservation and food security, highlighting their unique characteristics and contributions to sustainable agriculture.

Significance of Indigenous Cattle:

Biodiversity Conservation: Indigenous cattle breeds possess diverse genetic traits adapted to specific environmental conditions and traditional farming practices. Preserving these breeds ensures the maintenance of genetic diversity within cattle populations, which is essential for resilience to environmental stressors and disease resistance.

Adaptation to Local Environments: Indigenous cattle have evolved over generations to thrive in diverse ecological settings, including harsh climates, rugged terrains, and limited-resource environments. Their resilience and ability to utilize locally available feed resources contribute to the sustainability of agricultural systems and resilience to climate change.

Cultural Heritage: Indigenous cattle breeds are deeply rooted in cultural traditions and livelihoods of communities around the world. They often hold symbolic and spiritual significance, representing cultural identity and ancestral connections. Preserving indigenous cattle breeds helps safeguard traditional knowledge and cultural heritage associated with livestock husbandry.

Food Security: Indigenous cattle play a vital role in providing nutritious food, such as milk, meat, and by-products, to millions of people, particularly in rural and marginalized communities. Their contributions to small-scale agriculture and subsistence farming systems contribute to household food security and livelihoods, enhancing resilience to food crises and economic shocks.

Challenges and Conservation Strategies:

Genetic Erosion: Indigenous cattle breeds face threats from genetic erosion due to crossbreeding with exotic breeds, habitat loss, and changing agricultural practices. Conservation efforts focused on genetic preservation, breed improvement, and sustainable breeding programs are essential to prevent further loss of genetic diversity.

Market Pressures: Economic incentives favoring high-yielding exotic breeds often lead to the marginalization of indigenous cattle breeds in commercial livestock production systems. Promoting value-added products, eco-labeling schemes, and market incentives for indigenous cattle products can enhance their economic viability and market competitiveness.

Policy Support: Adequate policy frameworks and institutional support are critical for promoting the conservation and sustainable use of indigenous cattle breeds. Policies should address issues such as breed registration, access to grazing lands, genetic resources management, and market access for indigenous cattle products.

Table 1. The most important aspects of preserving indigenous cattle.

Aspect	*Description*	*References*
1. Biodiversity Conservation	Indigenous cattle breeds possess diverse genetic traits adapted to specific environments, contributing to genetic diversity within cattle populations.	1, 2
2. Adaptation to Local Environments	Indigenous cattle have evolved to thrive in diverse ecological settings, showcasing resilience to environmental stressors and utilization of local feed resources.	3, 4
3. Cultural Heritage	Indigenous cattle breeds hold cultural significance, representing ancestral connections and traditional knowledge associated with livestock husbandry.	5, 6
4. Contribution to Food Security	Indigenous cattle provide nutritious food, including milk, meat, and by-products, supporting food security and livelihoods in rural and marginalized communities.	7, 8

In conclusion, indigenous cattle breeds represent invaluable assets for biodiversity conservation, cultural heritage preservation, and food security enhancement. Their unique genetic traits, adaptation to local environments, and contributions to sustainable agriculture underscore the importance of prioritizing their conservation and sustainable utilization. By addressing the challenges and implementing effective conservation strategies, we can ensure the resilience and continued contributions of indigenous cattle to global food security and livelihoods.

Key words: biodiversity, conservation, food security, indigenous cattle

REFERENCES

1. Reist-Marti, S. B., Simianer, H., & Gibson, J. (2003). Effects of optimal contribution selection on genetic diversity in livestock populations. Journal of Animal Breeding and Genetics, 120(6), 371-390.
2. Leroy, G., Baumung, R., Boettcher, P., Scherf, B., & Hoffmann, I. (2016). Review: Sustainability of crossbreeding in developing countries; definitely not like crossing a meadow!. Animal, 10(2), 262-273.
3. Hanotte, O., Bradley, D. G., Ochieng, J. W., Verjee, Y., Hill, E. W., & Rege, J. E. (2002). African pastoralism: genetic imprints of origins and migrations. Science, 296(5566), 336-339.
4. Mbole-Kariuki, M. N., Sonstegard, T., Orth, A., Thumbi, S., Bronsvoort, M., Kiara, H., ... & Woolhouse, M. (2014). Genome-wide analysis reveals the ancient and recent admixture history of East African Shorthorn Zebu from Western Kenya. Heredity, 113(4), 297-305.
5. Porter, V., Alderson, L., Hall, S. J., & Sponenberg, D. P. (2016). Mason's world encyclopedia of livestock breeds and breeding (Vol. 1). CABI.
6. Felius, M. (1995). Cattle breeds: an encyclopedia. Trafalgar Square Publishing.
7. FAO. (2009). Indigenous knowledge: the case of indigenous cattle breeds. Retrieved from http://www.fao.org/3/x0490e/x0490e0h.htm
8. Thornton, P. K., Kruska, R. L., Henninger, N., Kristjanson, P. M., Reid, R. S., Atieno, F., ... & Ndegwa, T. (2002). Mapping poverty and livestock in the developing world. International Livestock Research Institute.

POLİTİK VE STRATEJİK BİR BİTKİ: KENEVİR

A POLITICAL AND STRATEGIC PLANT: HEMP

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Özet

Kenevir algısal olarak uyuşturucu ile bir arada değerlendirilen bir bitki gibi görünse de içeriği ve kullanım alanlarına bakıldığında aslında stratejik ve politik bir bitkidir. Algısal sorunlar, yasal olarak ekiminin zor olması ve altyapı eksikliği olsa da çevresel, ekonomik, sosyal ve sağlık alanında farklı etkileri vardır. Karbon yakalama özelliği, sürdürülebilir yapısı, toprak üzerindeki verimlilik açısından çevresel bir üründür. Farklı sektörlerde kullanım sağlaması, çiftçiler için yüksel gelir sağlaması, bölgesel bir ekim ürünü olması açısından kalkınma odaklıdır. Tıp, kozmetik ve gıda alanında kullanılan sağlıklı bir üründür. Türkiye 1960'lı yılların sonunda haşhaş ekimi ile ilgili Amerika Birleşik Devletleri tarafından baskı altına alınmış, dönemin ABD Başkanı Richard Nixon tarafından Türkiye Başbakanı Süleyman Demirel'e mektup yazılarak haşhaş (kenevir) ekimine yönelik kısıtlama yapılması istenilmiş, Başbakan Demirel tarafından "Türkiye'de 120 ton afyon yetişiyor. Bu, sizin gençliğe bir hafta yetmez!" ifadesi ile teklif red edilmiştir. 1971 yılında askeri müdahale ile Nihat Erim hükümeti kenevir ekimini durdursa da 1974 yılında Bülent Ecevit tarafından ekim yeniden başlatılmış. Dönem araştırmacılar ABD'nin ve Batı toplumlarının ambargo nedeninin altında aslında kenevir ekimi olduğu savı çok güçlüdür. Zira 1980 darbesi sonrasında kenevir ekimi yeniden yasaklanmıştır. 2016 yılına gelindiğinde Türkiye 19 il belirleyerek izine tabi olacak şekilde kenevir ekimini yeniden yasallaştırmıştır. Bu çalışmada; kenevirin Türkiye'deki tarihsel durumu politik ve stratejik bakış açısı ile ele alınacak, ekonomik değeri açısından kalkınmaya sağlayacağı etki üzerindeki rolü araştırılacaktır.

Abstract

Although cannabis is commonly perceived as a plant associated with drugs, it is in fact a strategic and political plant when viewed through the lens of its content and areas of use. Despite the existence of perceptual challenges, the difficulties associated with legal cultivation and the lack of infrastructure, it has a multitude of environmental, economic, social, and health impacts. From an environmental perspective, it can be considered a product due to its carbon capture, sustainable structure, and productivity on soil. It is development-oriented in terms of its use in different sectors, providing high income for farmers, and being a regional cultivation product.

It is a healthy product used in medicine, cosmetics, and food. At the end of the 1960s, Turkey was subjected to pressure from the United States of America regarding poppy cultivation. In a letter to Turkish Prime Minister Süleyman Demirel, then-US President Richard Nixon requested restrictions on poppy (hemp) cultivation. Prime Minister Demirel responded with a rhetorical question, "120 tons of opium grows in Turkey. This is not enough for your youth for a week!" and the proposal was rejected. In 1971, the military intervention led to the cessation of hemp cultivation by the Nihat Erim government. However, in 1974, Bülent Ecevit initiated a resumption of this practice. Historians of the period have persuasively argued that the rationale behind the embargo imposed by the United States and Western societies was, in fact, hemp cultivation. Following the 1980 coup, hemp cultivation was once again prohibited. By 2016, Turkey had re-legalized hemp cultivation in 19 provinces, subject to a permit. This study will examine the historical situation of hemp in Turkey from a political and strategic perspective, and investigate its role in terms of its economic value and its impact on development.

LOW COST BIOETHANOL PRODUCTION FROM VARIOUS PLANT BIOMASS INCLUDING HEMP BY NANO-COUPLED RECOMBINANT B-GLUCOSIDASE FROM *CLOSTRIDIUM CLARIFLAVUM*

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Abstract

The demand for alternative energy is steadily rising in both transportation and industrial sectors. Among the leading sources, biofuel stands out, utilizing thermostable cellulases to convert cellulosic material into fermentable sugars. In this study, a 1.4 kb fragment of the thermophilic strain *Clostridium clariflavum*, encoding endo-1,4-β-glucanase, was cloned and expressed in *E. coli* using the pET-21a(+) vector through standard procedures. The β-glucanase was then purified via precipitation with ammonium sulfate and affinity chromatography (immobilized metal ion). Various techniques including agarose gel electrophoresis, SDS-PAGE, enzyme assays, scanning electron microscopy, saccharification, and immobilization were employed to analyze the enzyme. The purified enzyme exhibited a 2.42-fold purification, with a specific activity of 28.71 U mg-1, 26.31% recovery, and a molecular weight of 52 kDa. It demonstrated stability at 75°C and pH 5-10, showing heightened activity in the presence of Zn^{+2} and Mg^{+2}, while being less active in the presence of Mn^{+2}, Cu^{+2}, and Co^{+2}, and significantly affected by EDTA. Saccharification experiments using 50 units of the enzyme at 60°C for 72 hours yielded a saccharification percentage of 21.7% and 20.4 % for pre-treated *Saccharum munja* (soft part) and hemp respectively, as analyzed by scanning electron microscopy. Upon enzyme immobilization with magnetic nanoparticles, improved saccharification percentage and reusability were achieved. The saccharification process was repeated 12 times using the immobilized β-glucanase, retaining at least 50% enzyme activity, leading to a significant reduction in the cost of biofuel production. Furthermore, the yeast strain *Wickerhamomyces anomalus* was employed to maximize bioethanol production (3.73±0.10 g/L). These findings underscore the efficacy of recombinant β-glucanase in biofuel production and highlight the potential of repeated saccharification processes using immobilized enzymes for cost-effective production.

Key words: β-glucosidase, hemp, nano-particles, *Clostridium clariflavum*

ENHANCING FABRIC STRUCTURES DERIVED FROM TURKISH HEMP FIBERS WITH ECO-FRIENDLY NATURAL DYE APPLICATIONS

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Abstract

Introduction and Purpose: The textile industry is one of the largest and most polluting sectors, contributing to pollution such as water pollution and greenhouse gas emissions. As a response, the sustainability of natural fibers like hemp is becoming increasingly crucial. Hemp offers multiple annual harvests, high yields, requires minimal pesticides, is easy to cultivate, and has a low carbon footprint, making it an ideal candidate for eco-friendly fabric production. This study was aimed at contributing to gate-to-gate sustainability by dyeing fabrics obtained from Turkish hemp fibers with natural dyes.

Materials and Methods: Eight different natural colorants—oad, hibiscus, *Alkanna tinctoria*, *Lawsonia inermis*, *Beta vulgaris*, *Glycyrrhiza*, *Cortex Granati fructuum*, and *Curcuma longa*—were examined in two groups as substantive and mordant dyes. The natural colorants were applied to knitted hemp-blended fabrics without mordant, with a biomordant, and with a conventional mordant in the laboratory-type sample-dyeing machine using three different prescriptions. In the dyeing process with mordant dyes, alum and vinegar are used as conventional and natural mordants, respectively. The most eco-friendly processes were determined by performing color fastness tests on the samples obtained.

Results: The color fastness tests of the dyed samples revealed that most combinations met expected results from laundering (ISO 105 C06), water (ISO 105 E01), and rubbing (ISO 105 X12). All samples except those dyed with oad and *Cortex Granati fructuum* had rather poor color fastness to artificial light (ISO 105 B02).

Discussion and Conclusion: Cumulative analysis revealed that the samples dyed with oad and *Cortex Granati fructuum* had the highest color fastness results for all the tests. Specifically, it was proved that oad was effective for low-temperature dyeing without mordant using minimal dyestuff, while *Cortex Granati fructuum* was optimal for high-temperature dyeing under similar conditions. Consequently, it was recognized that substantive dyes yielded the highest results and that mordant dyes were inappropriate for these applications.

Key Words: Natural Colorant; Mordant; Biomordant; Hemp; Color Fastness

TREATMENT OF TWO DYES: CRYSTAL VIOLET AND CONGO RED CONTAINED IN WASTEWATER USING THE ELECTROCOAGULATION/ELECTRO-FLOCCULATION TECHNIQUE

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Abstract

Electrocoagulation is used to treat Congo red and crystal violet. The objective is to optimize the optimal parameters: pH, current density and electrolysis time. The treatment is carried out with the iron and aluminum electrode. the iron electrode gave better yields on the treatment of two dyes compared to the aluminum electrode. the sludge underwent IR, SEM and XRD analyzes in order to know the mechanism of the reaction.

Keywords: Electrocoagulation, Electro-flocculation, dyes, sewage sludge, wastewater.

PURSUIT OF CLEAN ENERGY: PEROVSKITE-BASED SOLAR CELLS

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Abstract

In a world yearning for a widespread progress and advancement in many areas and disciplines, a crucial question arises: can we evolve without sacrificing the environment? Unsustainable land management practices, depletion of natural resources, and improper waste disposal, along with other human behaviors foremost, such as the businesses and industries, exacerbate environmental challenges.

A promising path for mitigating these challenges, renewable energy, sunlight and wind as examples are replenished, natural sources offering a path towards sustainability. The sunlight, abundant and freely available, the energy source behind the photovoltaic panels, the solar panels. A solar cell, have the ability to convert sunlight directly into electricity, a process known as the photovoltaic effect through the application of semi-conductor materials. By connecting numerous solar cells, series of panels are formed capable of powering homes, businesses and large-scale utility projects. The well-established type of solar cells, silicon-based solar cells, the dominant in this industry is reaching the **theoretical efficiency limit.** With the aim of pushing the boundaries of efficiency, new materials and technologies are constantly explored. Our ongoing research is driven towards the perovskite-based solar cells, the perovskite material has intriguing optical and electronic properties, in order to predict and understand the material's behavior, we work with the density functional theory (DFT), a series of analysis and calculations to explore the various perovskite compositions and their potential. Moreover, due to compositional flexibility, the crystal has diversity of options related to processing different architectures for the solar cell. Therefore, the perovskite as an energy material, become a new player in solar cell technology, towards a more reliable and sustainable option, overcoming stability hurdles and seeking lead-free alternatives. We explore and delve into the perovskite-based solar cells, thus significantly contributing to the renewable energy sector.

KEYWORDS: Renewable energy, Sustainability, Photovoltaics (PV), Cell architectures, Perovskite solar cells, Density functional theory (DFT).

RECYCLING OF WASTE COMPOSITE MATERIALS FOR USE AS FILLER IN GLASS-POLYESTER COMPOSITES FOR NAVAL USE

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Abstract

Composite materials occupy a preponderant place in several technological sectors, such as space, aeronautics, automobiles, rail, naval and many others. The production of composite parts, like all other design processes, generates shavings and waste that is difficult to recycle. This waste generates chemical pollutants during its incineration and visual pollutants when it is piled up. It is also an economic loss which is reflected in the cost of parts. Their recycling can be a socio-economic solution of capital importance. For this purpose, the crushing and incorporation of waste as filler was adopted. The study we carried out consists of loading a polyester resin used in the field of shipbuilding, at different particle sizes and at different percentages. This resin was subsequently used to produce various laminate plates, which were cut with a diamond disc to produce standardized test pieces. These specimens underwent various mechanical tests to highlight their resistance characteristics. These tests (traction, resilience, hardness, pyrolysis, and microscopy) have demonstrated that the fillers incorporated in the polyester resin are a positive contribution to the composite material used for shipbuilding. This study, which highlights the importance of recycling waste from composite materials, will allow the incorporation of filler in certain parts used for the construction of boats in the shipyard which supervised the latter.

Keywords: Recycling, composite, glass, polyester, traction, resilience.

EXAMINING TWO BISKRA PLANTS FROM THE SAHARA TO DETERMINE WHETHER THEIR PHENOLIC COMPONENTS HAVE ANY POTENTIAL INSECTICIDAL

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Abstract

The present work, is about the dosage of the phenolic compounds of two Saharan plants, Anvillea radiata and Astragalus armatus and their insecticidal (Aphis gossypii) and microbial (Staphylococcus aureus, Escherichia coli, Pseudomonas aeruginosa. Candida albicans) effectiveness. The dosage of the total polyphenols and flavonoids is carried out by the method of Folin-Ciocalteu and AlCl3 respectively, the phenol contents of Anvillea radiata ethanol = 91.06 ± 13.8., Astragalus armatus ethanol = 82.17 ± 10.8, Anvillea radiata chlorophorme = 24.17 ± 4.12 and Astragalus armatus chloroform = 35.28 ± 13.3µgEGA / mg DM. While the flavonoid contents remain low for all extracts (Anvillea radiata ethanol = 5.40 ± 2.8, Astragalus armatus ethanol = 0.3125 ± 0.2, Anvillea radiata chloroform = 1.6 ± 0.6 and Astragalus armatus chloroform = 0.312 ± 25.7 µg EGA / mg DM). Both chloroform and ethanolic extracts from A. radiata revealed antibacterial activity against staphylococcus aureus bacilli, with zones of inhibition of 10 ± 2.6 mm and 16.5 ± 2.1mm respectively,on the other hand the four extracts of the two plants showed an insecticidal effect for the three doses.

Key words: Characterization; antioxidants; phenolic compounds; flavonoids; Saharan plants

IN VITRO A-AMYLASE AND HEMOGLOBIN GLYCATION INHIBITORY POTENTIAL OF NIGELLA SATIVA ESSENTIAL OIL, AND MOLECULAR DOCKING STUDIES OF ITS PRINCIPAL COMPONENTS

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Abstract

Nigella sativa is plant that is endowed with various pharmacological activities including antioxidant, anticancer, anti-inflammatory, antibacterial, antidiabetic, and immunostimulant. This study aims to investigate the antidiabetic activity of the N. sativa essential oil on two key enzymes the α-amylase and hemoglobin glycation. After the extraction procedure, the N. sativa essential oil, were subject to qualitative and semi-quantitative analysis using GC/MS, for the identification of the different bioactive compounds. This was followed by an evaluation of the in vitro inhibition capacity of the α-amylase and the hemoglobin glycation. Finally, a molecular docking study was conducted to determine the bioactive compounds responsible for the antidiabetic activity. The extracted essential oil showed the presence of different bioactive compounds including α-phellandrene (29.6%), β-cymene (23.8%), 4-caranol (9.7%), thymol (7%). The N. sativa essential oil was found to be endowed with antidiabetic properties, the IC50 value for the α-amylase inhibitory activity was 0.809 mg/mL, indicating an inhibitory impact of the enzyme. The IC50 value for the N. sativa essential oil's hemoglobin antiglycation activity was 0.093 mg/mL. For most predominating phytochemicals present in the N. sativa essential oil, molecular docking studies against human pancreatic α-amylase and human hemoglobin enzymes revealed that these compounds can serve as lead molecules to develop new antidiabetic compounds.

Keywords: Nigella sativa; Essential oil; α-amylase; hemoglobin glycation; diabetes.

DESIGN AND MODELING OF NEW HEMP-BASED COMPOUNDS AGAINST COLORECTAL CANCER BY THE APPLICATION OF STATISTICAL METHODS

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Abstract

The field of discovery of new therapeutic compounds has evolved due to the application and development of statistical methods which make it possible to analyze and process the experimental data of compounds in order to predict and improve their therapeutic activities. QSAR is among the most used methods in this field, this method allows the development of the relationship between the structural descriptors of molecules and their biological activities IC50 (half-maximal inhibitory concentration) in order to predict new analogues with the desired activity values by modifying the chemical structure of compounds. Additionally, a molecular

docking study is a method used to predict the most favorable conformation between the proposed compounds and the protein responsible for biological activity. In addition, the study of the pharmacokinetic and ADME-Tox (Absorption, Distribution, Metabolism, Excretion and Toxicity) properties of compounds is essential to evaluate the distribution, metabolism, elimination and toxicity of compounds in the body. Simultaneously, in previous research, the application of these statistical methods has facilitated the process and minimized the costs of drug discovery based on various bioactive plants, including cannabis, a plant cultivated and used as a result of its richness in active compounds, which exhibits a wide range of therapeutic properties, such as anti-inflammatory, anesthetic, and antiproliferative activity against human cancer cell lines, namely HCT-116 colorectal cancer cell lines. Colorectal cancer, is the third most common malignant cancer, with increasing incidence rates among young adults aged less than 50 years worldwide. Fortunately, preliminary studies by researchers have verified the antiproliferative activity of compounds synthesized from hemp against HCT-116.

Keywords: Hemp, Colorectal Cancer, Drug-Design, Molecular Modeling, QSAR, Molecular Docking, ADME-Tox.

INVESTIGATION OF THERAPEUTIC POTENTIAL OF METHANOL EXTRACT OF *EUCALYPTUS GLOBULUS* LEAF IN MITIGATING ETHANOL-INDUCED INFERTILITY IN ALBINO RATS

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Abstract

Infertility is a disease of the reproductive system and is defined as the failure to achieve a pregnancy after 12 months or more of regular unprotected sexual intercourse or the inability to stay pregnant. This research investigates the therapeutic potential of methanol extract of *Eucalyptus globulus* leaf in mitigating ethanol-induced infertility in albino rats. Determination of acute toxicity profile, hormonal analysis and semen profile of the of methanol extract of *Eucalyptus globulus* leaves (MEEGL), was carried out using standard method. The percentage yield of Eucalyptus globulus leaves is 36.7%. Qualitative phytochemical analysis of Eucalyptus globulus leaves revealed that flavonoids, tannins, and phenols were highly detected, then alkaloids, terpenoids and glycosides were moderately present, whereas saponins, steroids and hydrogen cyanide were slightly detected. The results showed that median Lethal dose (LD50) of the ethanol extract shown not toxic effect up to the dose of 5000 mg/kg body weight. The result showed that groups treated with 200, 400 and 600 mg/kg body weight of extract show a significant ($P>0.05$) disease in stem sluggish and dead sperm with corresponding increase in active sperm, normal and sperm count when compared with untreated group. The result shows a significant increase in testosterone level, Luteinizing hormone and follicle stimulating hormone level when compared with untreated group. It is concluded that the methanol extract of the Eucalyptus globulus leaves has considerable anti-infertility effects on ethanol induced infertility, confirming the reason for its wide use in the traditional treatment of impotence and other related diseases conditions.

Keywords: Infertility, sperm count, Eucalyptus globulus, Methanol extract

THE ROLE OF HEMP-BASED MATERIALS IN BUSINESS STRATEGIES: ENVIRONMENTAL AND ECONOMIC IMPACTS

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Abstract

Hemp, a highly resilient and fast-growing plant variety that can be cultivated in various climates and soil types, is an annual crop that requires low labor and has an intensive production process. It can be harvested within a short period (70-90 days). During its cultivation, hemp absorbs carbon dioxide from the atmosphere and can serve as a carbon sink by storing it throughout its lifespan. Therefore, it plays a significant role in reducing greenhouse gas emissions and combating climate change. Hemp has over 25,000 product varieties in the global market and can be used to produce textiles, paper, food, medicine, and many other industrial products, making its applications quite extensive. Industrial hemp is also utilized as biomass, besides fiber and seed, reducing competition with other food and feed crops on arable lands. It has been reported to cause less harm to the environment, prevent soil compaction, and contribute to the preservation of agricultural biodiversity. Moreover, in countries with limited energy resources, hemp biomass can be utilized as an energy source. Hemp is a versatile and sustainable plant, serving as an important tool in the fight against climate change.

However, due to misinformation about hemp, significant regulations have been imposed worldwide, resulting in adverse economic consequences for businesses involved in hemp production, making it almost unprofitable. As the number of businesses operating in this field increases, the number of products and customer potential will also expand, contributing to reaching the 2030 climate change targets effectively.

This study will investigate the role of hemp-based materials in businesses from both economic and environmental perspectives.

A DECISION SUPPORT SYSTEM THAT DETECTS CHANGES IN AGRICULTURAL PLANTING AREAS DUE TO CLIMATE CHANGE AND MAKES RECOMMENDATIONS FOR NEW AGRICULTURAL PLANTING AREAS (ADAPT-AG)

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Abstract

Climate change presents significant challenges to agricultural plantations globally, impacting productivity, sustainability, and socio-economic aspects. This study evaluates the performance of MLANN, CNN, RNN, SVM, KNN, and RF methods with fixed datasets to select optimal methods. Analysis reveals that MLANN, SVM, and RF methods yield optimal outcomes, suggesting their suitability for future system development. The research emphasizes leveraging these methods for enhanced plantation resilience and sustainability. By integrating AI technologies and sustainability indicators, proactive measures can be implemented to address climate change impacts on biomass carbon sequestration, biodiversity conservation, and plantation productivity. The study underscores the importance of understanding and managing climate change effects on agricultural systems, emphasizing the role of MLANN, SVM, and RF methods in developing resilient plantation systems.

Key Words: Climate Change, AI, Decision Support System, Agricultural Planting Areas

UNDERSTANDING THE CHALLENGES OF LEAD-BASED PEROVSKITE SOLAR CELLS AND PROSPECTS FOR SUSTAINABLE ALTERNATIVES

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Abstract

The exceptional optoelectronic properties of halide perovskites, characterized by their general formula ABX_3, have garnered significant attention in the field of solar energy. However, their commercialization has been hindered primarily by a significant obstacle – their lack of stability, largely attributed to the use of specific elements. Lead-based perovskite solar cells, renowned for high efficiency due to the presence of lead in the B site of the perovskite structure, this very element is toxic and exhibits inherent instability therefore it poses a significant environmental challenge. Consequently, the quest for lead alternatives commenced, focusing on synthetic design strategies involving elements like tin, germanium, bismuth, as well as their combinations. Double perovskites are also regarded as viable alternatives to lead perovskites in this context. Similar to lead-based perovskites, they exhibit favorable properties. However, it is worth noting that double perovskites offer the advantage of avoiding the use of toxic elements like lead while still demonstrating promising stability and efficiency characteristics. In this study, we introduce a range of lead-free perovskite materials as potential solutions to tackle the issues of instability and toxicity associated with lead-based perovskites. Our objective is to explore alternative materials that can offer improved environmental compatibility without compromising on performance of the solar cell, we rely on powerful simulation tools like the Solar Cell Capacitor Simulator (SCAPS) that plays an important role in modeling and simulating the behavior of these devices. By allowing to input the properties of various perovskite materials and device structures, SCAPS can also predict the cell's performance under different conditions. This information is invaluable for identifying promising designs and optimizing factors like layer thickness or material composition to achieve the highest possible efficiency. By investigating these lead-free perovskite options, we aim to contribute the development of more sustainable and stable perovskite-based photovoltaic technologies.

Key Words: Photovoltaic energy, perovskite solar cells, lead-free, stability, efficiency, modelling, SCAPS.

AGROECOLOGICAL CONDITIONS FOR OPTIMAL CULTIVATION OF INDUSTRIAL HEMP (*Cannabis sativa* L.) IN THE TERRITORY OF THE REPUBLIC OF SERBIA

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Abstract

The Kingdom of Yugoslavia was once one of the largest producers and exporters of the hemp in Europe. The largest areas in the former Yugoslavia were 100.000 ha (in 1949), but they were constantly reduced later. In the territory of the Republic of Serbia and AP Vojvodina, hemp was grown on about 50.000 ha. The main reason why the culture of hemp plant had such a large presence was, above all, favorable soil and climatic conditions. Today, due to various restrictions and prohibitions, industrial hemp is grown on only about 1.000 ha in the mentioned area.

Industrial hemp (*Canabis sativa* L.) differs from indian hemp in its function, cultivation technology, application, as well as in the amount of psychoactive substance (THC) which is not higher than 0.3%. The best soils for the cultivation of hemp are chernozems, alluvial soils and meadow chernozems, which are represented in the study area on a total of 1.731.900 ha, approximatelly. For cultivation, it requires well-prepared and fertilized soil whose pH value ranges from 5.8 to 7.0. Hemp is also an indicator of soil fertility, given that if the soil is heterogeneous (uneven), its cultivation varies considerably in height and overall development.

Climatic conditions of the mentioned area are also one of the important conditions for growing industrial hemp. They are appropriate and favorable, because the conditions of the length of daylight, the minimum germination temperature (1-2°C) and the optimal temperature for intensive vegetative growth of about 20 °C are met. Hemp requires a lot of moisture in the soil, but it also reacts negatively to excessive moisture, especially in the first period of growth and development. From the above mentioned, it can be accepted the fact that the agroecological conditions for growing industrial hemp are satisfying and provide potential for the development of the Serbian economy.

Key words: soil, climate factors, hemp

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CANNABIDIOL INTERACTS SYNERGISTICALLY WITH CISPLATIN IN VARIOUS BONE CELL LINES

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Abstract

Recent years have seen increased interest in the medical applications of cannabinoids isolated from hemp inflorescences. Cannabidiol (CBD), one of the non-psychotropic cannabis-derived compounds, exhibits antiepileptic, anticancer, anti-inflammatory, and antimicrobial properties. This study aimed to elucidate the anticancer properties of CBD in bone cancer cell lines (Saos-2, SW1353, and MG-63), both as a monotherapy and in combination with cisplatin (CIS). The Chou-Talalay method for combination was used for determining synergism at all doses. Hemp inflorescence were cultivated by Yozgat Bozok University Hemp Research Institute and air-dried in a room protected from sunlight. Decarboxylated plant material was obtained by heating at 105°C for 1 hour. Supercritical CO_2 extraction (scCO2) system was used to obtain crude hemp extract. A simple winterization process called dewaxing was performed at -20°C for 48 hours and the precipitated wax was removed using filtration. The enriched cannabinoid fraction from crude hemp extract was obtained using a molecular distillation system. CBD was isolated from the enriched cannabinoid fraction via a medium-pressure flash chromatography system. After removing the solvent from the separated CBD using a vacuum concentrator, its purity was checked by HPLC. MTT assay was performed by our research group to measure the anticancer effect of CBD and CIS on cell proliferation (NCI-60 screening method). The safety of CBD and CIS was tested in human normal epithelial amniotic cells (FL) in LDH assays. Additionally, DNA Laddering, Tunnel, Cell migration, Topoisomerase I, and DAPI staining were performed to reveal the mechanism of action of these combinations. Accordingly, the results indicate that CBD reduces the viability and proliferation of bone cells and exerts synergistic interactions with CIS. CBD did not cause significant cytotoxicity in the FL cell line. As a result, CBD can be considered as part of bone cancer treatment as adjuvant therapy when combined with CIS.

Keywords: Hemp, Cannabidiol, Cisplatin, Anticancer, Combination

INTRODUCTION

Osteosarcoma is a malignant tumor that can present with bone and joint pain and a local mass in the bone. Although it occurs at all ages, the incidence is highest in adolescents and the most common sites are the distal femur, proximal tibia, and proximal humeral metaphysis. Due to the poor prognosis of osteosarcoma with its early metastasis and unresponsiveness to treatment, this aggressive malignancy has become a major cause of death in adolescents and young adults. Standard treatment for osteosarcoma consists of surgery, radiation therapy, and adjuvant chemotherapy, similar to general cancer treatment. Because patients with bone cancer do not respond well to primary chemotherapy, the 5-year survival rate in patients receiving secondary treatment decreases from 75% to 25%. Therefore, further research on the combination approach of innovative treatment strategies for osteosarcoma is urgently needed (1-5).

Plant metabolites are candidate molecules that can be used in new anticancer drug development studies due to their very different structural features that can enter into unique interactions with biomolecules in their spatial arrangements. Medical cannabis, which has such molecules, has been used in pharmacological studies for many years. Phytocannabinoids are secondary metabolites with psychoactive and non-psychoactive pharmacological effects obtained from Cannabis sativa. CBD is the main non-psychoactive compound. For this reason, it is legally approved for use in research and is frequently trialed as a pain reliever in inflammatory diseases and as a chemotherapeutic in patients with different types of cancer (6-8).

Today, combined treatment methods with effective molecules have resulted in significant clinical results. Interaction studies of many secondary metabolites and currently used FDA-approved drugs, whose preclinical studies are ongoing, have led to new, more powerful pharmacologically effective molecules. In addition, in disease regimes that are difficult to treat, such as bone cancers, revealing some unknown properties of molecules that have proven effective in other diseases on bone cancers may make positive contributions to the treatment processes. Therefore, the cannabis metabolite cannabidiol (CBD) and cisplatin (CIS), which have significant pharmacological effects, may have the potential to be a new combination due to their different structural properties and the way they form new, unique, and powerful chemical associations. This project examined the combined effects of CDB and CIS molecules using the human bone osteosarcoma cell line (Saos-2, SW1353, and MG-63) and the FL normal cell line.

MATERIAL and METHODS

CBD isolation

The hemp inflorescences were dried in a clean room away from sunlight for three months. After drying, it was pulverized to a size of 80 mesh using a grinder and stored in vacuum at a room temperature. The samples were then left for decarboxylation at 105 degrees for 1 hour in an oven to convert CBD-A to CBD. After the decarboxylation process, a total of 150 g of dry hemp sample was placed in a 2 L supercritical extractor container and set up 230 bar, 50^{o}C and 50 kg/h cycle conditions. Thus, we obtained approximately 2 g of extract from 150 g of product. Since supercritical CO_2 extraction also extracts plant waxes, the extracts were dewaxed through the winterization process before proceeding with the subsequent processes. To separate the solidified wax, the solution was filtered through filter paper in a vacuum. Then, the molecular distillation method was used to separate the terpenes and chlorophylls that come with phytocannabinoids during extraction. During purification, flash chromatography used ethanol and water as solvents to separate phytocannabinoids from each other. Once the molecules have been separated, rotary evaporators were used to remove this solvent from the phytocannabinoids. When the required purity analyses were checked using HPLC (2.7 µm, 4.6x150 mm, NexLeaf CBX, PDA detector, mobile phase acetonitrile: water (9:1), analysis time: 15 min), a single peak belonging to CBD was observed and isolation its efficiency was measured as 80%. CBD samples obtained as a result of flash chromatography were dissolved in DMSO to 20 mg/mL for use in subsequent studies.

Cell proliferation assay of binary drug combinations

The antiproliferative effects of CBD alone and in binary combinations with cisplatin were examined using two human bone osteosarcoma cell lines (MG-63 [ATCC CRL-1427] and Saos-2 [ATCC HTB-85]), one human bone chondrosarcoma cell line (SW-1353 [ATCC HTB-94]), and one normal cell line (FL [ATCC CCL-62]). The data obtained from the MTT test were analyzed with CalcuSyn software. To obtain the optimal combination ratio, the Total Growth Inhibition (TGI) of these molecules was used as the recommended equipotency ratio. Therefore, for two-drug combinations that were conducted at the same time, the ratios used were, for example, A+B (a:b), B+C (b:c), and A+C (a:c). Absorbance data were loaded for automated calculation of the slope of the median-effect plot (*m*), the dose that produces a 50% effect such as TGI (D*m*), and the linear correlation coefficient of the median-effect plot (*r*) parameters, as well as the combination index (CI) and dose reduction index (DRI) using CalcuSyn (9).

Cytotoxicity test

Whether the drug/combo to be tested are cell cytotoxic or cytostatic was determined by the LDH method (10). An increase in the amount of cells that die during the incubation period, depending on the substance tested, will result in an increase in LDH in the culture supernatant. Lactate dehydrogenase (LDH) is a cytoplasmic enzyme that is found in most cells and is stable. For this purpose, the LDH cell cytotoxicity kit was used according to the manufacturer's procedure.

DNA fragmentation by agarose gel electrophoresis

DNA laddering activity of the drug/combo was evaluated by using a DNA laddering assay in accordance with the standard method. Briefly, 7.5 x 10^5 cells were placed into 25 cm^2 culture flasks and treated with TGI concentrations of the compounds at 37°C with 5% CO_2 overnight. First, DNA-containing precipitate was extracted from the digest with a 50 µL phosphate-citrate buffer and centrifuged at 1500 x g for 5 minutes, and then 40 µL of supernatant was transferred to a microcentrifuge tube. Tween20 (5 µL) solution (0.25% in ddH_2O) and RNase A (5 µL) solution were added to the supernatant and then incubated at 37°C for 30 min. Next, proteinase K (5 µL) was added to each tube and re-incubated at 37°C for 5 min. Finally, the DNA-containing precipitate of the microcentrifuge tube was added to 5 µL of loading buffer and loaded to 1.5 % agarose gel containing 0.5 µg/mL ethidium bromide and electrophoresed at 200 mA for 40 min. After electrophoresis, DNA fragmentation on gels was imaged using a UVP gel imaging system (11).

Terminal deoxynucleotidyl transferase dUTP nick end labeling (TUNEL) assay

For *in vitro* detection of apoptosis at the single-cell level was assessed using TUNEL assay and was performed according to the manufacturer’s protocol (13, 14).

Migration assay

A wound-healing assay was used to determine the effect of the compounds on the migration of cells. It is a method based on measuring the proliferation ability of cells in the medium containing the test substance. Cells are loaded at 70,000 cells / 200 µL in each well of the 24-well plate with coated poly-L-lysine and incubated for 24 hours. After incubation, the cell monolayer in a straight line scraped to create a scratch with a sterile pipet tip. The cell debris was removed and the edge of the scratch was smooth by washing the cells with medium for the in vitro scratch assay. Then, the old medium is discarded and approximately 1 mL of fresh medium is added and test molecules are placed at the GI50 dose. From this moment, the specimens begin to be photographed. Photographs were taken on scratch, in which the test substances were put every 24 hours, until the gap in the scratch, which was used as a control, was filled (12, 14).

DNA topoisomerase I inhibition assay

DNA topoisomerase I inhibitory activities of the compounds in cell-free systems were evaluated by using topoisomerase I assay kit. The principle of the assay is to measure the conversion of supercoiled pHOT1 plasmid DNA to its relaxed form in the presence of DNA topoisomerase I alone and with test compounds. The supercoiled substrate (pHOT1 plasmid DNA) and its relaxed product can easily be distinguished in agarose gel because the relaxed isomers migrate more slowly than the supercoiled isomer (13, 14).

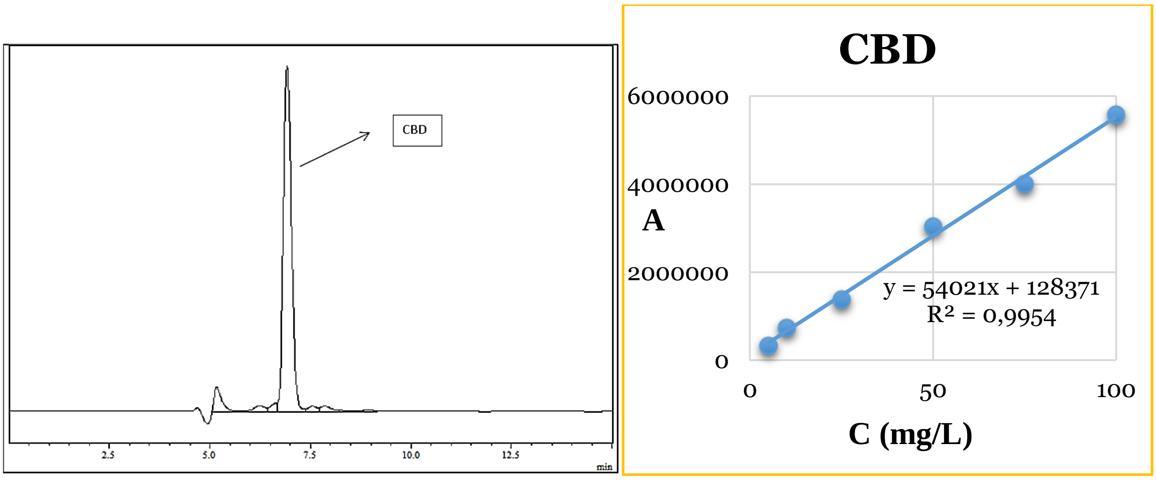
DAPI staining

DAPI stains and visualizes cell nuclei in fluorescence microscopy. Fixed cells are typically incubated in DAPI for 10 minutes, then rinsed in PBS three times to remove excess stain. Once mounted, antifade reagents can be added. Samples can then be visualized under a fluorescence microscope with a blue/cyan filter for DAPI.

RESULT and DISCUSSION

Characterization of the CBD cannabinoid

The CBD cannabinoid was assigned to appropriate peaks (expected retention time) in the chromatogram, as shown in Figure 1. Accordingly, the amount of CBD obtained was measured as 517.81 ppm.



A B

Figure 1. HPLC purity analysis result of CBD (*A*). CBD calibration curve (***B***).

Evaluation of the synergy according to mass-action methodology

Accordingly, the anticancer activity of the CBD and CIS on Saos2, MG63 and SW1353 bone cancer cell lines (GI50 values between 4,51-6,68 µM, TGI values between 9,84-25,79 µM and LC50 values 32,13-682,41 µM) is shown in Table 1. The antiproliferative effect they exhibit in FL and MRC5 normal cell lines (GI50 values between 3,39-10,88 µM, TGI values between 11-94-37,86 µM and LC50 values 124,91-639,10 µM) is shown in Table 2. This result shows that CBD has less antiproliferative effect on normal cells than on cancer cells. As stated in the NCI60 screening methodology, high Lethal Concentration (LC50) values indicate that the test substances have less cytotoxic effects and is a desired situation. Low GI50 values indicate that the cytostatic effects of the test substances are greater, and this is also a desired situation. When we look at the effect of CBD on the normal cell line FL and MRC5 in terms of NCI60 survival parameters, it can be said that the GI50, TGI, and LC50 values are within the desired levels (Tables 1 and 2).

After performing the MTT cell proliferation assay for each drug alone against cells, CalcuSyn software was used to both generate single drug dose-effect curves and calculate mass-action law parameters (D*m*), (*m*), and (*r*) (Tables 3, 4, and 5). As shown in Table 5, CBD and CIS inhibited cell growth in a dose-dependent manner. In MG63 cells, the D*m* values (TGI) of the tested drugs were found to be 15,79 for CBD. The potencies (D*m* values) of the drugs in this table are listed from largest to smallest as follows: CBD > CIS. When the D*m* values of these drugs in Saos2 cells were examined in the same table, the D*m* values were found to be 17,63 for CBD and the order of potency (D*m* values) was; CBD > CIS. In SW-1353 cells, the Dm values (TGI) of the tested drugs were found to be 16,23 for CBD. The potencies (D*m* values) of the drugs in this table are listed from largest to smallest as follows: CBD > CIS. The dose-effect curves of the tested drug on the cells were flat sigmoidal ($m < 1$). All (*r*) values of the curves were above 0.95, indicating acceptable compliance with the mass-action law.

Table 1. GI50, TGI and LC50 values for compounds against Saos2, SW1353 and MG63

(*µM*)	**Saos2**			**SW1353**			**MG63**		
	GI50	**TGI**	**LC50**	**GI50**	**TGI**	**LC50**	**GI50**	**TGI**	**LC50**
CBD	5,21	11,38	57,15	4,51	9,84	32,13	4,61	10,07	42,88
CIS	5,92	14,71	524,62	5,04	25,79	682,41	6,68	13,49	492,34

Table 2, GI50, TGI and LC50 values for compounds against FL and MRC5

(*µM*)	**FL**			**MRC5**		
	GI50	**TGI**	**LC50**	**GI50**	**TGI**	**LC50**
CBD	3,49	12,69	124,91	3,39	13,06	193,20
CIS	6,53	37,86	639,10	10,88	11,94	573,98

Table 3. Drug and Drug Combos

Drug	**Combo**
CBD (160)	CBD + CİS (16:8)
CIS (80)	

Table 4. The combination index method

Range of CI*	Description	Range of CI*	Description
< 0.1	Very strong synergism	1.10 - 1.20	Slight antagonism
0.1 - 0.3	Strong synergism	1.20 - 1.45	Moderate antagonism
0.3 - 0.7	Synergism	1.45 - 3.3	Antagonism
0.7 - 0.85	Moderate synergism	3.3 - 10	Strong antagonism
0.85 - 0.90	Slight synergism	10 >	Very strong antagonism
0.90 - 1.10	Nearly additive		

The results of the single-drug cytotoxicity test met the prerequisites of the Chou-Talalay method to initiate in vitro pharmacodynamic drug interaction analysis. Therefore, we tested all possible combinations of dual drugs in a fixed-ratio combination design. All curves were smooth sigmoidal ($m<1$) with a linear correlation coefficient (*r*) above 0.95. The parameters (*m*, D*m*, and *r*), combination index (CI), and Fa-DRI table of this study for CBD and CIS combinations are presented in Table 5. The Chou-Talalay method for drug combination is based on the median effect equation, which provides the theoretical basis for the combination index (CI), which allows the quantification of drug interactions where CI<1, =1, and >1 indicate synergy, additive effect and antagonism. Firstly, this study focused on the evaluation of the synergistic-antagonistic effect of CBD and CIS combinations with CI values for fa = 0.5. Accordingly, when the combinations tested in MG63 cells were examined at fa = 0.5; Synergism was seen between CBD and CIS (0,92). When the combinations tested in Saos2 cells were examined at fa = 0.5; Synergism was seen between CBD and CIS (0,65). When the combinations tested in SW1353 cells were examined at fa = 0.5; Synergism was seen between CBD and CIS (0,69). Secondly, this study focused on the appropriate Dose Reduction Index (DRI) from many synergistic dual and triple drug combinations based on real experimental data points. The results are shown in the Fa-DRI table (Table 6). Dose reduction index (DRI), DRI=1, >1, and <1 indicate no dose reduction, appropriate dose reduction, and inappropriate dose reduction, respectively, for each drug in the combination. The main aim of combination therapy is to provide synergistic effects (CI < 1), and reduce the dose of specific toxic drugs (DRI > 1) and, as a result, eliminate the possibility of drug resistance. Therefore, only the DRI values of synergistic combinations are focused here.

Table 5. Parameters were calculated from the median-effect equation and the median-effect plot*,**.

		Combination Index (CI) Values at					
		ED50	**ED75**	**ED90**	**D*m***	***m***	**r**
	CBD	N/A	N/A	N/A	15,7931	1,0283	0,98337
MG63	CIS	N/A	N/A	N/A	47,02353	1,4528	0,85099
	CBD+CIS	0,92264	0,65351	0,46978	12,47618	1,63446	0,95865
	CBD	N/A	N/A	N/A	17,6306	1,07769	0,99342
Saos2	CIS	N/A	N/A	N/A	45,96013	1,35586	0,84741
	CBD+CIS	0,65932	0,75366	0,86736	9,75343	0,98406	0,96114
	CBD	N/A	N/A	N/A	16,23892	1,15511	0,98489
SW1353	CIS	N/A	N/A	N/A	54,03418	1,424	0,85331
	CBD+CIS	0,69087	0,83602	1,01588	9,75343	0,98406	0,96114

*Dose and effect data were obtained from the MTT assay and were subjected to CalcuSyn analysis.

Parameters were calculated from the median-effect equation and the median-effect plot. "*m***" is slope, signifies shape; "**D*m***" is TGI (µM), signifies potency; and ***r*** is linear correlation coefficient, signifies conformity.

Table 6. Dose-Reduction Index (DRIa) for each drug in the combination*

MG63	**Drug alone**		**Dose Reduction Index (DRI)**	
Fa	**CBD**	**CIS**	**CBD**	**CIS**
0,5	15,79	47,02	1,266	7,538
Saos2	**Drug alone**		**Dose Reduction Index (DRI)**	
Fa	**CBD**	**CIS**	**CBD**	**CIS**
0,5	17,6306	45,9601	1,808	9,424
SW1353	**Drug alone**		**Dose Reduction Index (DRI)**	
Fa	**CBD**	**CIS**	**CBD**	**CIS**
0,5	16,23	54,03	1,665	11,08

*Dose-reduction index (**DRI**) was calculated from the DRI equation and algorithm using CalcuSyn software. **DRI**=1, >1, and <1 indicates no dose-reduction, favorable dose-reduction, and not favorable dose-reduction, respectively, for each drug in the combination.

Accordingly, as can be seen from the DRI values at 50% inhibition (fa = 0.5) for MG-63 cells, 1,266 times less CBD and 7,538 times less CIS are required to achieve a 50% inhibition rate in the combination of CBD and CIS (Table 6). The combination of CBD and CIS yielded favorable DRIs ranging from 1,808-9,424-fold dose reduction at fa = 0.5 in Saos2 cells (Table 6). At 50% inhibition (fa = 0.5) for SW-1353 cells, the combination of CBD (1,665-fold dose reduction) and CIS (11,08-fold dose reduction) yielded favorable DRIs (Table 6). These results show that in the near future, the combined use of CBD has the potential to be used to significantly increase the effectiveness of chemotherapeutics in the treatment of bone cancer.

Cytotoxic activity of the drug/combo

The measurement of the cytoplasmic LDH enzyme mixed with the extracellular environment as a result of drug/combo-induced membrane deformations provides some information about their cytotoxic activities. The cytoplasmic lactate dehydrogenase activity is measured with the help of an LDH cytotoxicity kit. In this study, cytotoxicity induced by drug/combo was measured using TGI concentrations. Accordingly, drug/combo that was found to be effective in the MTT proliferation test showed moderate cytotoxicity values varying between about 10 - 13 % for bone cell lines at TGI concentration (Table 7).

Table 7. % Cytotoxicity for tested drug/combo at TGI concentrations against the cells

% Cytotoxicity	**MG63**	**Saos2**	**SW1353**
CBD	12±2.1	10±2.4	13±2.3
CIS	12±2.2	13±2.0	12±2.3
CBD+CIS	12±1.8	12±1.9	11±2.0

Effect of the drug/combo on Cell Morphology

In this study, the morphological effects of the drug/combo on bone cancer cells Saos2 was observed and photographed 24 hours after application. Observed morphological alteration images here were distinguished in all cell lines treated with the drug/combo. Some of them like weak cell attachment or floating cells, decreasing cell volume, and cell blebbing were determined in the majority of the cells (Figure 2). The changes that occurred in the cell morphology by applying TGI doses of the drug/combo indicate that the CIS+CBD combo was more effective than CIS and CBD individual drugs. (Figure 2).

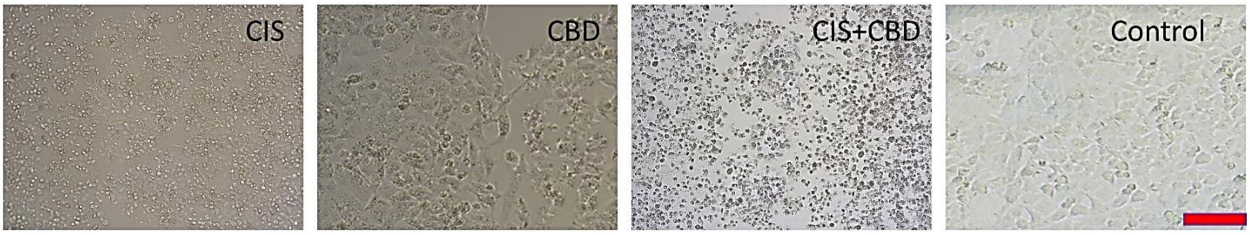


Figure 2. Effect of the drug/combo on the morphology of Saos2 cell lines. DMSO treated cells as controls. All scale bars show 100 µm.

Effect of the combo on cell migration

Cell migration capacity is an important characteristic in cancer and is also a target of new anticancer agents. Cancer cells with migration capacity can escape the apoptosis mechanism. Therefore, one of the goals of newly developed anticancer drugs is to significantly reduce the migration capacity of cancer cells. Here, it has been observed that the combination of CIS+CBD reduces cell migration (Figure 3).

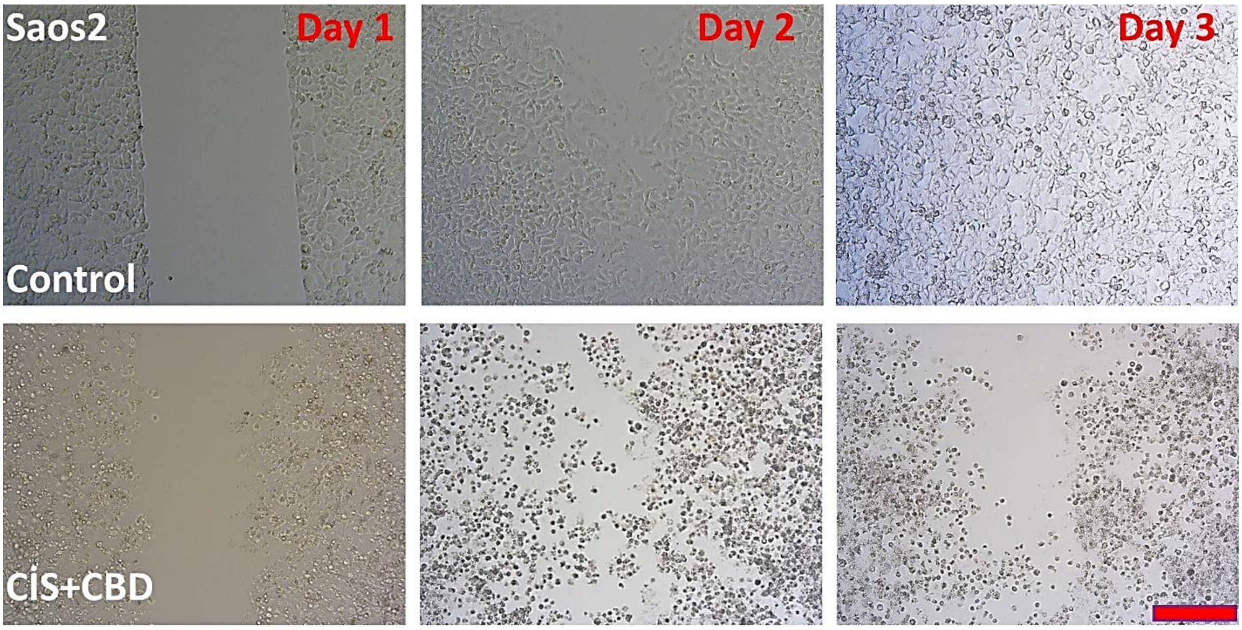


Figure 3. Effects of the combo on cell migration on Saos2 cell line. All scales are 100 µm.

Evaluation of the TUNEL assay results of the drug/combo

We performed a TUNEL assay to investigate whether drug/combo inhibits cell proliferation by apoptosis. Saos2 cell lines were incubated with TGI concentrations of the drug/combo overnight and apoptosis was detected using a TUNEL assay. As shown in Figure 4A, Saos2 cells treated with drug/combo exhibited brown stains, indicating the fragmented DNA in apoptotic cells, whereas no apoptotic signal was observed in the cells treated with DMSO. According to the TUNEL assay, the antiproliferative activity of the combo is stronger than individual CIS and CBD.

Evaluation of the DAPI staining results of the drug/combo

The application of drug/combo on Saos2 cells was followed by staining with DAPI (blue) fluorescent dyes to determine their effect on cell death. As shown in Figure 4B, upon examination of the DAPI staining, it was observed that the application of drug/combo to Saos2 cells increased cell death (the nuclei of the treated cells with drug/combo appeared densely stained blue). In summary, the application of combo resulted in more increased cell death compared with CIS treatment.

Determination of topoisomerase I inhibition activities of the drug/combo

In this study, the effects of drug/combo on topoisomerase I activity were determined using the topoisomerase I inhibition test. According to the test results, it is seen from Figure 4C (upper) that the CBD and CIS partly inhibited the DNA relaxing activity of topoisomerase I at TGI concentrations. According to these results, it can be said that topoisomerase I inhibition is responsible for part of the anticancer effect of CBD.

Determination of DNA laddering potentials of the drug/combo

In this study, the presence of the apoptotic mechanism based on the antiproliferative activity of the drug/combo was investigated using a DNA banding (DNA laddering) experiment. For this purpose, DNA was isolated from Saos2 cells treated with the respective drug/combo at TGI concentrations. As seen in Figure 4C (bottom), when compared with the DNA isolated from untreated control cells, a significant banding was observed in the DNA samples isolated from cells treated with combo compared to the individual. These findings support the antiproliferative activity of the combo stronger than individual CIS and CBD.

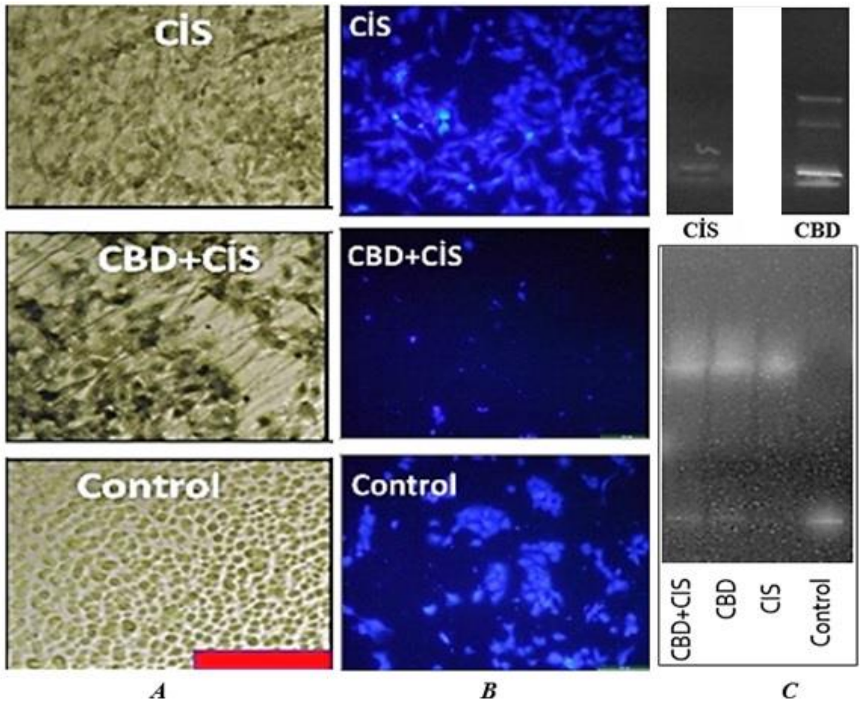


Figure 4. Phase-contrast images of the Saos2 cancer cell line examined by colorimetric TUNEL assay (***A***). TUNEL-positive cell nuclei with dark brown were observed under a phasecontrast microscope. All scales are 100 µm. DAPI staining in Saos2 cancer cell lines (***B***). Treatment with combination for 24 h showed increase in apoptosis evident from the brightly stained nuclei in comparison with control. Inhibition of recombinant human topoisomerase I activity by drug/combo (***C***, upper). Effects of the drug/combo on DNA laddering in Saos2 (***C***, bottom) cell lines.

CONCLUSIONS

Consequently, combining drugs could be pivotal in achieving complete remission in bone cancer patients who are debilitated due to suboptimal treatment practices. As a result, drug combinations may constitute a driving force to achieve complete remission in bone cancer patients who are weak due to poor treatment practices. It is clear that the in vitro use of CBD and CIS combination applications presented in this study provides great benefits compared to conventional monodrug applications (15). However, these findings require validation through in vivo studies. One notable advantage of using drug combinations is the potential for reduced side effects, as each drug may operate through distinct mechanisms. Overall, the results indicate that the CBD and CIS combination has considerable clinical potential for the treatment of bone cancers and warrants further preclinical and clinical investigations.

REFERENCES

1. Lamoureux F, Trichet V, Chipoy C, Blanchard F, Gouin F, Redini F. Recent advances in the management of osteosarcoma and forthcoming therapeutic strategies. Expert Rev Anticancer Ther. 2007;7(2):169–81.

2. Raymond AK, Jafe N. Osteosarcoma multidisciplinary approach to the management from the pathologist's perspective. Cancer Treat Res. 2009;152:63–84.

3. Alessandra L, Costantino E, Paolis MD, Mercuri M, Bacci G. Primary bone osteosarcoma in the pediatric age: state of the art. Cancer Treat Rev. 2006;32(6):423–36.

4. Li J, Jiang W, Shan W, Luo A, Qu G, Zhang J, Luo X, Xia J. The synergistic anticancer effect of CBD and DOX in osteosarcoma. Clin Transl Oncol. 2023 Aug;25(8):2408-2418.

5. Xu F, Sun G, Peng Z, Liu J, Li Z, Yan J. Cannabidiol promotes apoptosis of osteosarcoma cells in vitro and in vivo by activating the SP1-CBX2 axis. Am J Transl Res. 2022 Feb 15;14(2):1188-1203.

6. Saponaro F, Ferrisi R, Gado F, Polini B, Saba A, Manera C, Chiellini G. The Role of Cannabinoids in Bone Metabolism: A New Perspective for Bone Disorders. International Journal of Molecular Sciences. 2021; 22(22):12374.

7. Zeng F, Wade A, Harbert K, Patel S, Holley JS, Dehghanpuor CK, Hopwood T, Marino S, Sophocleous A, Idris AI. Classical cannabinoid receptors as target in cancer-induced bone pain: a systematic review, meta-analysis and bioinformatics validation. Sci Rep. 2024 Mar 9;14(1):5782.

8. Nielsen, S. S. R., Pedersen, J. A. Z., Sharma, N., Wasehuus, P. K., Hansen, M. S., Møller, A. M. J., Søe, K. (2024). Human osteoclasts in vitro are dose dependently both inhibited and stimulated by cannabidiol (CBD) and Δ9-tetrahydrocannabinol (THC). Bone, 181.

9. Aydın, D., Özkan, K., Aydın, A. (2021). The Combination of Amygdalin with Some Anticancer, Antiparasitic, and Antigout Drugs Against MG63, Saos2, SW1353, and FL Cells In Vitro. J Med Food., 24(11):1230-1234.

10. Aydin, A., Korkmaz, N., Tekin, Ş., and Karadağ, A. (2014). Anticancer activities and mechanism of action of 2 novel metal complexes, C16H34N8O5}Ag2Cd and C11H16N7O2Ag3Ni. Turkish Journal of Biology, 38,6, 24.

11. Aydın, A., Karadağ, A., Tekin, Ş., Korkmaz, N., and Özdemir, A. (2015). Two new coordination polymers containing dicyanidoargentate(I) and dicyanidoaurate(I): synthesis and characterization, and a detailed in vitro investigation of their anticancer activities on some cancer cell lines, Turkish Journal of Chemistry, 39:3, 4.

12. Aydın, A., Ökten, S., Erkan, S., Bulut, M., Özcan, E., Tutar, A., Eren, T. (2021). In–Vitro Anticancer and Antibacterial Activities of Brominated Indeno[1,2-b]qinoline Amines Supported with Molecular Docking and MCDM. ChemistrySelect, 6, 3286.

13. Aydın, A., Korkmaz, N., Kısa, D., Türkmenoğlu, B., Karadağ, A. (2022). Dicyanoargentate(I)-based complexes induced in vivo tumor inhibition by activating apoptosis-related pathways. Appl Organomet Chem., 36(10), e6844.

14. Aydın, A., Karadağ, A., Tekin, Ş. et al. (2019). Three new dicyanidoaurate(I)-based complexes exhibiting significant antiproliferative property: synthesis and characterization. Gold Bull., 52, 35–50.

15. Aydın, A. and Karadağ, A. (2022). Kannabinoidler ve Kanser. In: Sağlık Bilimleri Açısından Kenevir. Hamdi Temel, Ahmet Karadağ, Editor, Çukurova Nobel Tıp Kitabevi, Yozgat, PP 57-81.

WATER AND SUSTAINABLE DEVELOPMENT A COMBINED RELATIONSHIP. IMPACT OF THE MOBILIZATION OF SURFACE WATER RESOURCES IN SEMI-ARID AREAS: CASE OF THE FOUM TOUB REGION, NORTHEAST OF ALGERIA

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Abstract

Generally, the hill reservoir is a work for improving existing agriculture through irrigation of small areas and therefore improve irrigated land, it may have other objectives. The off-road feasibility study (region) remains fundamental before embarking on any applied research project. Our proposed work is a socio-economic importance for Timgad region. The results of this work are a useful scientific contribution by both socio-economic operators and policy makers to any development plan. In the study area, Water resources are closely related to the geological formations, hydrological and geotechnical study of the area, so the analysis of these is essential. The main objective of the establishment of the retaining Foum Toub is to contribute to the irrigation of the plain of Foum Toub, regulate the flow of Oued Foum Toub and minimize the silting of the dam Koudiet Lemdaour. For this, the sites selected for the construction of this work are represented by an impermeable bedrock. Loose material, favorable to serve as borrow areas are located in the surrounding depressions and the sandstone that can be used as the dike construction materials.

Key words: Feasibility, hill reservoir, Foum Toub, Timgad.

FABRICATION OF HYDROGELS USING *COMMIPHORA WIGHTII* RESIN, EVALUATION OF THEIR MICROBIAL AND HEMOLYTIC PROPERTIES

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Abstract

Skin wounds are becoming a major concern for wound healing and healthcare, as they rank among the world's top causes of death. In this study a set of hydrogel materials have been prepared from biopolymer known as guggul gum (*Commiphora Wightii* Resin) and acrylic acid/acrylamide copolymers by means free-radical polymerization. Ammonium persulphate radical was used as an initiator and N'-N methylenebisacrylamide as crosslinker linker in the synthesis process. The synthesized hydrogels were characterized via Fourier Transform Infrared (FTIR), Raman, X-ray diffractometer (XRD) and Energy dispersive X-ray spectroscopy (EDX) and scanning electron microscopy (SEM). The optimization process was carried out by varying the quantity of guggul gum. The surface morphology was highly porous and rough due to presence of guggul gum. EDX analysis confirmed the presence of carbon, hydrogen and oxygen. Furthermore, swelling behavior and biodegradability were also evaluated using aqueous and PBS media at different pH and 37 °C. These hydrogels showed a very remarkable antibacterial activity against *Staphylococcus aureus* and *Escherichia coli*. The properties of hydrogels were enhanced by increasing the quantity of guggul gum. The hemolysis was less than 5 % which proved them safe for healing purposes. These hydrogels could be used as dressing materials in applications related to wound healing.

Keyword: Guggul gum, Hydrogels, hemolysis, Wound dressing,

FROM A NATIONAL PHARMACEUTICAL STRATEGY PERSPECTIVE: MEDICAL CANNABIS

Dr. Yavuz Gökalp Yıldız

* See Also: "Yavuz Gökalp Yıldız, "Ulusal İlaç Sanayi Stratejisi Açısından TIBBİ KENEVİR", Zet Yayınları, Ankara 2024"

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Abstract

Until recently, the "*Cannabis Sativa L.*" plant, which was considered the starting product of "drug addiction" and classified as a banned plant, has undergone a rapid transformation in the last 20 years regarding its cultivation and usage permissions. The factors causing this rapid shift towards "*liberalization*" are among the major curiosities. At the same time, this liberalization is associated with illusions of legalizing illegal trends and significant misinformation.

Hemp is one of the main products of the lands of Anatolia. People living in these lands have had intense interactions with hemp for centuries. Thus, the discussions today are more about legal and administrative interactions in this geography than social interactions. Briefly highlighting recent developments without going into the details of the historical process; Hemp discussions that started in Turkiye in 2016 peaked with the support of President Recep Tayyip Erdoğan from 2019 onwards[1]. Following this support, the "hemp wind" began to blow everywhere. Especially since there was no industrial hemp infrastructure (*which was established in the early years of the Republic but collapsed due to wrong policies*), this breeze eventually gave way to disappointments. Subsequently, when the "*cannabis as a drug active ingredien*t" law was enacted on March 23, 2023, interest started to shift towards "*medical cannabis*". While the regulations to implement this law were being worked on in Turkey, a "hemp freedom" based on relaxed medical rules occurred in many European Union countries. Even though Turkiye is not a full member of the EU, the integration with the Union has made it mandatory to make legal and administrative arrangements in this area.

In the context of these legal and administrative regulations, examining the trends of "*liberalization in hemp*" related to the medical effectiveness of the "*Cannabis Sativa L.*" plant has become important.

Conceptual Definition

"*Industrial hemp*" is cultivated for the production of various industrial products or food, and there is a significant difference in its genetic makeup from forms that have psychoactive effects. "*Medical Cannabis*" refers to strains suitable for pharmaceutical applications, involving a technical and controlled long-term cultivation process. For industrial hemp cultivation, a balance is maintained between the amount of tetrahydrocannabinol (THC) produced and the amount extracted, where the THC content does not exceed 0.2% and contains psychoactive

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[1] "On January 9, 2019, President Recep Tayyip Erdoğan made a statement about hemp, saying: 'We destroyed hemp in our country. Hemp was used to produce textiles like undershirts and vests because it absorbs sweat differently. Friends appearing as foes took hemp production out of our country. We are importing hemp. If there are things that need to be done based on hemp, they are being done with imported products. The Ministry of Agriculture and Forestry is starting to work on this. Someone had to start this work. Now, we are also undertaking this task.'

substances[2]. The term "medical cannabis" used in our study includes this classification.

Cannabinoids found in the hemp plant are also linked to "*specific receptors*"[3] in the human brain and body, connecting to cannabinoid receptors located throughout the body. These are biologically derived from the plant, and are the main active ingredients in both medical applications and pharmaceutical preparations.

Cannabinoids are medically categorized into three types:

Phytocannabinoids, which are naturally occurring cannabinoids derived from the flora of the plant. These include chemicals thought to protect the plant from UV radiation, pests, and herbivores.

Endocannabinoids[4], which are cannabinoids produced by the human body itself. Endocannabinoids are vital in regulating sleep, mood, pain control, and dependency responses. In cases where endocannabinoids are produced sufficiently by the body, synthetic cannabinoids can be offered as an alternative, which mimics the main psychoactive component of cannabis, THC.

Synthetic Cannabinoids are artificially created chemicals that act on the same receptors as THC and play a role in compensating for a deficiency of endocannabinoids in the body.

Interactions of Cannabinoids

Cannabinoids are compounds that can be either plant-derived or synthetically produced, primarily including components such as THC, CBD, CBN, CBG, CBL, and CBC. These compounds interact with the endocannabinoid system in the human body, which regulates many different functions, especially within the nervous system and the immune system[5].

Receptors and Cannabinoid Interactions

Cannabinoids bind to specific receptors in the endocannabinoid system, particularly CB1 and CB2 receptors: CB1 receptors are primarily found in the brain and spinal cord, as well as in some peripheral tissues. Activation of CB1 receptors can regulate the release of neurotransmitters, which are chemicals that facilitate communication between neurons or between a neuron and another type of cell, thus influencing functions such as pain, memory, motor control, and sensory perception. The psychoactive effects of THC are due to the activation of these receptors. CB2 receptors are mainly located in immune system cells and some peripheral tissues outside the neurons. Activation of CB2 receptors can modulate immune responses such as inflammation and pain.

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[2] *European Monitoring Centre for Drugs and Drug Addiction. Medical use of cannabis and cannabinoids: questions and answers for policymaking.* Luxembourg: Publications Office of the European Union; 2018.

[3] "In the human brain and body, 'specific receptors' are protein structures that recognize certain molecules or stimuli and, as a result of this recognition, initiate a specific response within the cell. These receptors enable cells to perceive environmental signals and respond appropriately."

[4] *Gary Starr, Stephen Dahmer*, Understanding Medical Cannabis,1st Edition, Routledge, 2020

[5] Mechoulam R, Parker LA. "The Endocannabinoid System and the Brain." July 2012,Annual Review of Psychology 64(1); Roger G Pertwee , "Targeting the endocannabinoid system with cannabinoid receptor agonists: pharmacological strategies and therapeutic possibilities", Philos Trans R Soc Lond B Biol Sci,2012 Dec 5;367(1607):3353-63; Vincenzo Di Marzo , Fabiana Piscitelli ; "The Endocannabinoid System and its Modulation by Phytocannabinoids, Neurotherapeutics", 2015 Oct;12(4):692-8; Ligresti A., et al. "From Phytocannabinoids to Cannabinoid Receptors and Endocannabinoids: Pleiotropic Physiological and Pathological Roles Through Complex Pharmacology." Physiol Rev, 2016 Oct;96(4):1593-659.

Specific Effects of Cannabinoids

THC and its derivatives (Δ8-THC, Δ8-THCA, Δ9-THC, THCA-A/B/C4, THC-C1, THCV, THCVA) have psychoactive effects. Their high affinity for binding to CB1 receptors allows them to exert significant effects on the central nervous system, helping to reduce pain, decrease nausea, suppress appetite, and reduce inflammation.

CBD and its derivatives (CBDA, CBDM, CBD-C1, CBDV, CBDVA) are not psychoactive compared to THC and have anti-inflammatory, anxiolytic (anxiety-reducing), antiepileptic, and antipsychotic effects. They do not show strong direct binding to CB1 and CB2 receptors, but can indirectly affect the endocannabinoid system by enhancing or reducing the activity of certain receptors (such as serotonin receptors). Research continues on CBDV and CBDVA for the treatment of epilepsy and other neurological conditions.

CBN, which forms through the oxidation of THC, is typically found in aged cannabis products. CBN is known for its low affinity for CB2 receptors and is claimed to have effects such as pain reduction and sleep regulation.

CBG, considered the "parent molecule" of cannabinoids, and its derivatives (CBGM, CBGA, CBGAM, CBGV, CBGVA) are thought to have antibacterial properties, and some studies suggest they may have antitumoral and anti-inflammatory effects on certain types of cancer.

CBL and its derivatives (CBLA, CBLV) are less researched cannabinoids, and definitive information about their potential therapeutic effects is limited. These compounds are proposed to have anti-inflammatory and neuroprotective properties that could reverse or prevent further neuron damage.

CBC and its derivatives (CBCA, CBCV, CBCVA) are suggested to have potential in fighting inflammation and reducing pain. CBCA is the acidic precursor of CBC and is thought to have similar effects. Research continues on CBCV and CBCVA, which are variants of this structure, believed to possess similar biological activities to CBC.

Medical Uses of Cannabis and Clinical Research

It is important to consider current research on the interactions of cannabinoids with specific cellular systems and receptors such as the *limbic system*, *lysophosphatidylinositol*, and *GPR55*[6].

The limbic system plays a central role in functions such as emotions, memory, motivation, and pleasure. THC binds to CB1 receptors, which are highly concentrated in various areas of the limbic system, influencing mood, motivation, and perception of pleasure, and plays a role in managing psychological conditions like anxiety and depression. It is suggested that THC's side effects on the limbic system include temporary memory loss and mood changes. The effects of CBD on the limbic system are generally associated with its anxiolytic (anxiety-reducing) and antipsychotic properties, and it is claimed to have therapeutic effects on stress, anxiety, and depression.

Lysophosphatidylinositol is a lipid molecule that plays a role in intracellular signal

[6] Stahl, S. M. "Stahl's Essential Psychopharmacology: Neuroscientific Basis and Practical Applications." ; Lutz, B., Marsicano, G., Maldonado, R., & Hillard, C. J. (2015). "The endocannabinoid system in guarding against fear, anxiety, and stress." Nature Reviews Neuroscience, 16(12), 705-718; O'Sullivan, S. E. (2007). "Cannabinoids go nuclear: evidence for activation of peroxisome proliferator-activated receptors." British Journal of Pharmacology, 152(5), 576-582; Ryberg, E., Larsson, N., Sjögren, S., Hjorth, S., Hermansson, N. O., Leonova, J., ... & Greasley, P. J. (2007). "The orphan receptor GPR55 is a novel cannabinoid receptor." British Journal of Pharmacology, 152(7), 1092-1101; Kapur, A., Zhao, P., Sharir, H., Bai, Y., Caron, M. G., Barak, L. S., & Abood, M. E. (2009). "Atypical responsiveness of the orphan receptor GPR55 to cannabinoid ligands." Journal of Biological Chemistry, 284(43), 29817-29827.

transmission, and GPR55 (G protein-coupled receptor 55) is a G protein-coupled receptor found in the human body that plays a role in various biological functions. Both can interact with cannabinoids to influence various physiological processes. The effects of GPR55 on cancer biology are a significant research topic. Activation of this receptor can trigger cell proliferation in a negative sense in cancer types. Ongoing studies suggest that while THC can activate cell proliferation, CBD and CBG are able to block GPR55 receptors, contributing to their anticancer, neuroprotective, and anti-inflammatory effects.

Diseases Thought to Be Treatable with Cannabis:

Antitumoral Effects of Cannabinoids[7]

Research indicates that THC and CBD can trigger the process of apoptosis (programmed cell death) in brain tumor cells. For example, a 2014 study demonstrated that THC caused cell death and slowed tumor growth in glioma cells. CBD has been noted to inhibit the growth and proliferation of tumor cells and also prevent invasion and metastasis. A 2009 study showed that CBD reduced the emergence of glioblastoma cells—a primary malignant brain tumor that can develop in the brain or spinal cord—and triggered cell death. Some studies suggest that cannabinoids, particularly THC, can slow tumor growth by obstructing blood flow to tumors.

THC, CBD, and Cancer[8]

It has been shown that THC can induce apoptosis (programmed cell death) and halt cell growth in various cancer cell types. Laboratory studies on brain, lung, and pancreatic cancer cells have documented these effects of THC. CBD is also thought to combat cancer through mechanisms similar to THC, additionally stopping the cell cycle and inhibiting tumor angiogenesis (formation of new blood vessels). Moreover, CBD is said to show synergistic effects with traditional cancer treatments; for instance, when used with radiotherapy, CBD enhances its efficacy against tumor cells and displays relatively low toxicity towards normal cells, potentially offering an advantage in reducing side effects.

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[7] Velasco, G., Sánchez, C., & Guzmán, M. (2012). "Towards the use of cannabinoids as antitumour agents." Nature Reviews Cancer, 12(6), 436-444.; Massi, P., Solinas, M., Cinquina, V., & Parolaro, D. (2013). "Cannabidiol as potential anticancer drug." British Journal of Clinical Pharmacology, 75(2), 303-312.; Ligresti, A., Moriello, A. S., Starowicz, K., Matias, I., Pisanti, S., De Petrocellis, L., ... & Di Marzo, V. (2006). "Antitumor activity of plant cannabinoids with emphasis on the effect of cannabidiol on human breast carcinoma." The Journal of Pharmacology and Experimental Therapeutics, 318(3), 1375-1387.; Caffarel, M. M., Andradas, C., Mira, E., Pérez-Gómez, E., Cerutti, C., Moreno-Bueno, G., ... & Sánchez, C. (2010). "Cannabinoids reduce ErbB2-driven breast cancer progression through Akt inhibition." Molecular Cancer, 9(1), 196.; Ed.: Rosaria Meccariello ve Rosanna Chianese, "Cannabinoids in Health and Disease", IntechOpen, EBOOK (PDF) ISBN978-953-51-4198-3,15 June 2016

[8] Velasco, G., Sánchez, C., & Guzmán, M. (2012). "Towards the use of cannabinoids as antitumour agents." Nature Reviews Cancer, 12(6), 436-444.; Caffarel, M. M., Andradas, C., Mira, E., Pérez-Gómez, E., Cerutti, C., Moreno-Bueno, G., ... & Sánchez, C. (2010). "Cannabinoids reduce ErbB2-driven breast cancer progression through Akt inhibition." Molecular Cancer, 9(1), 196.; Massi, P., Solinas, M., Cinquina, V., & Parolaro, D. (2013). "Cannabidiol as potential anticancer drug." British Journal of Clinical Pharmacology, 75(2), 303-312.; Ligresti, A., Moriello, A. S., Starowicz, K., Matias, I., Pisanti, S., De Petrocellis, L., ... & Di Marzo, V. (2006). "Antitumor activity of plant cannabinoids with emphasis on the effect of cannabidiol on human breast carcinoma." The Journal of Pharmacology and Experimental Therapeutics, 318(3), 1375-1387.; Whiting, P. F., Wolff, R. F., Deshpande, S., Di Nisio, M., Duffy, S., Hernandez, A. V., ... & Schmidlkofer, S. (2015). "Cannabinoids for Medical Use: A Systematic Review and Meta-analysis." JAMA, 313(24), 2456-2473.; Sara Jane Ward, Aron H Lichtman, Daniele Piomelli, Linda A Parker, "Cannabinoids and Cancer Chemotherapy-Associated Adverse Effects", *JNCI Monographs*, Volume 2021, Issue 58, December 2021, 78–85

THC, CBD, and Parkinson's[9]

Research has highlighted that cannabinoids, particularly CBD, exhibit antioxidant properties and can reduce damage from oxidative stress. Dopaminergic neurons, which increase dopamine-related activity in the brain, are sensitive to such damage; thus, studies suggest that CBD's neuroprotective effects might slow the progression of Parkinson's disease. Inflammation in Parkinson's disease accelerates neuron loss, while CBD and other cannabinoids are reported to decrease activation of microglial cells in the brain—which protect the nervous system against foreign substances and microorganisms but can be harmful when overly active—thus reducing inflammation and potentially alleviating symptoms and slowing disease progression. Some studies, especially those on THC, indicate that it can directly affect motor functions and alleviate symptoms such as muscle stiffness, tremors, and movement difficulties.

THC, CBD, and Alzheimer's[10]

Alzheimer's disease is a progressive neurodegenerative disease characterized by the gradual death of neurons in the brain, resulting in dementia. Researchers have explored the potential benefits of cannabinoids, especially CBD and THC, in managing the symptoms of Alzheimer's and slowing its progression. CBD acts as a powerful antioxidant, reducing damage caused by free radicals and aiding in neuron protection. CBD can also halt the formation of beta-amyloid plaques, which play a central role in the pathology of Alzheimer's disease. THC and CBD have been found to modulate microglial cell activity, reducing inflammation and limiting neuronal damage. Additionally, some studies suggest that cannabinoids may stop the increase of tau protein in the brain. Small-scale clinical trials on individuals with Alzheimer's have shown that cannabinoids can improve behavioral and psychological symptoms, with THC specifically noted to reduce memory loss, irritability, and aggressive behavior.

[9] Chagas, M. H. N., Zuardi, A. W., Tumas, V., Pena-Pereira, M. A., Sobreira, E. T., Bergamaschi, M. M., ... & Crippa, J. A. S. (2014). "Effects of cannabidiol in the treatment of patients with Parkinson's disease: An exploratory double-blind trial." Journal of Psychopharmacology, 28(11), 1088-1098.; Lotan, I., Treves, T. A., Roditi, Y., & Djaldetti, R. (2014). "Cannabis (medical marijuana) treatment for motor and non-motor symptoms of Parkinson disease: An open-label observational study." Clinical Neuropharmacology, 37(2), 41-44.; Zeissler, M. L., Eastwood, J., McCorry, K., Hanemann, C. O., Zajicek, J. P., & Carroll, C. B. (2019). "Cannabidiol (CBD) as a Promising Anti-Dopaminergic Agent: Implications for Parkinson's Disease." Neuropharmacology, 1(1), 1-11.; Fernández-Ruiz, J., Sagredo, O., Pazos, M. R., García, C., Pertwee, R., Mechoulam, R., & Martínez-Orgado, J. (2013). "Cannabidiol for neurodegenerative disorders: Important new clinical applications for this phytocannabinoid?" British Journal of Clinical Pharmacology, 75(2), 323-333.; Crippa, J. A. S., Hallak, J. E. C., Zuardi, A. W., & Moreira, F. A. (2016). "Cannabinoids and Parkinson's Disease." In Cannabinoids in Neurologic and Mental Disease (pp. 173-186). Academic Press.

[10] Cao, C., Li, Y., Liu, H., Bai, G., Mayl, J., Lin, X., ... & Cai, J. (2014). "The potential therapeutic effects of THC on Alzheimer's disease." Journal of Alzheimer's Disease, 42(3), 973-984.; Esposito, G., De Filippis, D., Carnuccio, R., Izzo, A. A., & Iuvone, T. (2006). "The marijuana component cannabidiol inhibits beta-amyloid-induced tau protein hyperphosphorylation through Wnt/beta-catenin pathway rescue in PC12 cells." Journal of Molecular Medicine, 84(3), 253-258.; Aso, E., & Ferrer, I. (2014). "Cannabinoids for treatment of Alzheimer's disease: moving toward the clinic." Frontiers in Pharmacology, 5, 37.; Watt, G., & Karl, T. (2017). "In vivo Evidence for Therapeutic Properties of Cannabidiol (CBD) for Alzheimer's Disease." Frontiers in Pharmacology, 8, 20.; Campbell, V. A., & Gowran, A. (2007). "Alzheimer's disease; taking the edge off with cannabinoids?" British Journal of Pharmacology, 152(5), 655-662.; Ed.: Linda A. Parker, "Cannabinoids and the Brain", MIT Press; 1st edition (14 Feb. 2017)

THC, CBD, and Multiple Sclerosis (MS) [11]

MS is a chronic inflammatory disease of the central nervous system, characterized particularly by damage to the myelin sheath, the protective covering of nerve fibers in the brain and spinal cord. Cannabinoids, especially THC and CBD, have been effective in reducing spasticity (muscle stiffness) and pain in MS patients. For example, Sativex (nabiximols), an oral spray containing THC and CBD, has been approved in many countries for the treatment of "neurogenic movement disorders" (spasticity) associated with MS. Clinical studies have shown that this medication significantly reduces spasticity symptoms in MS patients. Research has highlighted CBD's anti-inflammatory properties and potential neuroprotective effects. CBD can slow the progression of MS by inhibiting microglial cell activation and reducing the production of cytokines, a group of proteins and peptides involved in cell communication that are inflammatory. Additionally, cannabinoids are thought to be able to reduce damage to the myelin sheath and support the survival of nerve cells.

THC, CBD, and Epilepsy[12]

Particularly CBD has come to the forefront in the treatment of this condition and has been approved for the treatment of certain types of epilepsy. Studies indicate that CBD has the potential to reduce epileptic seizures and can be effective especially in forms of epilepsy that are resistant to treatment. Epidiolex (a medication containing pure CBD) has been evaluated in various clinical studies and has shown significant efficacy in treating challenging types of epilepsy such as Dravet syndrome and Lennox-Gastaut syndrome. These studies have demonstrated that CBD significantly reduces the frequency of seizures.

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[11] Zajicek, J., Fox, P., Sanders, H., Wright, D., Vickery, J., Nunn, A., & Thompson, A. (2003). "Cannabinoids for treatment of spasticity and other symptoms related to multiple sclerosis (CAMS study): multicentre randomised placebo-controlled trial." The Lancet, 362(9395), 1517-1526.; Rog, D. J., Nurmikko, T. J., Friede, T., & Young, C. A. (2005). "Randomized, controlled trial of cannabis-based medicine in central pain in multiple sclerosis." Neurology, 65(6), 812-819.; Koppel, B. S., Brust, J. C., Fife, T., Bronstein, J., Youssof, S., Gronseth, G., & Gloss, D. (2014). "Systematic review: Efficacy and safety of medical marijuana in selected neurologic disorders: Report of the Guideline Development Subcommittee of the American Academy of Neurology." Neurology, 82(17), 1556-1563.; Pryce, G., & Baker, D. (2015). "Emerging properties of cannabinoid medicines in management of multiple sclerosis." Trends in Neurosciences, 38(4), 272-282.; Russo, M., Calabrò, R. S., Naro, A., Sessa, E., Rifici, C., D'Aleo, G., ... & Bramanti, P. (2015). "Sativex in the management of multiple sclerosis-related spasticity: An overview of the last decade of clinical evaluation." Multiple Sclerosis and Related Disorders, 17, 22-31.

[12] Devinsky, O., Marsh, E., Friedman, D., Thiele, E., Laux, L., Sullivan, J., ... & Wong, M. (2016). "Cannabidiol in patients with treatment-resistant epilepsy: an open-label interventional trial." The Lancet Neurology, 15(3), 270-278.; Devinsky, O., Cross, J. H., Laux, L., Marsh, E., Miller, I., Nabbout, R.,.. & Wright, S. (2017). "Trial of cannabidiol for drug-resistant seizures in the Dravet syndrome." New England Journal of Medicine, 376(21), 2011-2020.; Stockings, E., Zagic, D., Campbell, G., Weier, M., Hall, W. D., Nielsen, S., ... & Degenhardt, L. (2018). "Evidence for cannabis and cannabinoids for epilepsy: a systematic review of controlled and observational evidence." Journal of Neurology, Neurosurgery & Psychiatry, 89(7), 741-753.; Klotz, K. A., Schulze-Bonhage, A., & Antonio-Arce, V. S. (2018). "Cannabidiol for epilepsy: New hope on the horizon?" Seizure-European Journal of Epilepsy, 58, 6-8

THC, CBD, and Chronic Pain[13]

The pain-relieving ability of cannabinoids is linked to their effects on both the central and peripheral nervous systems. Particularly, THC and CBD have effects that modulate pain signals and reduce pain perception. These effects occur through cannabinoid receptors CB1 and CB2 in the body. THC's binding to the CB1 receptor can reduce the transmission of pain signals from neurons, thus lowering pain perception. The activation of the CB2 receptor located in peripheral tissues and immune cells can also modulate inflammatory processes and reduce inflammatory pain. Considering three major types of pain; it has been noted that products containing THC are effective in neuropathic pain arising from nerve damage. In managing chronic pain associated with chronic rheumatic diseases, the anti-inflammatory effects of CBD may be significant. The use of cannabinoids for managing pain in cancer patients is considered, especially in situations where traditional painkillers do not work or as an alternative option against developing tolerance.

Legal Status and Regulations: Parameters of Cannabis Liberalization

The liberalization of cannabis over the past 20 years can be viewed as a broad process influenced by many factors. Analyzing this process includes several key parameters from both societal and scientific perspectives:

Increase in Scientific Research: Research on cannabis, particularly its active ingredients cannabidiol (CBD) and tetrahydrocannabinol (THC), has helped us better understand their medical benefits. For instance, the effectiveness of cannabis-based treatments for conditions like some types of epilepsy, chronic pain, and multiple sclerosis (MS) has been demonstrated. These findings have encouraged the relaxation of regulations on the medical use of cannabis.

Transition to the Robotic Era and Artificial Intelligence: While speculative, the association of cannabis liberalization with the social issues that could be exacerbated by the transition to the robotic era and artificial intelligence suggests the presence of socio-economic and political dynamics. The chaotic environment created by numerous factors, where future anxiety predominates, can detach individuals from society and lead to despair. This despair accelerates the dissolution of identities and personalities, deepening anxiety about the future within the difficulties of living in the present. Anxiety disorders, psychological issues, and the masses of disempowered individuals along with cannabis... In this context, the potential for cannabis to become a control tool is considered.

Change in Social Perception: Especially in Western societies, perceptions regarding the prohibition of cannabis have shifted. The stigmatization of cannabis as an illegal substance, particularly leading to the incarceration of large populations for minor offenses, has faced increasing criticism. Furthermore, arguments that cannabis is less harmful than legal alcohol

[13] Whiting, P. F., Wolff, R. F., Deshpande, S., Di Nisio, M., Duffy, S., Hernandez, A. V., ... & Kleijnen, J. (2015). "Cannabinoids for Medical Use: A Systematic Review and Meta-analysis." JAMA, 313(24), 2456-2473.; Andreae, M. H., Carter, G. M., Shaparin, N., Suslov, K., Ellis, R. J., Ware, M. A., ... & Sacks, H. S. (2015). "Inhaled Cannabis for Chronic Neuropathic Pain: A Meta-analysis of Individual Patient Data." The Journal of Pain, 16(12), 1221-1232.; Mücke, M., Phillips, T., Radbruch, L., Petzke, F., & Häuser, W. (2018). "Cannabis-based medicines for chronic neuropathic pain in adults." The Cochrane Database of Systematic Reviews, 3, CD012182.; Hill, K. P., Palastro, M. D., Johnson, B., & Ditre, J. W. (2017). "Cannabis and Pain: A Clinical Review." Cannabis and Cannabinoid Research, 2(1), 96-104.; Russo, E. B. (2008). "Cannabinoids in the management of difficult to treat pain." Therapeutics and Clinical Risk Management, 4(1), 245-259.; M.Köstenberger, G. Nahler, T. M. Jones, S. Neuwersch & R. Likar , The Role Of Cannabis, Cannabidiol And Other Cannabinoids In Chronic Pain. The Perspective Of Physicians, Journal Of Neuroimmune Pharmacology, 31 August 2021,Volume 17, Pages 318–333, (2022)

and tobacco have become popular. On the other hand, governments and policymakers often use various tools to gain public support and ensure social peace during periods of societal change. The liberalization of cannabis can serve as such a political tool, having the potential for broad social acceptance, especially among younger generations.

Social Adaptation and Restructuring: The potential economic contributions of the cannabis industry have driven many countries to legalize this plant. Cannabis offers a wide range of products from clothing and biofuels to food products and building materials. Moreover, the legalization of cannabis has been seen to increase tax revenues and employment. Changes in the economic structure require societies to adapt to new conditions. The liberalization of cannabis during such a transformation period could potentially facilitate social adaptation and ease the transition to new economic conditions.

International Trends and Comparative Law: The legalization of cannabis in some countries has played a pioneering role in similar legal changes in other countries.

Legal and Criminal Justice Reforms: The unfair aspects of enforcing cannabis prohibitions, particularly the disproportionate impact on ethnic minorities, have led to legal reforms in many countries. These reforms are often considered as part of broader criminal justice reforms.

Is Regulation Needed in the Medical Cannabis Field?

Humanity is experiencing rapid change and transformation. The swift transition, for which people are psychologically and socially unprepared, takes them out of their accustomed environments without adaptation, leading to significant sociological change. This structural transformation will shake socio-political structures as much as perceptions. In this context, countries that do not regulate the field of medical cannabis could face certain dangers and drawbacks:

Increase in Illegal Trade: Lack of regulations could encourage the illegal acquisition and distribution of medical cannabis, strengthening elements of organized crime.

Patient Safety Issues: Absence of regulatory standards on the quality, purity, and dosage of medical cannabis could endanger patient safety. Fake or contaminated products can lead to health issues. Moreover, regulations in neighboring countries could cause confusion and legal conflicts, affecting patients' travel to these countries.

Medical Oversight: The lack of scientific research and oversight on the medical use of cannabis could hinder the development of effective treatments, leading to dependency in this field.

Legal Uncertainties: Without regulations, protecting the legal rights of both patients and healthcare providers becomes challenging. This can create legal uncertainties, complicating the protection of individuals' rights and potentially hindering patients from using cannabis-based medicines.

Public Health Impacts: Without adequate regulations, misuse of medical cannabis could increase, leading to widespread public health issues.

CONCLUSION

Particularly in the last 20 years, medical advancements in treating conditions like chronic pain, cancer pain, depression, anxiety, sleep issues, and neurological disorders have highlighted an increasing focus on research related to cannabis and cannabinoids. The rising interest of patients in products derived from cannabis and cannabinoids and the positive effects of these solutions have also led to a shift in scientific research in this direction.

Due to the evolution of international drug control, the use of cannabis or cannabis-based products for specific medical indications is not prohibited today. International law provides a general regulatory framework for the cultivation and marketing of cannabis, while EU law establishes the criteria for allowing the marketing of medical products, including those containing cannabinoids, in EU member states. However, magistral and official formulas are exempt from EU marketing authorization rules and are left to the discretion of EU member states, resulting in varying access to these medical products containing cannabinoids across EU countries.

On one hand, although some EU member states have approved it for medical use, many countries avoid approving or licensing drugs produced from synthetic cannabinoids. It is also important to consider that cannabinoids are included in the EU "*Novel Food Catalogue*."

Moreover, there is a widespread misconception that all cannabinoids derived from "*Cannabis Sativa L*." contain psychoactive substances. Studies and regulations are being conducted on cannabinoids other than THC to demonstrate that they are not psychoactive. For example, in 2018, *the World Health Organization's Expert Committee on Drug Dependence (WHO-ECDD) recommended that preparations recognized as pure CBD should not be subject to international drug control due to their lack of psychoactive properties and the absence of any reported abuse or dependence cases*[14]. Consequently, it would not be correct to categorize THC and CBD in the same category. Following this decision, the UN Commission on Narcotic Drugs, consisting of 53 countries, reviewed the classification of cannabis and its derivatives based on the recommendations of the World Health Organization. The WHO has advised removing cannabis from Schedule IV of the 1961 Single Convention on Narcotic Drugs.

The basic rule of a correct strategy is: '*Correct cannot be produced with incorrect inputs*.'

Considering advancements in pharmaceutical chemistry and the ethical impacts of technologies and treatments; the influence of genomics on drug discovery and the transition to personalized treatment plans; and the importance of interdisciplinary research and collaboration in guiding future pharmaceutical breakthroughs, it is evident that a feasible legal-regulatory framework is essential for cannabis. In this context, we must consider that cannabis, especially in the production of molecules, will be an important element in the national pharmaceutical industry strategy, which is as important, if not more so, than the national defense industry.

[14] www.who.int/medicines/access/control-substances/ecdd_41_meeting/en/

ATATÜRK DÖNEMİ BİR SANAYİLEŞME HAMLESİ: "KENDİR VE KETEN SANAYİ TÜRK ANONİM ŞİRKETİ"

AN INDUSTRIALISATION MOVE IN THE ATATURK ERA: "KENDİR VE KETEN SANAYİ TÜRK ANONİM ŞİRKETİ"

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Özet

Dünyanın en eski bitkisel hammadde kaynaklarından biri olan kenevir (kendir) Türk tarımı için de büyük önem arz etmiştir. Ülke tarımı ve sanayisine yönelik birçok önemli kararın alındığı Cumhuriyet Dönemi başlarında, kenevir alanında yerli bir sanayi oluşturulamamıştır. Özellikle Kastamonu'da ciddi bir kenevir üretimi yapılmasına rağmen üretilen kenevir, hammadde olarak ihraç edilmiştir. Kenevirin iç piyasada işlenememesi ve işlenmiş kenevir ürünlerine duyulan ihtiyaç, ithalatı zorunlu kılmıştır. Bu sıkıntı kenevirin işlenmesine yönelik yerli sanayiye duyulan ihtiyacı ortaya çıkarmış ve bu ihtiyacı gidermek adına da Cumhuriyet'in ilk yıllarından itibaren gerçekleşen hızlı sanayileşme sürecinin bir ürünü olarak Cumhuriyet'in ilanının 10. yılında 300.000 lira sermaye ile "Kendir ve Keten Sanayi Türk Anonim Şirketi" kurulmuştur. 31 Ekim 1933'te İstanbul'da kurulan ve üretime başlayan şirket Türkiye ekonomisine senelerce hizmet etmiş ve kendir, keten, jüt, manila, sizal ve emsalinden ip, sicim, urgan ve halat imal etmiştir. Fabrika, ayakkabıcılara kundura ipi ve İstanbul ve Ege'nin çeşitli fabrikalarının ipe yönelik tüm ürünlerini temin etmesinin yanında deniz yollarının, askeriyenin ve petrol şirketlerinin de halat ihtiyacını karşılamıştır. Bu süreçte şirket, dört defa İzmir Fuarına, üç defa da Selanik Panayırına katılmış ve ürünlerinin kalitesinden dolayı İzmir'den altın madalya ile Selanik'ten ise iki kez fevkalade mükafatla dönmüştür. Fabrika kuruluşundan itibaren 300-600 arasında işçi istihdamı sağlamış olmasının yanı sıra bulunduğu bölgenin gelişmesinde de etkin bir rol oynamıştır. Ülke ekonomilerini derinden etkileyen II. Dünya Savaşı yıllarında kenevir fiyatlarında artış yaşanmış ve bu artış fabrikanın üretiminde ciddi düşüşe neden olmuştur. Savaş sonrası dönemde üretimde düşüş devam etmekle birlikte fabrika üretimine devam etmiştir. Bu çalışmada Kendir ve Keten Türk Anonim Şirketi'nin kuruluşu ve faaliyetleri, nitel araştırma yöntemlerinden doküman analizi metodu kullanılarak ve arşiv belgeleri, süreli yayınlar ve telif-tetkik eserlerden faydalanılarak incelenmiştir.

Anahtar Kelimeler: Kenevir, Keten, Atatürk Dönemi, Tarım, Sanayi.

Abstract

Hemp, one of the oldest vegetable raw material sources in the world, has also been of great importance for Turkish agriculture. In the early Republican Period, when many important decisions were taken for the country's agriculture and industry, a domestic industry could not be established in the field of hemp. Although there was a serious hemp production especially in Kastamonu, the hemp produced was exported as raw material. The inability to process hemp in the domestic market and the need for processed hemp products necessitated imports. This problem revealed the need for a domestic industry for the processing of hemp, and in order to meet this need, "Kendir ve Keten Sanayi Türk Anonim Şirketi" was established with a capital of 300,000 liras in the 10th year of the proclamation of the Republic as a product of the rapid industrialisation process that took place from the first years of the Republic. Founded on 31 October 1933 in Istanbul and starting production, the company served the Turkish economy for many years and manufactured ropes, twines, ropes and ropes from hemp, flax, jute, manila, sizal and the like. In addition to supplying shoemakers with shoelaces and various factories in Istanbul and the Aegean region with all their rope-related products, the factory also met the rope needs of shipping lines, the military and oil companies. During this period, the company participated four times in the Izmir Fair and three times in the Thessaloniki Fair and returned from Izmir with a gold medal and from Thessaloniki with two extraordinary awards due to the quality of its products. Since its establishment, the factory has employed between 300-600 workers and played an active role in the development of the region in which it is located. During the years of World War II, which deeply affected the economies of the country, hemp prices increased and this increase caused a serious decrease in the production of the factory. Although the decline in production continued in the post-war period, the factory continued its production. In this study, the establishment and activities of Kendir ve Keten Türk Anonim Şirketi were analysed by using the document analysis method, one of the qualitative research methods, and by making use of archival documents, periodicals and copyrighted works.

Key Words: Hemp, Flax, Atatürk Period, Agriculture, Industry.

DEVELOPMENT OF PHOSPHATE-BASED PHOTOCATALYSTS FOR THE DEGRADATION OF ORGANIC POLLUTANTS IN WASTEWATER

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Abstract

Over the past decades, the increasing in the development of industry has led to a growing demand for energy and environment destruction especially the water pollution because of the considerable amounts of colored wastewater being discharged into the environment [1].

For this reason, various degradation techniques including advanced oxidation processes (AOPs), and in particular photocatalysis, have been proposed as alternatives for the efficient degradation of dyes ,and thus for purifying wastewater, during recent years[2].

The photocatalysis is one of the most useful advanced oxidation techniques and is another way of using photons to clean up the air or water. Indeed, photons are absorbed by a photocatalyst, most often in a heterogeneous medium, liquid-solid or gas-solid [3,4]. During the last years, we have developed many photocatalysts based on phosphate [5,6].

In the case, the objective of this work is to study the photocatalytic activity of bismuth phosphate ($BiPO_4$) as a phosphate-based material. To understand the correlation between the structural, morphological and the photocatalytic activity of $BiPO_4$ powders. The photocatalysts prepared by co precipitation and solid-state reaction were analyzed by X-ray diffraction (XRD), scanning electron microscopy (SEM), Raman and photoluminescence spectroscopy (PL). The photocatalytic activity of $BiPO_4$ prepared by two methods are tested for the degradation of Rhodamine B and orange G as polluting dyes in aqueous medium. The degradation efficiency and photoluminescent properties of $BiPO_4$ powder prepared by different methods are compared and the results of characterization techniques are discussed.

Keywords: Environment, phosphate, bismuth phosphate, organic pollutants, photocatalytic properties.

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References

1. E. Amaterz, A. Tara, A. Bouddouch, A. Taoufyq, B. Bakiz, A. Benlhachemi, and O. Jbara, Rev. Environ. Sci. Biotechnol. **19**, 843 (2020).

2. C. A. Martínez-Huitle and E. Brillas, Appl. Catal. B Environ. **87**, 105 (2009).

3. J. Li, W. Cui, P. Chen, X. Dong, Y. Chu, J. Sheng, Y. Zhang, Z. Wang, and F. Dong, Appl. Catal. B Environ. **260**, 118130 (2020).

4. Y. Liu, Y. Zhu, J. Xu, X. Bai, R. Zong, and Y. Zhu, Appl. Catal. B Environ. **142–143**, 561 (2013).

5. A. Bouddouch, E. Amaterz, B. Bakiz, A. Taoufyq, F. Guinneton, S. Villain, J. Gavarri, M. Ezahri, J. Valmalette, and A. Benlhachemi, Water Environ. Res. **92**, 1874 (2020).

6. B. Akhsassi, A. Bouddouch, Y. Naciri, B. Bakiz, A. Taoufyq, C. Favotto, S. Villain, F. Guinneton, and A. Benlhachemi, Chem. Phys. Lett. 139046 (2021).

PHYTOCHEMICAL CONSTITUENTS AND EFFECTS OF METHANOL EXTRACT OF *CALOTROPIS PROCERA* FLOWER ON HEMATOLOGICAL PARAMETERS IN ALLOXAN-INDUCED DIABETES IN WISTAR RATS

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Abstract

Diabetes remains life threatening disease all over the world. Herbal medicine is one of the options to curtail the diabetes complication in developing countries. *Calotropis procera* is one of such plant used locally for diabetes management. Phytochemical constituents of methanol extract of *calotropis procera* flower (MECPF) was carried out using high performance liquid chromatography (HPLC). The effects of the extract were then carried out on haematological parameters in alloxan-induced diabetes in Wistar rats. Thirty Wistar rat were divided into six groups of five animals each for the experiment and five of the group were made diabetes by administering180 mg/kg body weight (b.w) of alloxan intraperitoneally. After 72 hours of alloxan administration, four groups of the hyperglyceamic rats were orally administered with 100, 200 and 400 mg/kg bw of MECPF along with 500 µg/kg bw of glibenclimide. The remaining diabetic and none-diabetic groups were however given 0.2 mL of normal saline orally. On the 7th day, the experimental rats were euthanized and the blood sample was collected via cervical dislocation for total blood counting. The HPLC analysis of MECPF revealed the presence calotropin, calotropenin, calotropagenin, procesterol, calotoxin, caffeic acid, epicatechin, beta-sitosterol, stigmasterol, alpha-amyrin, calactin, quercetin, kaempferol, isorhamnetin, luteolin, lineolone, uscharidin, voruscharin and uscharin. Alloxan significantly ($p > 0.05$) reduced the PCV (31.00%), HB (4.47 g/dl), RBC (5.16 g/dl), MCHC (32.50 g/dl), PLT (134.00 cells/µl) with elevation of MCV (52.33), MCH (43.50 pg/cells), TWBC (17.23 cells/µl), L (34.00 cells/µl) in normal saline treated diabetic rat when compared with those treated with the MECPF. However, MECPF was able to revert the alteration of these hematological indices. The 200 and 400 mg/kg bw exhibit higher activities which compared well with the standard drug glibenclimide. Therefore, the reversion of the altered hematological parameters in alloxan-induced diabetes in rats by MECPF could be linked to its phytoconstituents. Hence, MECPF could be explored further for the management of diabetes.

Keywords: *Calotropis procera,* Diabetes, Phytoconstituent, Alloxan, Haematology.

Introduction

Diabetes mellitus is a group of metabolic diseases characterized by hyperglycemia resulting from defects in insulin action, insulin secretion, or both. It has been approximated that 451 million people 18–99 years have diabetes and that 693 million people are expected to have diabetes in 2045 around the world (Chen *et al*., 2022). It was estimated that almost half of all people (49.7 %) living with diabetes are undiagnosed. Moreover, there were an estimated 374 million people with impaired glucose tolerance (IGT) and it was projected that almost 21.3 million live births to women were affected by some form of hyperglycemia in pregnancy. In fact, diabetes is one of the most common causes of death worldwide (Lin *et al*., 2020).

One of the complications of diabetes mellitus include breakdown of hematopoietic system, increased oxidative stress, dyslipidemia, hyperglycemia and various other metabolic diseases. Unfortunately, no successful cure for diabetes mellitus has yet been found but can be managed using oral anti-diabetic drugs, insulin, herbs and diet modification. Although, many antihyperglycemic drugs and insulin stimulants are available, but the adverse side effects sometimes associated with these drugs have prompted an interest in the use of alternative natural products (Chinsembu, 2019).

Medicinal herbs are gaining more attention in the management of diabetes due to their widely acceptability and low toxicity. Medicinal plants have evolved over the centuries as essential parts of African civilization and are widely recognized today as representing its cultural and scientific heritage. These medicinal plants are considered as ingredients which can be used in drug development and synthesis (Al-Snafi, 2018).

Calotropis procera commonly called milkweed is a perennial shrub of *Apocynaceae* family and subfamily of *Asclepiadaceae*. It is a xerophytic, evergreen plant that is typically found in semi-arid and arid environments (Rowaily *et al.,* 2020). Traditionally, the root bark, leaves and stem back of *Calotropis procera* are used in India to treat a variety of illnesses, including fever, leprosy, malaria, and snakebite (Parrotta, 2001). Pharmacologically*,* various part of *Calotropis procera* have been reported to have antimicrobial activity, antifungal activity, anti-inflammatory activity, antioxidant activity, neuroprotective activity, anti-diabetic activity, cardiac activity, and anti-cancer activity (Niraj *et al*., 2024). In Nigeria, the flower of *Calotropis procera* is being used as antidiabetic agent but little scientific evidences to back up the claim. Therefore, this study is aim at determining the phytochemical constituents and effects of methanol extract of *calotropis procera* flower on hematological indices in alloxan-induced diabetes in Wistar rats,

Materials and Methods

Materials

Collection of plant Materials

The fresh flowers of *Calotropis procera* were collected within the premises of Federal University of Technology Minna, Niger State, Nigeria, Bosso Local Government Area. on October 2023. A taxonomic aid provided by Abdullah *et al*. (2003) was used to authenticate the plant materials by a Botanist in Biological Science Department, Federal University of Technology Minna, Niger State. The flowers were removed from the stalk, air dried, ground into powdered form, using a blender, and stored for future use.

Figure 1: *Calotropis procera* Flower

Preparation of plant sample

Fresh *Calotropis procera* flowers were collected, washed and then air dried at room temperature of 25°C for three weeks. Afterwards, the dried flowers pulverized using a rotary blender. The powdered flower was kept in a plastic tight container till further use.

3.2.3 Extraction of *C. procera* flower

Briefly, 250 g of *C. procera* flower powder was macerated with 1,500 mL of absolute methanol. The extract was filtered with filter paper after which the methanol was evaporated under reduced pressure in a rotary vacuum evaporator.

Experimental Animals

Wistar albino rats of weight (79g – 174g) were used for experiment and were obtained from Animal house center of the Department of Biochemistry in the Federal University of Technology, Minna. The Wistar rats were allowed to acclimatize in the Department of Biochemistry laboratory, Federal University of Technology, Minna, for one (1) week. Internationally accepted principles for laboratory animal use and care as contained in the Canadian Council on Animal Care guidelines on animal use protocol review (1997) and as also described by Adamu *et al*. (2010) was followed during the uses of the animals.

Induction of Diabetes

The rats were placed on overnight fasting with but was allowed access to water. Exactly 180 mg/kg bodyweight of alloxan monohydrate was administered intraperitonially to rats in the respective groups except the normalglyceamic group which was given alloxan equivalent volume of cold physiological saline. Fasting blood glucose was checked after 72 hours and rats with blood glucose ≥ 150 mg/dl were considered diabetic and selected for the study. The treatment went on daily for seven days and the animal euthanized on the 7th day.

Animal Grouping and treatment of animals

The animal grouping and their respective treatment is shown below:

Group 1: Non-diabetic + 0.2 mL of distilled water

Group 2: Diabetic + 500 µg/kg bw. of glibenclimide

Group 3: Diabetic + 0.2 mL of distilled water

Group 4: 100 mg/kg bw. of methanol extract of *C. procera* flower

Group 5: 200 mg/kg bw. of methanol extract of *C. procera* flower

Group 6: 400 mg/kg bw. of methanol extract of *C. procera* flower

RESULTS

HPLC profiling *C. procera* flower

The HPLC analysis of methanol extract of calotropis procera revealed nineteen compounds with phenolic compounds in abundance (Table 1). Phenols, sterols, glycoside, alkaloids are majorly the classes of compounds present in MECPF.

Table 1: HPLC profiling *C. procera* flower

Phenolics	Retention	Area	Height	External units
Calotropin	3.700	2570.5060	52.269	0.0000 %
Calotropenin	5.883	701.5710	12.548	0.0000
Calotropagenin	7.966	833.6570	16.497	0.0000
Procesterol	9.116	93.8850	5.058	0.0000
Calotoxin	9.950	75.1300	4.492	0.0000
Caffeic Acid	10.500	144.7200	4.139	0.0000
Epicatechin	11.300	85.7700	3.843	0.0000
Beta-Sitosterol	11.850	125.1210	4.023	0.0000
Stigmasterol	12.333	69.6140	3.613	0.0000
Alpha-Amyrin	12.816	67.2000	3.776	0.0000
Calactin	13.466	67.7580	3.387	0.0000
Quercetin	15.500	839.7910	14.507	0.0000
Kaempferol	17.233	2685.2335	36.596	0.0000
Isorhamnetin	19.400	170.3135	6.196	0.0000
Luteolin	19.950	73.7525	5.151	0.0000
Lineolone	20.500	147.6340	4.697	0.0000
Uscharidin	21.066	75.0620	4.289	0.0000
Voruscharin	21.416	155.9395	4.597	0.0000
Uscharin	23.083	106.4570	4.310	0.0000

Effect of MEDPF on Red Blood Cell Indices in Diabetic Rats

The effects of MEDPF on red blood cell indices in diabetic rats is shown in Table 2. Administration of alloxan significantly reduced the levels of HB, PCV and RBC. However, after 7 days treatment with methanol extract of *Calostropis procera,* restorations of these parameters were observed. The reversion of these parameters depend on dosage given to the rats. The least reversion was observed in 100 mg/kg bw. of the extract while 400 mg/kg bw. showed high restorative values.

Table 2: Effect of MEDPF on Red Blood Cell Indices in Diabetic Rats

GROUP	HB (g/dl)	PCV (%)	RBC (cells/µl)
1	12.91 ± 0.58^{d}	39.5 ± 0.50^{c}	11.55 ± 0.78^{d}
2	11.00 ± 0.81^{c}	38.50 ± 0.50^{c}	9.32 ± 0.68^{c}
3	4.47 ± 1.09^{a}	31.00 ± 1.00^{a}	5.16 ± 0.30^{a}
4	6.69 ± 0.64^{b}	35.50 ± 1.50^{b}	5.34 ± 0.19^{a}
5	8.32 ± 0.24^{b}	36.5 ± 0.50^{b}	8.44 ± 0.14^{b}
6	11.19 ± 1.64^{c}	38.5 ± 0.50^{c}	9.48 ± 0.08^{c}

Value is represented as mean ± standard deviation (SD) of five animals. Value on the same column with the same alphabet superscript is not significantly ($p < 0.05$) difference

Group 1: Non-diabetic + 0.2 mL of distilled water, Group 2: Diabetic + 500 µg/kg bw. of glibenclimide, Group 3: Diabetic + 0.2 mL of distilled water, Group 4: 100 mg/kg bw. of MECPF, Group 5: 200 mg/kg bw. of MECPF, Group 6: 400 mg/kg bw. of MECPF.

Effect of MEDPF on White Blood Cell Indices in Diabetic Rats

The effects of MEDPF on white blood cell indices in diabetic rats is shown in Table 3. Administration of alloxan significantly ($p < 0.05$) reduced the levels of MCHC and PLT with significant ($p < 0.05$) elevation of MCH, TWBC, L and MCV. However, after 7 days treatment with methanol extract of *Calostropis procera,* these parameters were restored and some of these parameters were compared well with standard drug treated drugs. The highest restoration of these parametres was also observed in 400 mg/kg bw.

Table 3: Effect of MEDPF on White Blood Cell Indices in Diabetic Rats

Group	MCH (pg/cells)	MCHC (g/dl)	PLT (cells/µl)	TWBC (cells/µl)	L (cells/µl)	MCV (fl)
1	31.50 ± 0.50^{a}	$41.50 \pm 1.50^{c,d}$	153.50 ± 2.50^{c}	$7.17 \pm 0.21^{a,b}$	21.50 ± 0.50^{a}	40.50 ± 0.50^{ab}
2	31.00 ± 1.00^{a}	38.00 ± 1.00^{b}	155.00 ± 2.00^{c}	$7.88 \pm 0.17^{a,b}$	21.50 ± 0.50^{a}	39.00 ± 1.00^{a}
3	43.50 ± 2.50^{d}	32.50 ± 1.50^{a}	134.00 ± 3.00^{a}	17.23 ± 1.53^{c}	34.00 ± 2.00^{d}	52.33 ± 1.53^{d}
4	36.00 ± 1.00^{b}	38.00 ± 0.00^{b}	$151.50 \pm 1.50^{b,c}$	$7.02 \pm 0.14^{a,b}$	21.00 ± 1.00^{a}	39.00 ± 0.00^{a}
5	35.50 ± 0.50^{b}	42.50 ± 1.50^{d}	147.50 ± 2.50^{b}	8.13 ± 0.07^{b}	25.50 ± 0.50^{c}	39.50 ± 0.50^{b}
6	34.00 ± 1.00^{b}	$40.00 \pm 1.00^{b,c}$	148.50 ± 0.50^{b}	6.38 ± 1.33^{a}	23.50 ± 0.50^{b}	39.50 ± 0.50^{a}

Value is represented as mean ± standard deviation (SD) of five animals. Value on the same column with the same alphabet superscript is not significantly ($p < 0.05$) difference

Group 1: Non-diabetic + 0.2 mL of distilled water, Group 2: Diabetic + 500 µg/kg bw. of glibenclimide, Group 3: Diabetic + 0.2 mL of distilled water, Group 4: 100 mg/kg bw. of MECPF, Group 5: 200 mg/kg bw. of MECPF, Group 6: 400 mg/kg bw. of MECPF.

DISCUSSIONS

Alloxan monohydrate, an analogue of glucose induces chemical diabetes in many animal species by its toxic action onpancreatic beta cells involved in oxidation of essential sulphydryl (-SH) groups, inhibition of glucokinase enzyme, generation of free radicals and disturbances in intracellular calcium homeostasis (Busari *et al*., 2015). The underlying mechanism involves the selective uptake of the compound due to its structural similarity to glucose as well as highly efficient uptake mechanism of the pancreatic beta-cells (Busari *et al*., 2015). During diabetes, the immune system and several haematological parameters change (Mansi and Lehham, 2008). Additionally, toxicological research has shown that ingesting medications/medicinal plants can change the usual haematological values (Ajagbona *et al*., 1999). Therefore, haematological measures may be crucial in determining a drug's adverse effects and those of medicinal plants and their extracts (Yakubu *et al.,* 2007). The increase in RBCs may be attributable to the extract's stimulation of the formation of stromal cells and macrophages in the bone marrow's erythropoietin and colony-stimulating factor (Usman and Osuji, 2007). Hence, the extract might triggers stem cells in the bone marrow to produce red blood cells (Lodish *et al*., 2010). White blood cell (WBC), packed cell volume (PCV), and haemoglobin (Hb) concentration values were lowered in diabetic rats in the current investigation. However, treatment with the methanol extract from *C. procera* reversed the WBC, PCV, and Hb concentration values in diabetic rats. This is consistent with earlier studies that have established the incidence of anaemia in people with diabetes (Merlin *et al*., 2007). Furthermore, MCV determine the size of RBCs, while MCH indicates the concentrations as well as weight of haemoglobin in the RBCs (Busari *et al*., 2021). The alteration of MCH and MCV as obtained actually reflected the previous alteration in RBC, PCV and HB observed in this study. Significant increase of WBC and L in alloxan-induced diabetic rats might be as a result of the inflammatory response induced-defense mechanism in response to alloxan-induced toxicity.

The presence of the various phytochemicals might be responsible for these gradual change in the haematological parametres after treatment with the extract of *C. procera.* Phenolics such as caffeic acid, Kaempferol, quercetin and luteolin are found appreciably in the extract. Most of these phenolic compounds possessed antioxidant, anti-inflammation and antidiabetic activities. Hence, there is possibility of these compounds to have quenched the reactive oxygen species induced by the alloxan. Specifically, calotoxin was reported to have possessed antidiabetic activity *in* vitro by inhibiting dipeptidyl peptidase-IV (Sewidan *et al.,* 2020). It can be concluded from this experiment that the methanol extract of *C. procera* could reverse the altered haematological parametrs in alloxan-induced diabetes in Wistar rats.

REFERENCES

Chen, W., Mao, M., Fang, J., Xie, Y., & Rui, Y. (2022). Fracture risk assessment in diabetes mellitus. Frontiers in Endocrinology, 13.

Chinsembu, K. C. (2019). Diabetes mellitus and nature's pharmacy of putative antidiabetic plants. Journal of herbal medicine, 15, 100230.

Al-Rowaily, S. L., Abd-ElGawad, A. M., Assaeed, A. M., Elgamal, A. M., Gendy, A. E. N. G. E., Mohamed, T. A., ... & Elshamy, A. I. (2020). Essential oil of Calotropis procera: Comparative chemical profiles, antimicrobial activity, and allelopathic potential on weeds. *Molecules*, *25*(21), 5203.

Busari, M. B., Muhammad, H. L., Ogbadoyi, E. O., Kabiru, A. Y., Sani, S., & Yusuf, R. S. (2015). In vivo Evaluation of Antidiabetic Properties of Seed Oil of Moringa oleifera Lam.

Busari, M. B., Hamzah, R. U., Muhammad, H. L., Yusuf, R. S., Adeniyi, J. O., Ibrahim, Y. O., & Adakole, J. O. (2021). Phenolics-rich extracts of Nauclea latifolia fruit ameliorates lead acetate-induced haematology and lung tissues toxicity in male Wistar rats. *Scientific African*, *11*, e00686.

Mansi, K.; Lehham, J. Effects of Artemisia sieberi on heart rate and some hematological values in normal and alloxan-induced diabetic rats. J. Basic Appl. Sci. Res. **2008**, 4, 57–72. [Google Scholar].

Sewidan, N., Khalaf, R. A., & Mohammad, H. (2020). In-Vitro Studies on Selected Jordanian Plants as Dipeptidyl Peptidase-IV Inhibitors for Management of Diabetes Mellitus. *Iranian Journal of Pharmaceutical Research: IJPR*, *19*(4), 95.

Ajagbonna, O.P.; Onifade K.I. & Suleiman, U. Hematological and biochemical changes in rats given extract of Calotropis procera. Sokoto J. Vet. Sci. **1999**, 1, 36–42. [Google Scholar].

Yakubu, M.T.; Akanji, M.A. & Oladiyi, A.T. Hematological evaluation in male albino rats following chronic administration of aqueous extract of Fadogia agrestis stem. J. Pharmacol. **2007**, 3, 34–38. [Google Scholar].

Usman, H. & Osuji, J.C. Phytochemical and in-vitro antimicrobial assay of the leaf extract of Newbouldia laevis. Afr. J. Tradit. Complement. Altern. Med. **2007**, 4, 476–480. [Google Scholar] [CrossRef] [PubMed].

Merlin, T.; Con, T.; Richard, M. & George, J. Anaemia in diabetes: An emerging complication of microvascular disease. Curr. Diabetes Rev. J. **2005**, 1, 107–126. [Google Scholar].

Olotu, I.A.; Luka, C.D. & Olotu, P.N. Evaluation of the effects of aqueous whole plant extract of Lepidium sativum, L. (Brassicaceae) on some biochemical and hematological parameters in streptozotocin-induced diabetic rats. J. Nat. Prod. Plant Resourse **2018**, 8, 19–25. [Google Scholar].

Niraj Kumar Singh, Bharat Bhushan & Yasharth Agrahari (2024). An Overview on the Phytochemical and Therapeutic potential of Calotropis procera, Pharmacological Research - Modern Chinese Medicine (2024), doi: https://doi.org/10.1016/j.prmcm.2024.100441

DIFFERENT CYTOKINE CONCENTRATIONS IN *Cannabis indica* LAM. EFFECT ON CANNABIDIOL (CBD) VALUES IN CALLUS CULTURES

FARKLI SİTOKİNİN KONSANTRASYONLARININ *Cannabis indica* LAM. KALLUS KÜLTÜRLERİNDEKİ KANNABİDİOL (CBD) DEĞERLERİ ÜZERİNE ETKİSİ

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Abstract

Callus cultures created under *in vitro* conditions enable the production of pharmaceutically valuable secondary metabolites. This study *Cannabis indica* Lam. It aims to determine the cannabidiol (CBD) values of callus cells of. *Cannabis indica* Lam cultured on MS (Murashige and Skoog) medium. Female leaf explants were left for callus induction in media containing naphthalene acetic acid (NAA), thidiazuron (TDZ), benzylaminopurine (BAP), kinetin (KiN) in different concentrations and combinations for 5 weeks. It was determined that the cannabidiol values in the methanol:chloroform extracts of callus tissues obtained from the applied cytokinin combinations were higher at 2 mg/L TDZ + 0,5 mg/L NAA concentration than other application concentrations. It has been recorded that CBD values at 0,5 mg/L QUIN + 0,5 mg/L NAA concentration are lower than other application concentrations. We think that in future studies, different chemical elicitor treatments to callus tissues grown in TDZ combinations with high CBD values can meet the need in CBD usage areas.

Key Words: CBD, TDZ, BAP, *Cannabis indica* Lam.

Özet

İn vitro koşullarda oluşturulan kallus kültürleri, farmasötik açıdan değerli olan sekonder metabolitlerin üretilmesine olanak sağlamaktadır. Bu çalışma *Cannabis indica* Lam. 'ın kallus hücrelerinin kannabidiol (CBD) değerlerinin belirlenmesini amaçlamaktadır. MS (Murashige ve Skoog) besiyerinde kültüre alınmış *Cannabis indica* Lam. dişi yaprak eksplantları, farklı konsantrasyon ve kombinasyonlarda naftalin asetik asit (NAA), thidiazuron (TDZ) benzilaminopurin (BAP), kinetin (KiN) içeren besiyerlerinde 5 hafta boyunca kallus indüksiyonuna bırakılmıştır. Uygulanan sitokinin kombinasyonlarında elde edilen kallus dokularının methanol: kloroform ekstrelerindeki kannabidiol değerlerinin 2 mg/L TDZ+ 0,5 mg/L NAA konsantrasyonundaki değerlerinin diğer uygulama konsantrasyonlarına göre yüksek olduğu tespit edilmiştir. 0,5 mg/L KİN + 0,5 mg/L NAA konsantrasyonundaki CBD değerlerinin ise diğer uygulama konsantrasyonlarına göre düşük olduğu kayıt altına alınmıştır. İleride yapılacak çalışmalarda CBD değerlerinin yüksek olduğu TDZ kombinasyonlarında yetiştirilen kallus dokularına farklı kimyasal elisatör muamelerinin CBD kullanım alanlarındaki ihtiyacın karşılanabileceğini düşünmekteyiz.

Anahtar Kelimeler: CBD, TDZ, BAP, *Cannabis indica* Lam.

INTRODUCTION

Hemp herb, also known as 'cannabis' or 'hemp' in English, belongs to the Cannabinaceae family; It is an annual, herbaceous, dioecious, flowering plant (Tanker et al., 2007). The female flowers of this dioecious plant, which has male and female flowers in different individuals, are surrounded by dense leaves and there are trichomes that secrete resin around these flowers. (Clarke 1981; Raman 1998). The Cannabis plant was named *Cannabis sativa* L. for the first time in 1753 by Carlous Linnaeus. In 1785, French biologist Jean-Baptiste Lamarck described the *Cannabis indica* species, which originated in India and was morphologically different from *C. sativa*. In 1924, Janischevsky discovered the *Cannabis ruderalis* species in Russia, which had different characteristics than the other two species (Anderson, 1980). *C. sativa* is the most widely produced species used mainly in oil and fiber production. *C. indica* is a species known as 'Indian hemp', which is between 0,90 and 2,5 m tall, is pyramid-shaped and frequently branched, is rich in psychoactive ingredients and is not suitable for fiber production. *C. ruderalisise* is the species known as 'wild hemp', its body is shorter, more differentiated than the other two species, and shows sparse branching (Çalışkan &Yıldırım, 2020).

Cannabis species have a very high economic value as they are rare plants due to their superiority in all areas of use (Gönen, 2009). It is known that the flowers and resin of Cannabis species were used in various religious rituals for meditation purposes when the biochemical contents of Cannabis species were not yet defined (Touw, 1981). Sources have revealed that in ancient civilizations, these plant species were used in the treatment of fatigue, rheumatism and malaria, and that the seed oil was used as an anti-inflammatory in eczema and psoriasis due to its protein content (Abel, 1980; Epstein, 2010). In his book El-Kanun Fi't-Tıb, Ibn Sina wrote that a compress made with boiled hemp root reduces fever (Çalışkan & Yıldırım, 2020; Sina, 1143).

The first negotiations were held at the 1912 Hague Convention congress to restrict the production and prohibit the consumption of Cannabis plants due to their psychoactive substance content, and these prohibitions became clear with the laws created in the following processes. (Elmas et al., 2023; League of Nations, 1937). In 1964, despite legal restrictions, Gaoni and Mechoulam determined the chemical structure of tetrahydrocannabinol (THC), the main component that causes the euphoric effect of cannabis, and started a new process (Gaoni & Mechoulam, 1964).

The structure of cannabidiol (CBD) is similar to Δ9-tetrahydrocannabinol (THC). However, it does not have the ability to bind strongly to CB1 receptors like THC (Pertwee, 2008; Casajuana et al., 2018). A study showed that Parkinson's disease, multiple sclerosis, and tremors caused by extreme emotional stress decreased by 20-50% in patients given 100-600 mg of CBD daily (Consroe, 1986). Research has shown that CBD; It has been shown to have anticonvulsant, antispasmodic, anxiolytic, antiemetic, antirheumatic and neuroprotective properties (Pertwee, 2008). Additionally, studies on Alzheimer's, some types of cancer and infertility are ongoing (Laun et al., 2019). Clinical studies with CBD have gained popularity in recent years because it does not have a psychoactive effect but has strong anticonvulsant activity.

It is noteworthy that CBD, which is non-psychoactive and has a relatively high concentration compared to THC, is more promising in clinical applications (Scuderi et al., 2009). CBD reduces the effect of THC and has an antipsychotic effect against it. Preparation of standard formulations with adequate THC dosage makes the use of the plant widespread. Current formulations are known to be well tolerated (Flores & Verpoorte, 2008; Kiskova et al., 2019; Fraguas & Torres 2018; Suryadevara et al., 2017).

One of the unique characteristics of plants is that secondary metabolites are produced in a wide variety of different numbers. Plant callus cultures have the advantage of obtaining much more material from a limited number of materials. In addition, it provides the opportunity to produce the desired products all year round, despite seasonal restrictions. While some secondary metabolites are more difficult to obtain from organized organ tissues, they are easily obtained from callus cultures (Sökmen & Gürel, 2001; Koo et al., 2005; Keskin & Kunter, 2007; Maharik et al., 2009; Çetin et al., 2011).

Due to the rapid consumption of many medicinal aromatic plant populations containing secondary metabolites of interest to the pharmaceutical industry, production in plant tissue cultures with new approaches for the sustainable production of high-value molecules has become important (Nosov et al., 2023). Using different in vitro culture techniques instead of a whole plant in the production of high-value secondary metabolites is the most effective alternative source. The advantages of this technique over traditional production are; It is independent of soil and climatic differences and environmental conditions, offers continuous production in quality and quantity, allows the discovery of new compounds that are not normally found in the donor plant, is not affected by agricultural policies and restrictions, and offers rapid production in a short time (Rao & Ravishankar, 2002).

In this study, *Cannabis indica* Lam, whose cultivation is restricted by legal regulations. It was aimed to determine the appropriate cytokinin and its concentrations in order to produce cannabidiol, which has high economic value, in callus tissues obtained from the plant.

MATERIALS AND METHODS

This research study was conducted at Fırat University Plant Tissue Culture Laboratory and Greenhouse.

Surface Sterilization and Culturing

Cannabis indica Lam grown in the greenhouse to start in vitro culture. Surface sterilization of plant leaves is required. Female leaves to be used as explant sources were washed under running tap water, disinfected with 70% ethanol, and taken into a laminar flow cabinet. Seed sterilization was achieved by treating sodium hypochlorite (5%), one of the disinfectants commonly used for seed sterilization, for 15 minutes. Distilled water was used 3 times with 5-minute intervals for surface washing (Chaohua et al., 2016).

By adding 3% sucrose and 6.8 g/L agar as carbon source, it was planted in Murashige and Skoog (MS) nutrient medium (Murashige & Skoog, 1962), prepared with the plant growth regulators in Table 1, and callus induction was initiated by taking it to the callus climate chambers.

Table 1. Medium contents prepared for *Cannabis indica* Lam. callus tissue induction

Groups	Medium content (mg/L)
Control	-
1.	0,5 Kin + 0,5 NAA
2.	0,5 BAP+ 0,5 NAA
3.	0,5 TDZ + 0,5 NAA
4.	1 Kin + 0,5 NAA
5.	1 BAP + 0,5 NAA
6.	1 TDZ + 0,5 NAA
7.	2 Kin + 0,5 NAA
8.	2 BAP+ 0,5 NAA
9.	2 TDZ + 0,5 NAA

Analysis of CDB with HPLC Device

Cannabis indica Lam grown in greenhouse. To extract cannabinoids from male and female plant parts and callus tissues grown on media, weigh approximately 25 mg of powdered samples using an analytical balance; 10 mL of methanol-chloroform solvent 9:1 (Backer et al., 2009) and 8:2 (v/v) was added. The organic phase containing cannabinoids from plant parts and callus tissues shredded in the homogenizer was collected in a 25 mL falcon tube. After the collected organic phase was centrifuged at 3000 rpm, it was taken into another tube, its solvent was evaporated under nitrogen flow, and it was dissolved in 1 ml of Acetonitrile and analyzed by HPLC-UV device.

For HPLC analysis of cannabidiol, a C18 HPLC column was used with the column oven temperature set at 35 ˚C and the autosampler temperature at 4 °C. The wavelength of the PDA detector was set to 220 nm and a mixture of water (0.085% H_3PO_4 and Acetonitrile (0.085% H_3PO_4) was used as the mobile phase. Mobile phase Gradient elution: 70% of B for up to 3 minutes, % of B for up to 7 minutes. 85 is programmed as 95% of B for up to 8.00 minutes and 70% of B for up to 10 minutes. After the analysis of the CBD is done with the HPLC – UV system, the calculations are carried out using Lab Solutions LC/GC 5.97. program (Shimadzu, Kyoto, Japan).

RESULTS AND DISCUSSION

Cannabis indica Lam. grown in Fırat University Plant tissue culture laboratory and greenhouse. The plants were matured and male and female individuals were separated. The amount of CBD in the stem, leaf and flower parts of female and male plants was determined by HPLC device (Table 2).

Table 2. *Cannabis indica* Lam. CBD values (ug/g) of 9:1 to 8:2 methanol:chloroform extracts of different parts of the plant

	Methanol: Chloroform	
Plant Parts	**9:1**	**8:2**
Female Flower	855,00 ± 46,02	1364,66 ± 10,30
Female Leaf	386,00 ± 1,38	563 ± 2,98
Female Body	86,44 ± 3,64	0,67 ± 0,00
Male Leaf	8,66 ± 2,18	6,89 ± 1,94
Male Body	0,88 ± 0,29	0,33 ± 0,01
Male Flower	0,27 ± 0,01	0,38 ± 0,00

It was determined that the 1364.66 ± 10.30 ug/g CBD value in the 8:2 methanol:chloroform extracts of female flowers was higher than other plant parts. It is known that the main production sites in Cannabis species are the epidermal glandular hairs located on the leaves, flowers, bracts and stem of the plant (Fairbairn, 1972). This resin, which has psychoactive properties and medicinal effects, is located mainly in the flowering branch tips and bracts of the female plant. In the leaves of male plants, resin secretion is very low. Cannabinoids are found in the tepals, stamens and pollen of male plants, but this amount is not as intense as in female plants (Dayanandan & Kaufman, 1976). These studies can also be supported for the CBD values in Table 2.

Unlike the study conducted by Backer et al. in 2009, when the results of 9:1 and 8:2 methanol:chloroform were compared, it was determined that the most suitable solvent ratio was 8:2 (Figures 1 and 2).

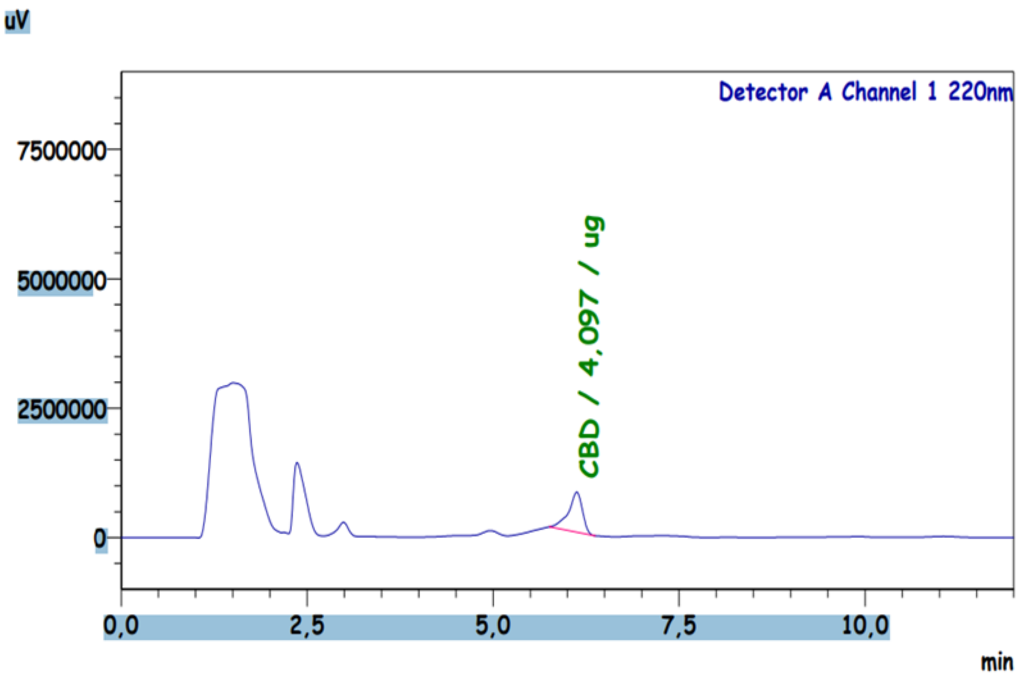

Figure 1. CBD chromatograms of 8:2 methanol:chloroform extracts of *Cannabis indica* Lam. female flowers

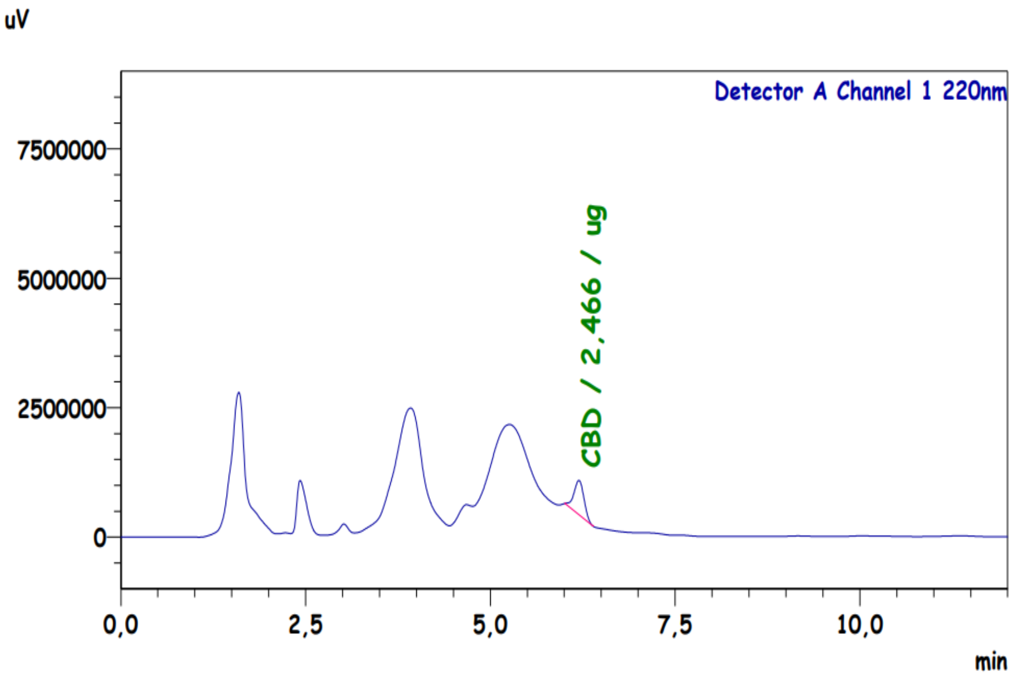

Figure 2. CBD chromatograms of 9:1 methanol:chloroform extracts of *Cannabis indica* Lam. female flowers

Table 3. *Cannabis indica* Lam. stimulated with different cytokinin combinations CBD values (ug/g) of 8:2 methanol:chloroform extracts of callus tissues

	Callus Weight per Magenta (g)	**CBD (ug/g)**
0,5 Kin + 0,5 NAA	4,11 ± 0,03	0,34 ± 0,08
0,5 BAP+ 0,5 NAA	9,83 ± 0,11	0,36 ± 0,01
0,5 TDZ + 0,5 NAA	7,3 ± 0,19	0,62 ± 0,00
1 Kin + 0,5 NAA	necrosis	-
1 BAP + 0,5 NAA	11,42 ± 0,08	0,38 ± 0,03
1 TDZ + 0,5 NAA	17,27 ± 0,04	0,47 ± 0,01
2 Kin + 0,5 NAA	necrosis	-
2 BAP+ 0,5 NAA	19, 39 ± 0,03	0,34 ± 0,00
2 TDZ + 0,5 NAA	18,58 ± 0,09	1,01 ± 0,04

Necrosis observed at different kinetin concentrations showed that; Cannabis indica does not have the appropriate cytokinin content for lam callus induction. The increased callus induction at high TDZ concentrations also directly affected the CBD contents.

CONCLUSION

The study data showed that CBD values in callus tissues; It has been determined that CBD values can be improved by applying the correct concentration of appropriate plant growth regulators and plant callus tissues can also be used in isolation and purification processes.

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Statement of Conflict of Interest

Authors have declared no conflict of interest

REFERENCES

Abel, E. L. (1980). Marijuana the first twelve thousand years Plenum Press. *New York, New York, USA*.

Anderson, L.C. (1980). Leaf variation among Cannabis species from a controlled garden. Botanical Museum Leaflets, Harvard University, 28(1), 61-69.

Casajuana Kögel, C., López-Pelayo, H., Balcells-Olivero, M.M., Colom, J., Gual, A. (2018). Psychoactive constituents of cannabis and their clinical implications: a systematic review. Adicciones, 30(2).

Chaohua, C., Gonggu, Z., Lining, Z., Chunsheng, G., Qing, T., Jianhua, C., et al. (2016). A rapid shoot regeneration protocol from the cotyledons of hemp (Cannabis sativa L.). Ind Crops Prod., 83, 61-65.

Clarke RC (1981) Marijuana botany: an advanced study, the propagation and breeding of distinctive Cannabis. Ronin Publishing, Oakland, CA.

Consroe, P., Sandyk, R., Snider, S.R. (1986). Open label evaluation of cannabidiol in dystonic movement disorders. International Journal of Neuroscience, 30(4), 277-282.

ÇALIŞKAN, U. K., & YILDIRIM, (2020). S. KENEVİR VE SAĞLIK ALANINDA KULLANIMI. *Journal of Faculty of Pharmacy of Ankara University*, *44*(1), 112-136.

Çetin, E.S.,Uzunlar, F., Baydar, N.G .(2011). UV-C Uygulamasının Gamay Üzüm Çeşidine Ait Kalluslarda Sekonder Metabolit Üretimi Üzerine Etkileri. Gıda. 36 (6): 319-326.

Dayanandan, P., & Kaufman, P. B. (1976). Trichomes of Cannabis sativa L.(Cannabaceae). *American Journal of Botany*, *63*(5), 578-591.

De Backer, B., Debrus, B., Lebrun, P., Theunis, L., Dubois, N., Decock, L., ... & Charlier, C. (2009). Innovative development and validation of an HPLC/DAD method for the qualitative and quantitative determination of major cannabinoids in cannabis plant material. Journal of Chromatography B, 877(32), 4115-4124.

ElSohly, M., Gul, W. (2014). Constituents of Cannabis sativa. Handbook of cannabis, 3, 1093.

Epstein, H.A. (2010). A natural approach to soothing atopic skin. Recommend a stretch marks therapy that lives up to its promises., 95.

Fairbairn, J.W. (1972). The trichomes and glands of Cannabis sativa L. Bull. Narc, 23, 29-33.

Flores-Sanchez, I. J., & Verpoorte, R. (2008). Secondary metabolism in cannabis. *Phytochemistry reviews*, *7*, 615-639.

Fraguas-Sánchez, A. I., & Torres-Suárez, A. I. (2018). Medical use of cannabinoids. *Drugs*, *78*(16), 1665-1703.

Gaoni, Y., Mechoulam, R. (1964). Isolation, structure, and partial synthesis of an active constituent of hashish. Journal of the American chemical society, 86(8), 1646-1647.

Gönen, S. (2009). Cannabis sativa. *Bitkisinin morfolojisi ve anatomisi üzerine bir araştırma*, *401*(00), 1-7.

Ibn Sina, A. (1143). Kanun fi at-Tibb (Canon of medicine) [in Arabic]. 2nd vol. Baku, Azerbaijan: The Institute of Manuscripts of Azerbaijan National Academy of Sciences.

League of Nations, (1937). Société des Nations, 258- 260.

Keskin, N., & Kunter, B. (2007). Ercis üzüm çeşidinin kallus kültürlerinde UV ışını etkisiyle resveratrol üretiminin uyarılması. *Journal of Agricultural Sciences*, *13*(04), 379-384.

Kisková, T., Mungenast, F., Suváková, M., Jäger, W., & Thalhammer, T. (2019). Future aspects for cannabinoids in breast cancer therapy. *International journal of molecular sciences*, *20*(7), 1673.

Laun, A.S., Shrader, S.H., Brown, K.J., Song, Z.H. (2019). GPR3, GPR6, and GPR12 as novel molecular targets: their biological functions and interaction with cannabidiol. Acta Pharmacologica Sinica, 40(3), 300.

Maharik, N., Elgengaihi, S., & Taha, H. (2009). Anthocyanin production in callus cultures of Crataegus sinaica boiss. *Int J Acad Res*, *1*(1), 30-34.

Murashige, T., & Skoog, F. (1962). A revised medium for rapid growth and bioassays with tobacco tissue cultures. Physiol Plant, 15, 473-497.

Nosov, A. V., Titova, M. V., Fomenkov, A. A., Kochkin, D. V., Galishev, B. A., Sidorov, R. A. & Nosov, A. M. (2023). Callus and suspension cell cultures of Sutherlandia frutescens and preliminary screening of their phytochemical composition and antimicrobial activity. *Acta Physiologiae Plantarum*, *45*(3), 42.

Pertwee, R.G. (2008). The diverse CB1 and CB2 receptor pharmacology of three plant cannabinoids: Δ9-tetrahydrocannabinol, cannabidiol and Δ9-tetrahydrocannabivarin. British journal of pharmacology, 153(2), 199-215.

Raman A (1998) The Cannabis plant: botany, cultivation and processing for use. In: Brown DT (ed) Cannabis: the genus Cannabis. Harwood Academic Publishers, Amsterdam, pp 29–54.

Rao, S. R., & Ravishankar, G. A. (2002). Plant cell cultures: chemical factories of secondary metabolites. *Biotechnology advances*, *20*(2), 101-153.

Scuderi, C., Filippis, D. D., Iuvone, T., Blasio, A., Steardo, A., & Esposito, G. (2009). Cannabidiol in medicine: a review of its therapeutic potential in CNS disorders. *Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives*, *23*(5), 597-602.

Sökmen, A., Gürel, E. (2001). Sekonder Metabolit Üretimi. Bitki Biyoteknolojisi. Vol. I. Doku Kültürü ve Uygulamaları. Editörler S. Özcan, E. Gürel ve M. Babaoğlu. S.Ü. Basımevi, s.211-261, Konya.

Koo, J. Y., Hwang, E. Y., Cho, S., Lee, J. H., Lee, Y. M., & Hong, S. P. (2005). Quantitative determination of amygdalin epimers from armeniacae semen by liquid chromatography. *Journal of Chromatography B*, *814*(1), 69-73.

Suryadevara U, Bruijnzeel DM, Nuthi M, Jagnarine DA, Tandon R, Bruijnzeel AW. (2017). Pros and cons of medical cannabis use by people with chronic brain disorders. Curr Neuropharmacol; 15: 800-814.

Tanker N, Koyuncu M, Coşkun M. Fam: Cannabinace. Farmasötik Botanik. 3. Basım. Ankara, Ankara Üniversitesi Basımevi; 2007. 184-185

Touw, M. (1981). The religious and medicinal uses of Cannabis in China, India and Tibet. Journal of psychoactive drugs, 13(1), 23-34.

THE IMPACT OF WATER STRESS ON SEED GERMINATION IN SELECTED LEGUME SPECIES IN ALGERIA

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Abstract

The increasing occurrence of drought has sparked significant interest among numerous researchers in understanding the mechanisms enabling plants to adapt to this stress or to select varieties that exhibit effective genetic resistance to various production-specific obstacles.

This study aims to evaluate the effect of water stress induced by polyethylene glycol (PEG 6000) at different concentrations on the germination of select legume species in Algeria. Water stress is a major limiting factor for plant growth in arid and semi-arid regions such as Algeria. Understanding the response of local legume ecotypes to this water stress can help identify varieties best suited to drought conditions in the region.

The experiment was conducted under controlled conditions by germinating four legume species (4X4 Bean, Chickpea, Sidi Aich Faba bean, and Kalvedon Wonder Pea) in Petri dishes with varying concentrations of PEG 6000 to simulate water stress (0%, 5%, 10%, 15%, 20%) for a period of 7 days. Germination parameters such as germination rate, germination speed, germination kinetics, and seedling vigor will be evaluated and compared among the different ecotypes subjected to various dilutions of PEG 6000.

The results of this study revealed significant variations in the germination response of legume species exposed to different dilutions of PEG 6000. The "Sidi Aich Faba bean" and "4X4 Bean" species exhibited better tolerance to water stress compared to "Chickpea" and "Pea" species, which proved to be more sensitive. These findings suggest that these varieties could be used in the selection of locally adapted legume cultivars for drought conditions in Algeria.

In conclusion, this study has contributed to enhancing our understanding of the effect of water stress induced by PEG 6000 at different concentrations on the germination of legume ecotypes in Algeria. The obtained results could have significant implications for the development of drought-resistant varieties, thereby improving agricultural productivity and the sustainability of cropping systems in arid and semi-arid regions of the country.

Keywords: water stress, PEG 6000, legumes, germination, resistance

SYNERGISTIC EFFECT OF GARLIC EXTRACT AND FOLIAR APPLICATION OF ASCORBIC ACID ON THE GROWTH OF OKRA (ABELMOSCHUS ESCULENTUS L.) UNDER DROUGHT STRESS

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Abstract

The measured increase in drought stress accentuated with crop production threats as well as agricultural soil damage, leads to great attention globally. Strategies based on soil amendment along with alleviation of harmful impacts of drought from crop are required to be established. Current study focused on garlic extract as soil modifier with ascorbic acid spray to alleviate the impact of drought stress on Okra (*Abelmoschus Esculentus* L.). Soil was amended with garlic extract two weeks before the experiment. field experiment with three replications was conducted by considering three levels of drought stress (50%, 30%, and 10% of field capacity) along with control. Whole set of experiment was divided into two splits; with ascorbic acid (AsA-150mg/L) and without ascorbic acid. The impact of drought was estimated by measuring seed germination parameters (mean germination time, germination percentage, plumule and radicle Length, seedling fresh and dry weight, and vigor index), morphological (root and shoot length, plant fresh and dry weight, no. of leaves, leaf fresh and dry weight), physiological (membrane stability index%, electrolyte leakage%, chlorophyll a and b, and carotenoids), and enzymatic and non-enzymatic antioxidants including Catalase, Superoxide dismutase, Peroxidase, Malondialdehyde, Hydrogen peroxide, and Total Sugars) were studied. In morphology Root, Shoot length, and fresh and dry weight of plant decrease with drought stress. Its lower level of photosynthetic pigments and membrane stability lead to an increase in electrolyte leakage. The level of studied antioxidants including (SOD, POD, Apx, catalase), total sugars, and oxidants (MDA, H_2O_2) increases with drought stress. These effects of drought stress were more evident at the T_3 level. Both mitigators alleviate the negative effects. The germination percentage and germination rate improved with mitigators, and MGT was reduced by mitigators application. The improved Plumule length and radicle length fresh and dry weight were also observed. In biochemical parameters, mitigators reduce the effect of drought stress by upregulating the level of antioxidants and reducing the ROS.

Key words: ascorbic acid, foliar application, drought, garlic extract

PROMOTION OF CONCERN FOR THE ENVIRONMENT

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Abstract

The purpose of this paper is to look at ways in which supranational organizations such as the European Union, of which Romania, the country where the author of the present paper lives, is a member, creates its environmental policies and raising awareness campaigns while creating a strong relation between environmental health and our own health. Our well-being, both psychological and physical, depends on our relationship with the environment, or so we are led to believe. Health and environmental policies are, eventually, intertwined. Especially in urban areas, we are frequently exposed to pollution of various kinds, air pollution, or noise pollution, being clearly felt when there is constantly heavy traffic. Practices such as allowing pedestrian streets events and promoting walking in parks and using bikes on beautiful days during weekends and holidays in the city work to leaving us experience the benefits and well-beings of such activities. In turn, such activities lead us to have a stronger connection with the environment and a stronger conviction that, indeed, any action of taking care of it, no matter how small, does matter. We could conclude that health and environmental policies, as well as political decisions taken at world level, as well as promotion of certain values and principles can have an evolutionary interpretation. They have an adaptive function, since having citizens obey these rules can be for our own good, for our own survival as a species, now, as well as in the future. We are definitely made aware of this aspect and we instinctively feel obeying these rules is the right way to act.

Keywords: Mainstream, Subcultures, Evolutionary psychology, Ideology

INTRODUCTION

Environmental care can be considered, in today’s world, a value which is universal around the world, regardless of culture and country. We can claim that we are living in an international, and even in a worldwide spread community, where we have certain culture identity manifestations applied at a large, world scale. Baciu (2012) devised the culture identity manifestations grid, which include those elements that can distinguish one culture from another, and which are grouped in the following categories: values, rituals, traditions, practices, symbols, and personalities.

While environmental care is the main value promoted ideologically, through supranational organizations such as the European Union, and through their policies, we can see that environmental care as a value is reinforced through various symbols, practices, rituals, and established traditions, present and established throughout communities. We can claim that enviornmental care is present everywhere as a consequence of globalization. We may complain that the world in becoming increasingly alike, with life in cities and the look of cities increasingly similar, to the point where we may not know where we are and fail to feel the specificity of the place, yet environmental care can be a positive aspect in which we lead an increasingly similar lifestyle.

We may understand today's world as being formed by levels. The two main levels are an international, global one, where everything is alike everywhere we are, and the other level is the nationalistic one, where we can witness the specific traditions and part of the specfic lifestyle, symbols, and values in a certain country. We can claim that the level where we are all alike, through sharing the same values and practices, and the level we can find a similar lifestyle and look of the urban area, through the use of a similar architecture, is the level which ensures a secure environment for us, as we notice familiar elements, which can bring us comfort. The level where there are differences is just as comfortable to see differences among cultures, yet to also hang on to famuiliar elements and values, so that we can reduce or even avoid the experience of culture shock.

Ideologically induced values and practices can be considered as part of living in a world, globalized community. These ideological values and practices are created and reinforced through promotion activities through environmental care policies, which also include promoting them at the level of the entire society through other means, including cultural means, e.g. through the presence of these issues in school textbooks, children's story books, school project-based activities related to environmental care, and so on. Environmental care policies can also intersect with other policies, such as those related to the health of the European Union citizens, e.g. those policies related to not leading a much too sedentary lifestyle, not spending all our time in the traffic pollution environment of the big cities, where chemical substances from car fuel can be harmful once we inhale them, and where noise pollution can lead to us being very stressed (Jariwala et al, 2017). In turn, stress has both psychological and physiological consequences, since, on the one hand, it makes us anxious and worried, or irritable, which can lead to us having various physical health issues such as high blood pressure and hair loss (Wang et al, 2023). Additionally, living in a chemically polluted environment can lead to us having skin and hair issues, as well as respiratory issues. We can also suffer more from heat in the cities and not have a comfortable environment if we lack green spaces. All of these issues are presented to us citizens in popular science articles, as well as in works of fiction, and various other events such as workshops and conferences, which are part of raising awareness campaigns. It can be noticeable how environmental care and health notions related to it have been popularized for the general public through materials accessible to anyone, and not meant just for specialists in the field.

RESEARCH AND FINDINGS

Supranational environmental agencies can be global or regional, and they can be found all over the world, grouped by continents and areas such as Europe, where Asia, the United Nations, Africa, the Carribbean, Antarctica, Oceania, and so on. As an example, for the United Nations, we have agencies such as the Food and Agriculture Organization, the Global Environment Facility, United Nations Environment Porgramme, United Nations Framework Convention on Climate Change Secretariat, and others. In the case of the European Union, the European Commission and the European Environment Agency are the main environmental agencies. Additionally, under the European Commission we have the following sub-divisions: Directorate-General for Climate Action, Directorate-General for Energy, Directorate General for the Environment, and Directorate-General for Maritime Affairs and Fisheries.

Why can these all agencies be mentioned under the larger category of supranational environmental agencies? It is for the same reason why environmental care policies can be considered in relation to the health of all human beings living on earth. We may not realize how many of aspects of our lives are intertwined with nature, and how much we depend on, and so does our health and our entire lifestyle on nature and on a healthy environment. While there has been a wide-scale move from rural to urban areas of the population worldwide, which still continues, this does not mean we are less dependent on nature. Not even the highly processed food and various facilities and comfortable life, as well as enough food resources do not make us completely separate from nature. Nature's health and our own health remain interrelated, as we can see from the promotion of healthy diets and lifestyles present within subcultures. Subcultures such as vegetarian, vegan, raw vegan, fruitarian, zero waste, green movement, focus on the dimension of caring for the environment, as well as for what is natural and for what is healthy and not too much processed food or not processed food at all. According to these subgroups, the main value is eating healthy, natural foods, likely with the least intervention on the environment through our activity and lifestyle, and to consider care for animals as well. We all know how we are constantly being made aware of species that are disappearing or that are endangered. We are also becoming more and more sensitive to feeling sympathetic to animals. This could be since, with today's technological advancements and comfortable living conditions in the city, we no longer need to hunt to survive, as life had to go on in the past times. Nowadays, we tend to behave in a more understanding way towards the environment, so that we intervene as little as possible on it.

Issues such as pollution, climate change, recycling, are all over the place, in the news, in our everyday talks, in mass-media. They are popularized everywhere and they even become part of conspiracy theories. In the case of environmental care, however, even conspiracy theories which claim under various dystopic scenarios how we human beings, through various practices, destroy our own planet, home, and our own living environment, together with our own health and well-being, can be regarded as raising awareness through a fantasy, fiction, or science-fiction type of scenario to an ongoing and current problem that should preoccupy us all.

While nowadays environmental care issues are mainstream, and even portrayed as the proper way to behave, and environmental case based lifestyles and subcultures form subgroups and sub-communities that are tolerated and even allowed to coexist in parallel with the mainstream, considering the degree of their radically different lifestyle, compared to the common-sense or minimal actions everyone is doing to protect the environment, e.g recycling, we may find it surprising to know that it all started as a counterculture movement. The green movement opposed the mainstream lifestyle, social behaviours, as well as rules and conventions. The environmentalists at the time were truly opposed to the mainstrea culture and society, as they had in mind to fight against the industrial development in order to stop climate change and to preserve the American wilderness (Kirk, 2007). Clearly, such ideas set them in a clear opposition to mainstream society and they could be considered rebels, if not complete outcasts, wishing, on top of it all, to change and ruin all the technological progress society could benefit from in order to have a comfortable lifestyle. The time of the modern environmental movement in America had its peak after the time of the Second World War.

Some environmentalists had a utopic vision, which was also considered impractical, and unrealistic, of preserving the world by returning to nature and by discarding all development of industrialization and modern life. This was the vision of the Transcendentalists in American culture, in the early 1800s, who opposed through their vision of return to nature the developing Industrialization Age. Ralpho Waldo Emerson and Henry David Thoreau believed that we could preserve the world by preserving the wilderness, or the natural environment, leaving it as untouched as possible by human activity (Lallanilla, 2020).

Of course, this can be understood as an idealistic, utopic vision of returning to Paradise, during the time when we were all innocent, and unknowing of all technological development which left, eventually, its mark on the environment and, consequently, on our health as well.

Environmental care organization Greenpeace began in 1977 with an anti-whaling campaign, in Canada (Zelko, 2013). What characterized this movement was using non-violence in order to protest (Zelko, 2013), which was considered, after World War II, something unusual. Nowadays, we can find many such manifestations of protests just with billboard adds and people gather in squares, and, what is more, they are under the watch of the police. They simply express themselves and need the watch of the police so that they do not resort to violent, physical action. They simply attract attention to the issue they support by getting out in the street and by being a quite large group, so that they show that they are solidary.

We can speak, nowadays, of a more permissive society, which allows subcultures to coexist with the mainstream, as well as everyone to express their opinions without needing to resort to violence. Protest manifestations are more about expressing personal opinions and raising awareness by various groups and communities to issues that should be of concern to the authorities, to the state, and to others that share the same mindset. This can be seen as the result of an individualist society, where individuals are accepted as being different, and allowed to express their different opinions, lifestyle choices, values, and principles, and, more than anything, to live according to them.

In spite of the environmental care policies being considered as the norm nowadays, in our globalized, interconnected world, we can still see extreme lifestyles of environmentalists, present under the form of subcultures which are tolerated alongside the mainstream culture. While we can claim that the environmentalists have had their victory on imposing themselves and changing the mainstream mindset and lifestyle, there are still some sub-groups which go to extremes in living an environmentalist's lifestyle.

As an example, zero waste subculture promotes a style in which we should practice wasting less and, ultimately, throwing away less waste which otherwise would have a negative impact on the environment (Korst, 2012).

Wight (2017) shows how those preoccupied by envronmental care in America believe that by getting eco-friendly products they can help. Switching from usual products to green consumerism can, therefore, for them, be regarded as a solution. Thus, for the environmentalists in America, during our contemporary times, there can be alternatives, or translations, for all regular products, including clothes, food, and cars, based on choosing the environmentalist version of them all. Wıght (2017) present the following scenario:

What does it mean to be an environmentalist in contemporary America? According to one popular theory, modern greens can awake and slip comfortably into $245 "eco-501" Levi's jeans and $200 organic cotton Patagonia pullovers. After consuming a guilt-free breakfast of organic tropical fruit (regardless of season) and Fair Trade coffee, they might commute to work in a Lexus hybrid. Environmentalists have so emphasized the importance of lifestyle choices and shopping that "consumer agency" is now the most pervasive form of eco-activism.

Consumerism has, indeed, become part of our lifestyle all over the world, with the move from rural to urban areas. Nowadays, we do not work to provide all resources for ourselves, including food and clothes, as well as means of transport. Instead, we rely on another need for other resources, namely those provided by means of services. We do work to provide for ourselves, yet we work in order to get money, which we can later on use in order to get what we need.

Some environmentalists believe that we can only get non-processed, natural food if we provide it for ourselves, meaning if we plant our own fruits and vegetables, and prepare all of our own food, in order to know what it contains.

This can be an example of an extreme case.

Still, the connection between environmental care policies and health policies can be regarded as extending to the way agricultural policies can work, under the conditions where the climate and the soil, function of the degree of pollution or other climate changes which are believed to be caused by careless human attitude towards nature can be visible at all times. This is because once we use harmful substances, or do not take care how we recycle or store them, the entire environment, soil included, will be affected by pollution. Once the soil is affected by harmful human activity and pollution, then it can lack some nutrients, and cause plants we use for food to lack nutrients which they would otherwise provide us with naturally. The way fruits and vegetables are grown and taken care of using modern methods and contemporary technology can affect the quality and nutrients in them. As an example, heavily treated fruits and vegetables which are not available in a natural way during a certain season, but we can find them at the supermarket and for sale in other stores can signal the fact that they may not be healthy due to all the subtances used to help treat them and preserve them.

Agricultural policies can be intertwined with environmental care policies, since the quality of the soil can ensure the health fruits and vegetables can bring to the citizens of a supranational organization such as the European Union. As an example, it is believed that the soil nowadays does not contain enough magnesium, hence all the leafy greens such as spinach cannot provide us with the sufficient amount of magnesium. As a result, we all need to take magnesium supplements. This is due to the pH of the soil not being enough as a consequence of pollution (Yaron et al, 1996).

Connections between the environment and health of the human beings can be related to environmental pollution and changes in the functioning of our immune system, which can become low (Glencross et al, 2020). We can also get cancer due to harmful substances, e.g. we can get lung cancer from air pollution (Cohen & Pope, 1995).

There can also be links between the availability of green spaces and our physical health. Green spaces such as parks can invite us to have physical activities, at least during the weekends, such as jogging and riding bikes, or other eco-friendly vehicles, which do not pollute the environment, since they are electric, or can be riden through our own force like usual, not electric, bikes, or simply walking. We are also encouraged by city halls in urban areas to take part in events during weekend such as pedestrian streets, where a portion of a certain boulevard is closed temporarily for traffic, and sometimes marathons are organized, or cycling races, or people are simply allowed to take walks or use their environmentally friendly vehicles instead of their cars.

Environmental care is not only promoted at the level of European Union policies, as well as at the level of supranational environmental agencies only. In the case of pedestrian streets events, the environmental care is promoted through entertainment. Other ways of promoting environmental care is through raising awareness of our own health, related to the way we can be less sedentary, breathe in healthier air, live in an environment with less harmful chemical substances, have healthier, less processed food, as well as live in a less noisy and more peaceful environment. We are also told to take care of recycling and not making too much waste. Even if we do not adopt the radical lifestyle of various subcultures, we can still realize, as we find out about their living style, that we need to pay attention to the way we interfere with our natural environment.

CONCLUSIONS

The relationship between human beings and nature has been noticeable throughout history. We have seen it as either hostile and needing to be tamed, or in need to be protected by us, as we have affected it with out highly developed technology. We have realized how each and every element in nature has its own role in the cycle of nature and that we need to take care not to destroy the delicate balance in nature. As an example, once we throw waste and dangerous substances in natural waters, we can lead to entire human communties to become sick. Additionally, the food in the waters, either in lakes, rivers and the sea, such as fish and other creatures, can become contaminated, as the sea creatures get sick. Once pollution reaches a high degree, then the water can become harmful to drink, and also the soil and the air can lead to us and the plants and animals we can have as food to become unhealthy. The natural cycle continues regardless of how highly developed we have become from a technological point of view. The topic of the relationship between various deathly diseases and malformations at birth and the polluted, unhealthy environment have become more and more frequently raised, as they are of crucial importance to the surviva of our species.

Ideology can set up rules and conventions through environmental care and health policies in order to help us improve our well being, be capable of working and, ultimately, surviving, ourselves and through our efforts the entire community. Therefore, we can claim that the various policies set up by supranational organizations such as the European Union, together with the various rules and punishments for not abiding by them all have an evolutionary psychology (Confer et al, 2010) purpose. This is because we feel the need to set up laws and rules through these polcies, but also to obey them. We obey them also because we become persuaded by individuals' and communities' examples around us, who are preoccupied by environmental care. Environmental care can be seen as the core point, or the basis for our well being and, ultimately, for our survival.

The fact that we react to our environment, be it urban, natural, indoors, outdoors, etc shows how we are built to enjoy a natural environment, where we feel a sense of well-being. We feel relaxed by the sounds of nature, which sis why we can find videos for relaxation based on sounds in nature. We enjoy fresh nature, without pollution, instinctively. We can claim that this instinct has an evolutionary psychology purpose as well.

We can see the eagerness with which environmental care activities have been taken over by the majority, under the influence of the others or due to their own convictions, via one way of promotion by the supranational organizations or another.

REFERENCES

Baciu, S. (2012). Culture: An Awareness-Raising Approach. Cavalliti Publishing House, Bucharest, Romania.

Cohen, A. J., & Pope 3rd, C. A. (1995). Lung cancer and air pollution. *Environmental health perspectives*, *103*(suppl 8), 219-224.

Confer, J. C., Easton, J. A., Fleischman, D. S., Goetz, C. D., Lewis, D. M., Perilloux, C., & Buss, D. M. (2010). Evolutionary psychology: Controversies, questions, prospects, and limitations. *American psychologist*, *65*(2), 110.

Glencross, D. A., Ho, T. R., Camina, N., Hawrylowicz, C. M., & Pfeffer, P. E. (2020). Air pollution and its effects on the immune system. *Free Radical Biology and Medicine*, *151*, 56-68.

Jariwala, H. J., Syed, H. S., Pandya, M. J., & Gajera, Y. M. (2017). Noise pollution & human health: a review. *Indoor Built Environ*, *1*(1), 1-4.

Kirk, A. G. (2007). *Counterculture green: The whole earth catalog and American environmentalism*. Goodman Publishers.

Korst, A. (2012). *The zero-waste lifestyle: Live well by throwing away less*. Ten Speed Press

Lallanilla, M. (2020). The History of the Green Movement. https://www.treehugger.com/what-is-the-green-movement-1708810

Wang, J., Zhu, L., Song, L., Zhou, Z., Chan, W., Li, G., ... & Lian, Y. (2023). A cohort study on the association between changing occupational stress, hair cortisol concentration, and hypertension. *Plos one*, *18*(5), e0285623.

Wight, P. (2017). The countercultural roots of green consumerism. *Shopping for change: Consumer activism and the possibilities of purchasing power*, 61-172.

Yaron, B., Calvet, R., & Prost, R. (1996). *Soil pollution: processes and dynamics*. Springer Science & Business Media.

Zelko, F. (2013). *Make It a Green Peace!: The Rise of a Countercultural Environmentalism*. Oxford University Press, USA.

HEMP-BASED FIBER-REINFORCED POLYMER COMPOSITES IN SEISMIC RETROFITTING OF EXISTING BUILDINGS

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Abstract

Due to their promising physical and mechanical properties, composite materials are widespread in many engineering fields, with advanced technical applications in civil, mechanical, aerospace, and biomedical scenarios. Seismic retrofitting using composite materials is one of the most common applications in civil engineering. Fiber-reinforced polymer composites (FRP) are used to retrofit structural elements in reinforced concrete buildings such as columns and beams by external confinement which substantially enhances both the axial compressive strength and the ductility of the concrete elements. Although carbon (CFRP) and glass (GFRP) are the most employed synthetic fibers, in recent years, the studies on the use of natural fibers (hemp, flax, jute, bamboo, coconut, etc.) in seismic retrofitting have increased. The most important reasons for this increment are attractive physical and mechanical properties, cost-effectiveness, easy availability, easy recycling, and lightweight features of natural fibers. When environmental impacts are considered, natural fiber utilization is less harmful to the environment and supports sustainable development compared to synthetic fibers. Natural fibers are renewable materials and can be easily found almost everywhere on the earth. They do not require non-renewable fossil resources for their production. Hemp is one of the most promising natural fibers in terms of industrial applications. There are many studies in which hemp fibers are used to improve and strengthen some properties of concrete, reinforced concrete structural elements, masonry, and timber structures. In this study, a comprehensive overview of hemp fiber usage in civil engineering applications has been conducted, concentrating on hemp-based fiber-reinforced polymer composites (HFRP) in seismic retrofitting of existing buildings. The pros and cons of hemp fiber usage in seismic retrofitting and hemp's potential to replace synthetic fibers such as carbon and glass have been discussed.

Key Words: Hemp, Natural Fibers, Seismic Retrofitting, Fiber-Reinforced Composites

EFFICIENT UTILIZATION OF LIGNOCELLULOSIC HEMP: PRETREATMENT

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Abstract

Lignocellulose is a sustainable, low-cost, renewable alternative resource used for producing renewable fuels and value-added products. The cell wall of lignocellulosic biomass, consisting of cellulose, hemicellulose, and lignin, naturally provides protection against pathogens. The efficient utilization of such lignocellulosic material can also be viewed as a goal for converting waste or idle products into high-value-added products. This approach can enable industrial revenue to be much more effective and efficient, in addition to enhancing industrial production diversity.

While the lignin structure in biomass provides rigidity to the plant, its attachment to cellulose through cross-links greatly hinders access to cellulose. Industrial hemp (Cannabis sativa L.), distinguished by its high cellulose and low lignin content compared to other plants, is a significant lignocellulosic biomass. Thus, the low lignin content of the hemp plant provides a considerable advantage for bioenergy production compared to other lignocellulosic biomass. The physicochemical cross-links between macropolymers in hemp biomass provide resistance against enzymatic attack and microbial digestion, but this chemical barrier can be overcome by breaking down these bonds through pretreatment processes. Pretreatment, by breaking down and dissolving hemicellulose and lignin, and making cellulose more accessible to enzymes and species, enables various applications. Therefore, during the production of biofuels, textiles, and paper from biomass, the lignin structure should be removed, and access to cellulose should be ensured.

Altering the structural characteristics of the plant cell wall to loosen the cellulose structure of biomass and convert it into fermentable sugars for use in different applications is an important issue, and this can be accomplished through a pretreatment. Pretreatment is a costly stage, but it is a crucial process in changing the structure of biomass by increasing enzyme accessibility to cellulose during saccharification, exposing the cellulose structure, and degrading the lignin structure bound to cellulose through cross-links.

Today, there are various methodological technologies available for pretreatment, including physical, chemical, and biological methods. An effective pretreatment process requires removing cellulose from its structure, preventing the formation of inhibitors that hinder the hydrolysis of carbohydrates, and being cost-effective.

In this paper, pretreatment technologies used to produce cellulose fibers with optimal chemical and physical properties, well-separated from lignin, are evaluated concerning the morphological structure of industrial hemp and current data. The analyses of the results of the pretreatment applied to the '*vezir*' variety of hemp plants are interpreted based on the conducted studies.

Keywords: Industrial hemp, *Vezir* Variant, Lignocellulose, Pretreatment

INTRODUCTION

Lignocellulose is a cheap, renewable and organic raw material that is abundant worldwide (Bhatia et al., 2019). Lignocellulotic biomass has the potential to reduce greenhouse gas emissions, improve the economy, respond positively to energy demand by being converted into usable valuable chemicals, fuels and energy (Patel et al., 2019). Lignocellulosic biomass includes residues such as forest waste, garden waste, agricultural waste, municipal waste and paper waste. Cellulose fibers, which constitute the most important structure of lignocellulosic biomass consisting of cellulose, hemicellulose and lignin, are connected to the hemicellulose and lignin structure by physical and chemical bonds. Lignin is the element that is a major obstacle to the hydrolysis of cellulose and hemicellulose in the plant cell wall by enzymes (Kirk and Farrell, 1987). Therefore, it is extremely important to partially or completely remove lignin by lignocellulosic pretreatment to reach the sugar building blocks of cellulose and hemicellulose. The pretreatment process of lignocellulosic feedstock has a major role in the fields of biofuel, biorefinery, paper industry, wastewater treatment, biodegradation and bioremediation (Sharma et al., 2019). Physical, chemical, physicochemical and biological methods are used for the pretreatment of lignocelluloses. Physical methods include mechanical digestion, microwave and pyrolysis methods. This method is based on the principle of reducing particle size to provide more surface area. Chemical methods include the use of concentrated and diluted various acids and alkalis to reveal the cellulosic content of biomass, as well as ionic liquids and organosolv processes. Physico-chemical processes include steam explosion, AFEX, CO_2 explosion and electrical catalysis. Microorganisms and enzymes are mostly used in biological processes. Mushrooms are generally used to eliminate lignin structure (Adıgüzel, 2013; Taymaz and Uslu, 2019). The use of alkali in the pre-treatment method of lignocellulose biomass is more preferred because it uses less energy and the process is relatively inexpensive. The main feature of the alkaline pretreatment method is that lignocellulose undergoes delignification, releasing carbohydrates, and also eliminating the lignin structure by breaking down the bonds between lignocellulosic materials (Kim et al., 2016). Sodium hydroxide (NaOH) has been extensively studied in the alkaline pretreatment method used in the biotransformation of lignocelluloses. NaOH is very effective in processing hardwood and agricultural waste (Gupta and Lee, 2010).

Industrial hemp plant is a source of lignocellulosic raw materials with potential for use in biofuel, paper and textile sectors. The hemp plant is superior to other ligocellulosic raw materials thanks to its high cellulose (70%) content and high biomass efficiency. Many studies have reported different pretreatment methods, including various acid and alkaline methods, liquid hot water, steam explosion, ionic liquids, to enhance the enzymatic hydrolysis of cannabis plants (Spos et al., 2010 ; Zhao et al., 2020a ; Aasim et al., 2023). The increase in sugar yield depends primarily on the pretreatment process used and then on the enzymatic hydrolysis process. Zhao et al. (2020a) compared liquid hot water (LHW), H 2 SO 4 and NaOH pre-treatment methods on hemp fibers and highlighted the advantages and disadvantages of each method. As a result of the study, they observed that NaOH pretreatment increased glucose yield more than other pretreatment methods. In this study, NaOH pre-treatment method was applied using *vezir*, the first industrial hemp variety registered in the country, and its morphological characteristics were compared.

RESEARCH AND FINDINGS

Obtaining Hemp

The hemp material used in the study was obtained from Yozgat Bozok University, a university specialized in "Industrial Hemp". *Vezir* variety cannabis plants were planted in special cultivation areas and harvested in 2022. Plants harvested for use in the experiments were dried in a suitable environment to equalize moisture levels.

Obtaining Hemp Fiber

The process of separating the fibers from the stems by mechanical methods was carried out within the Faculty of Agriculture of Yozgat Bozok University. As a result of the process performed here, the woody (tow) parts of the stems were removed and fibers were obtained.

Preparation of Hemp Fibers

After cleaning the hemp fibers from tows, they were washed three times and dried. The dried fibers were ground into fine powder by ball milling. The powder sample was characterized by SEM, EDX.

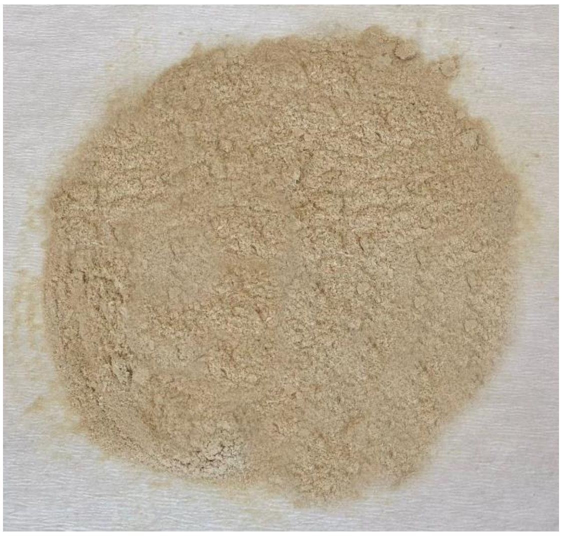

Figure 1. Raw fiber image.

Applying Chemical Pre-Treatment to Hemp Fibers

Hemp fibers were subjected to chemical treatment and structures such as lignin and pectin in the fiber content were removed and the results were compared.

When the literature is examined, plant fibers are chemically treated with ethylene, oxalic acid, sulfuric acid, hydrochloric acid, sodium hydroxide, sodium sulfite, etc. Pretreatment process was carried out using chemicals such as (Zhao et al., 2020b; Ji et al., 2021). Alkaline pretreatment process is one of the most commonly used methods because it uses less energy, is relatively cheap, and is not risky to use. In our study, Pakarinen et al. (2012) 2% NaOH was prepared according to the method used and the fiber-solution mixture was autoclaved at 121℃ for approximately 90 minutes. The solution coming out of the autoclave was neutralized with 37% HCl, washed three times with pure water and filtered. The upper part of the solution that reached to room temperature was filtered and the fiber precipitated at the bottom was dried and kept in the oven at 50° C for 1 day. SEM analysis was performed at Yozgat Bozok University to evaluate the changes in the structure of the pretreated fiber. Before SEM analysis, the samples were coated with a thin layer of gold to prevent any distortion, ensure equal distribution of the sample, and ensure homogeneous imaging.

Figure 2. Pre-treated fiber image.

CONCLUSION

Surface modification can be analyzed by SEM. Untreated raw fiber has a rougher surface due to the presence of wax, pectin, lignin and other contaminants (Agus Suryawan et al., 2017). The electron microscopy image of the natural sample showed a regular, highly compressed, woody, smooth structure representing an extremely well-organized surface structure (Figure 3). SEM images of hemp biomass after pretreatment showed that the surface area of the biomass was partially purified, the network-type features disappeared, and the hemicellulose and cellulose inner regions became loose (Figure 4). It is possible to say that 2% NaOH increases the surface area by disrupting the connection between lignin and hemicellulose and provides a cleaner surface structure.

EDX analysis was performed on the fibers to observe its result regarding the amount of carbon as well as oxygen present in the fiber. The oxygen and carbon ratio (O:C) defines the amount of lignin and hemicellulose in natural fibers. EDX analysis of untreated raw fibers and processed fibers is shown. The higher the ratio (O:C) of any natural fiber, the lower the amount of lignin and hemicellulose in that fiber. For alkali-treated fibers, the O:C ratio increases When the elemental trace values in Table 1 are examined, the O:C ratio of the raw *vezir* fiber was found to be 0.62, while the O:C ratio of the *vezir* processed fiber was found to be 0.83 (Table 1). This result showed that the O:C ratio of alkali-treated fibers increased and therefore lignins were removed.

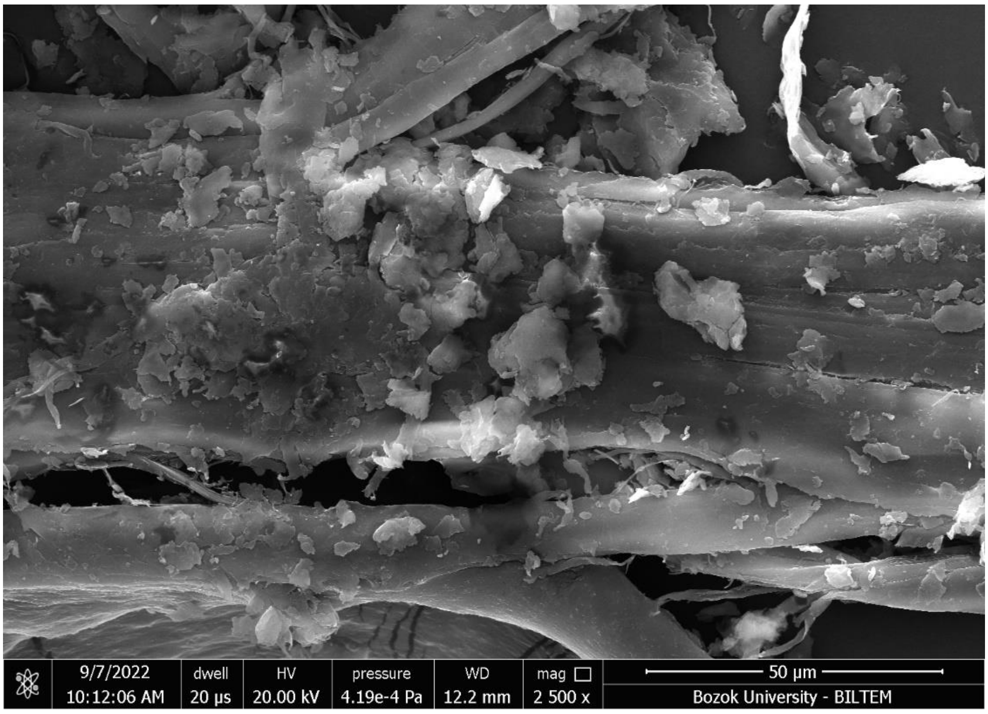

Figure 3. SEM image of raw fiber.

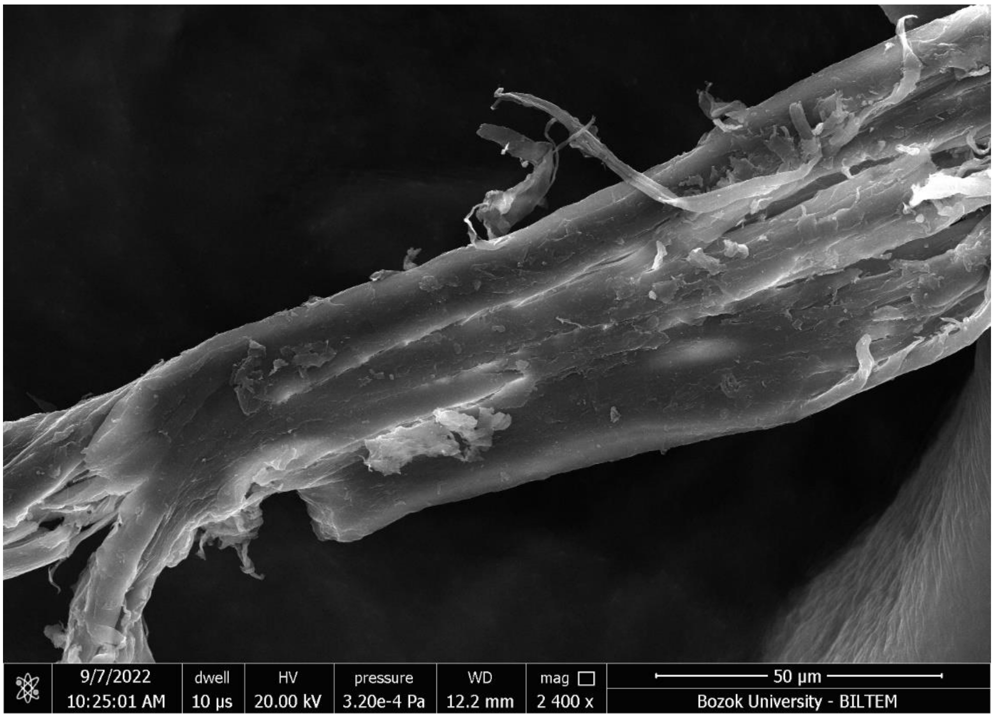

Figure 4. SEM image of the pretreated fiber.

Table 1. Raw and post-pretreatment EDX analysis of *vezir* variety fiber

***Vezir* raw fiber**			***Vezir* pretreated fiber**		
Element	**Weight %**	**Atomic %**	**Element**	**Weight %**	**Atomic %**
C	61.23	67.97	**C**	54.33	61.40
O	38.21	31.84	**O**	45.11	38.27
NaK	0.33	0.11	**NaK**	0.56	0.33
C:O	0.62		**C:O**	0.83	

In the study, as a result of the morphological and elemental analysis of the *vezir* variety cannabis plant, it was observed that lignin removal was partially achieved. Biomass pretreatment is an important step in the biological processing of feedstocks for biofuels and other bioproducts. Although each pretreatment method has its own advantages and disadvantages, it is not possible to choose a single method for all raw materials. Comparisons can be made by applying various pre-treatment methods to the industrial hemp plant. It is thought that the sugar yield will be high in the enzymatic hydrolysis of pre-treated industrial hemp. With further studies, new, cost-effective and environmentally friendly pre-treatment processes can be developed. It is very important to develop effective pretreatment processes and understand the mechanisms that occur in these pretreatment processes, and a better understanding of the chemical composition of lignocellulosic biomass is needed.

REFERENCES

Aasim, M., Baloch, F. S., Nadeem, M. A., Habyarimana, E., Ahmed, S., & Chung, G. (Eds.). (2023). *Biotechnology and Omics Approaches for Bioenergy Crops*. Springer Nature.

Adıgüzel, A. O. (2013). Pre-treatment and hydrolysis methods for bioethanol production from lignocellulosic material. *SAÜ Fen Bilimleri Enstitüsü Dergisi*, *17*, 381-397.

Bhatia, S. K., Gurav, R., Choi, T. R., Jung, H. R., Yang, S. Y., Moon, Y. M., ... & Yang, Y. H. (2019). Bioconversion of plant biomass hydrolysate into bioplastic (polyhydroxyalkanoates) using Ralstonia eutropha 5119. *Bioresource technology*, *271*, 306-315.

Gupta, R., & Lee, Y. Y. (2010). Pretreatment of corn stover and hybrid poplar by sodium hydroxide and hydrogen peroxide. *Biotechnology progress*, *26*(4), 1180-1186.

Ji, A., Jia, L., Kumar, D., & Yoo, C. G. (2021). Recent advancements in biological conversion of industrial hemp for biofuel and value-added products. *Fermentation*, *7*(1), 6.

Kim, J. S., Lee, Y. Y., & Kim, T. H. (2016). A review on alkaline pretreatment technology for bioconversion of lignocellulosic biomass. *Bioresource technology*, *199*, 42-48.

Kirk, T. K., & Farrell, R. L. (1987). Enzymatic" combustion": the microbial degradation of lignin. *Annual Reviews in Microbiology*, *41*(1), 465-501.

Pakarinen, A., Zhang, J., Brock, T., Maijala, P., & Viikari, L. (2012). Enzymatic accessibility of fiber hemp is enhanced by enzymatic or chemical removal of pectin. *Bioresource technology*, *107*, 275-281.

Patel, A. K., Singhania, R. R., Sim, S. J., & Pandey, A. (2019). Thermostable cellulases: current status and perspectives. *Bioresource technology*, *279*, 385-392.

Rajkumar, S., Tjong, J., Nayak, S. K., & Sain, M. (2015). Wetting behavior of soy-based resin and unsaturated polyester on surface-modified sisal fiber mat. *Journal of Reinforced Plastics and Composites*, *34*(10), 807-818.

Sharma, H. K., Xu, C., & Qin, W. (2019). Biological pretreatment of lignocellulosic biomass for biofuels and bioproducts: an overview. *Waste and Biomass Valorization*, *10*, 235-251.

Sipos, B., Kreuger, E., Svensson, S. E., Reczey, K., Björnsson, L., & Zacchi, G. (2010). Steam pretreatment of dry and ensiled industrial hemp for ethanol production. *biomass and bioenergy*, *34*(12), 1721-1731.

Taymaz, E.R., & Uslu, M.E. (2019). Lignoselülozik Biyokütlenin Ön Muamele Yöntemleri. *Soma Meslek Yüksekokulu Teknik Bilimler Dergisi*, *2*(29), 23-31.

Zhao, J., Xu, Y., Wang, W., Griffin, J., & Wang, D. (2020a). Conversion of liquid hot water, acid and alkali pretreated industrial hemp biomasses to bioethanol. *Bioresource technology*, *309*, 123383.

Zhao, J., Xu, Y., Wang, W., Griffin, J., Roozeboom, K., & Wang, D. (2020b). Bioconversion of industrial hemp biomass for bioethanol production: A review. *Fuel*, *281*, 118725.

BIO-PLASTIC ADOPTION: THE INTERPLAY OF ALTRUISM, INNOVATIVENESS, AND ENVIRONMENTAL MOTIVATION AMONG YOUNG CONSUMERS

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Abstract

One of the important elements of sustainable development goals (SDGs) is adoption of the sustainable consumption practices (United Nations, 2015). Sustainable consumption implies that goods and services should be consumed in a way that they have minimal impact on the environment. That means promotion of waste reduction, use of renewable resources, and curtailing emissions of greenhouse gases (GHGs). The increasing use of plastics and landfills filled with plastic waste and their environmental impact has been growing concern for globally community. According to an estimate, 8 million metric tonnes of plastic waste are released into oceans each year (Jambeck et al., 2015). The extensive use of plastics is a major source of environmental pollution and became a growing concern for countries around the world that requires immediate response. Several measures have been taken so far to reduce ever-increasing use of plastics. In this regard, bio-plastics have been introduced in many parts of the world as an alternative to conventional plastics. Bioplastics are plastic materials produced from renewable biomass sources which are environmentally friendly compared to conventional plastic. This study aims to analyze the impact of Altruism, Innovativeness, and environmental motivation on consumer switching intention in the context of bio-plastic. The data was collected by questionnaire survey (N=400) from young consumers of Lahore. Data were analyzed by using Smart-PLS by applying the structural equation model (SEM). Findings indicate that altruism, innovativeness, and environmental motivation have a significant impact on consumers' switching intentions.

Keywords: Sustainable Consumption, Bioplastics, Consumer Behavior, Consumption value, Pakistan.

INFERENCE ON SOME ENVIRONMENTAL FACTORS ON ANNUAL RAINFALL IN NIGERIA

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Abstract

Rainfall pattern changes over the years have been one of the global climate change concerns. In this study, the effect of some environmental factors namely temperature, carbon dioxide emission, and quantity of crude oil production are examined to see their effect on yearly rainfall pattern in Nigeria. The method of multiple regression analysis is applied to the data that span from 1971 to 2022. The expected outcome is that all selected environmental factors will negatively affect rainfall and the model to explain a large percentage of variability of these factors on rainfall.

Keywords: CO_2 emission; Rainfall; Temperature; Crude oil production; Regression

ANTIBIOTIC SENSITIVITY PROFILE OF COLIFORM ISOLATED FROM DIFFERENT WATER SOURCES IN ALIERO METROPOLIS, KEBBI STATE, NIGERIA

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Abstract

Water is one of the abundantly available substances in nature and also one of the basic necessities of life. The different water sources were collected in three (3) different provinces in Aliero metropolis, namely; Nasarawa, Kali and Tudun Wada sites. This was aimed to determine bacteriological quality, identify coliforms and to detect antibiotic sensitivity of the identified coliforms from water samples. Many organisms were identified in different water sources of Aliero metropolis. These were Escherichia coli, Citrobacter spp, Enterobacter spp, Bacillus spp,and Pseudomonas and all were found in different water sources giving a number of each specie (n=12) for Escherichia coli (n=7), Citrobacter spp, (n=6) Entrerobacter spp, (n=4) Pseudomonas spp, (n=3) and Bacillus spp. The presence of these bacterial species is a strong indication of poor hygiene by the ground water resources. Therefore, regular monitoring and assessment of drinking water is primarily a health based concern which protects public health through ensuring provision of quality water.

Keywords: Water, Coliforms, Antibiotic, Site

USE OF HEMP IN EXISTING BRANCHES OF INDUSTRIES IN ORDER TO DEVELOP THE HEMP INDUSTRY, TO COMPENSATE THE LOST TIME AND TO REACH THE HEMP INDUSTRY WHERE IT NEEDS TO BE AS SOON AS POSSIBLE

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Abstract

Introduction and Purpose: Situation tests have been carried out regarding the studies carried out so far for the development of the hemp industry. Mistakes have been identified regarding the hemp industry not being where it should be. The reasons for these errors and time losses have been determined.

Materials and Methods: Recommended practices for the development of the hemp industry are stated. Information about the ways and methods necessary to implement this recommendation is given.

Results: Starting everything from scratch and wasting time for the development of the hemp industry will cause new time losses for sectoral developments. To prevent this situation, established industries in our country should be directed to hemp use. If this method is followed, the lost time will be compensated and the hemp industry will be developed.

Key Words: Hemp industry, sectoral developments, compensation for time losses

INTRODUCTION

In this presentation, I will first determine the situation, then indicate where the problem originates from, then give information about the industrial branches where hemp can be used directly and without requiring much additional investment, and finally state my solution suggestions on the subject.

After our President, Mr. Recep Tayyip Erdoğan, brought hemp to the country's agenda, hemp and hemp industry attracted the attention of many people and some studies on this subject were started. Those who are interested in this subject were amazed by the preliminary information they acquired as a result of their research, and their interest increased as they learned about the potential of hemp. This information gained everyone's appreciation in a short time, and as the information spread, hemp became more popular with more people.

As in many similar issues, hearsay information on this issue, judgments made by those who do not have sufficient knowledge on the subject, and findings that may even be considered unrealistic about hemp began to be spread around in a short time. In addition, there are also those who see their dreams about the possible potential of hemp as a real business idea and those who think that these unfounded thoughts are a real project.

The hemp issue, which quickly came to the fore and spread at the same speed, began to lose interest after the facts began to be seen a little more. During the process until the issue was fully understood, the people I mentioned above and their negative effects caused many projects containing serious value to be wasted, possible potentials were damaged, and as a natural result of all these negativities, time and human energy were wasted.

I. WHAT HAS BEEN DONE WRONG

1.Those who are not fully informed about hemp and the hemp industry and who do not do the necessary research on this subject only deal with the issue based on hemp's possible potential and ignore the current situation and the development process that needs to be covered,

2. Those who first realized the potential of hemp were greedy and wanted to use the information they acquired for their personal benefit.

3. Those who prioritize their personal interests over social interests rush to achieve their goals, do not work to disseminate information to the public, keep the information to themselves, and behave in ways that shift the risk and work to others.

4. As a result of the emergence of those who want to use the potential of hemp for their individual interests rather than for the public good, this area, which can be considered new, is polluted in a short time and causes the work that needs to be done to be disrupted.

5. Neglecting studies on existing industrial branches in which hemp can be used and following a wrong path, such as the need to start everything from scratch. All actions regarding the issue are designed and implemented according to this wrong strategy,

6. Acting only according to dreams about possible potentials, without examining the current structure and developments in the world, without looking at the experiences of other countries in the hemp industry, without consulting information about the paths and methods followed in different countries,

7. Approaching the issue from the perspective of a street vendor or small tradesman, rather than from an industrialist mentality,

8. In this regard, people who are in the theoretical part of the work, those who work in the academic field, those who hold political authority, businessmen who think their capital structures are suitable for this job, consultants who do not have complete knowledge, researchers who do not have a technical perspective, farmers and people in the bureaucracy are almost They all engaged in similar behavior. The most interesting part is that everyone lost a bird in their hands for the sake of two birds they saw on the branch.

…

After all these and similar things had happened, those who made mistakes regarding the topics I mentioned above suddenly abandoned their foolish work and returned to their previous positions faster than they had started. The interesting thing is that they continued their lives where they left off, as if nothing had happened and they had done nothing. They did not hesitate to accuse him of the meaningless and ridiculous things they did and without paying attention to the damage they caused to the hemp industry.

Due to the greed for short-term gains made for this purpose, long-term losses have become inevitable. As a result of these types of negativities I mentioned, serious time was lost in terms of the development of the hemp industry. At the end of this process, it became clear that the direct and indirect contributions of hemp to our country in every field were delayed.

II. WHAT ARE THE REAL REASONS OF THESE NEGATIVENESS THAT I MENTIONED?

1. OBSTACLES AND OBSTACLES WITHIN THE BUREAUCRACY;

a) Among the provinces where hemp cultivation is permitted, there are no standards for the conditions required from those who will cultivate and each person has a different voice,

b) People in the relevant official authorities try to make those who want to produce as much as they can and regret their attempt, and create difficulties for those who want to produce at every stage of the work.

c) Treating those who apply for hemp cultivation as potential drug dealers,

d) Making veiled threats to keep producers on edge during the breeding process.

e) Telling producers about disposal methods that they do not even know or understand and trying to dissuade them from doing so,

f) Intimidating producers regarding the controls to be carried out,

g) Prejudicing and intimidating them that even if nothing happens to them in the first period, they will have difficulties in the following periods,

2. INDIVIDUAL BENEFIT ACCOUNTS;

As in many issues with serious potential regarding our country's economy and future, individual interests have taken precedence over public interests.

3. ACADEMIC DEFICIENCY;

Academicians should act according to their individual interests instead of acting according to their scientific perspective and the future of our country,

4. LOW PROFILE PERSONS AND PEOPLE WITHOUT INFRASTRUCTURE TRY TO ENTER THIS FIELD, THINKING THEMSELVES AS INDUSTRIALISTS;

The short-sighted approach of people who lack an industrialist mentality, resulting from their dreams and enthusiasm for making big profits in the short term, hinders the work to be done in this field.

5. EVEN IF IT IS POSSIBLE FOR EVERYONE TO COOPERATE, THEY PREFER TO STAY AWAY FROM COOPERATING

No system can be established and the work done in this field cannot be sustainable because those who enter or want to enter this field, which can be considered new in many respects and has high potential for added value, pursue monopoly ambitions instead of cooperation,

6. INDUSTRIALIST-UNIVERSITY COOPERATION HAS NOT BEEN BUILT

Industrialists failed to be like industrialists. Besides, the scientists did not behave like scientists.

7. ATTEMPTING TO PURSUE BIG DREAMS WITHOUT CONDUCTING THE NECESSARY R&D STUDIES AND CREATING THE NECESSARY INFRASTRUCTURE FOR THE INDUSTRY,

8. WHILE IT IS POSSIBLE TO EVALUATE THE CURRENT POTENTIALS, THEY WERE NOT GIVEN ATTENTION AND TIME WAS WASTED FOR SECTORS WITHOUT READY INFRASTRUCTURE.

For example, while it is possible to be successful in the short term in the field of chipboard, interest is shown in medical cannabis instead of being shown interest in this and working on it.

III. SOLUTION OFFERS

•Does not require any R&D work for the areas in which it will be used,

•Requires a small additional investment cost to become a semi-finished product,

•It has been tried in many places before and has proven itself positively,

•Transportation cost is much more economical and easier than its equivalent,

•The acquisition time is very short compared to its equivalents,

•Has positive effects on reducing general costs,

•Once finished, it is more durable and longer-lasting than other options produced from equivalent materials,

•Providing many direct and indirect benefits during and after its production as raw material,

…

There is no other option other than hemp with the above-mentioned properties.

IV. WHAT ARE THE OPPORTUNITIES WE HAVE WITH HEMP?

In this section, the sectors where hemp can be used directly after its production will be discussed. What I want to do here is to make suggestions for making existing industries compatible with hemp, rather than waiting to establish a new industry from scratch.

There is no need for investment to establish a new factory because we have a ready-made factory,

As of the current situation, there is idle capacity in many factories,

There is ready-made knowledge about production,

The personnel in the enterprises are sufficient for this job and there is no need for additional personnel.

There is no need for a new study on marketing and sales,

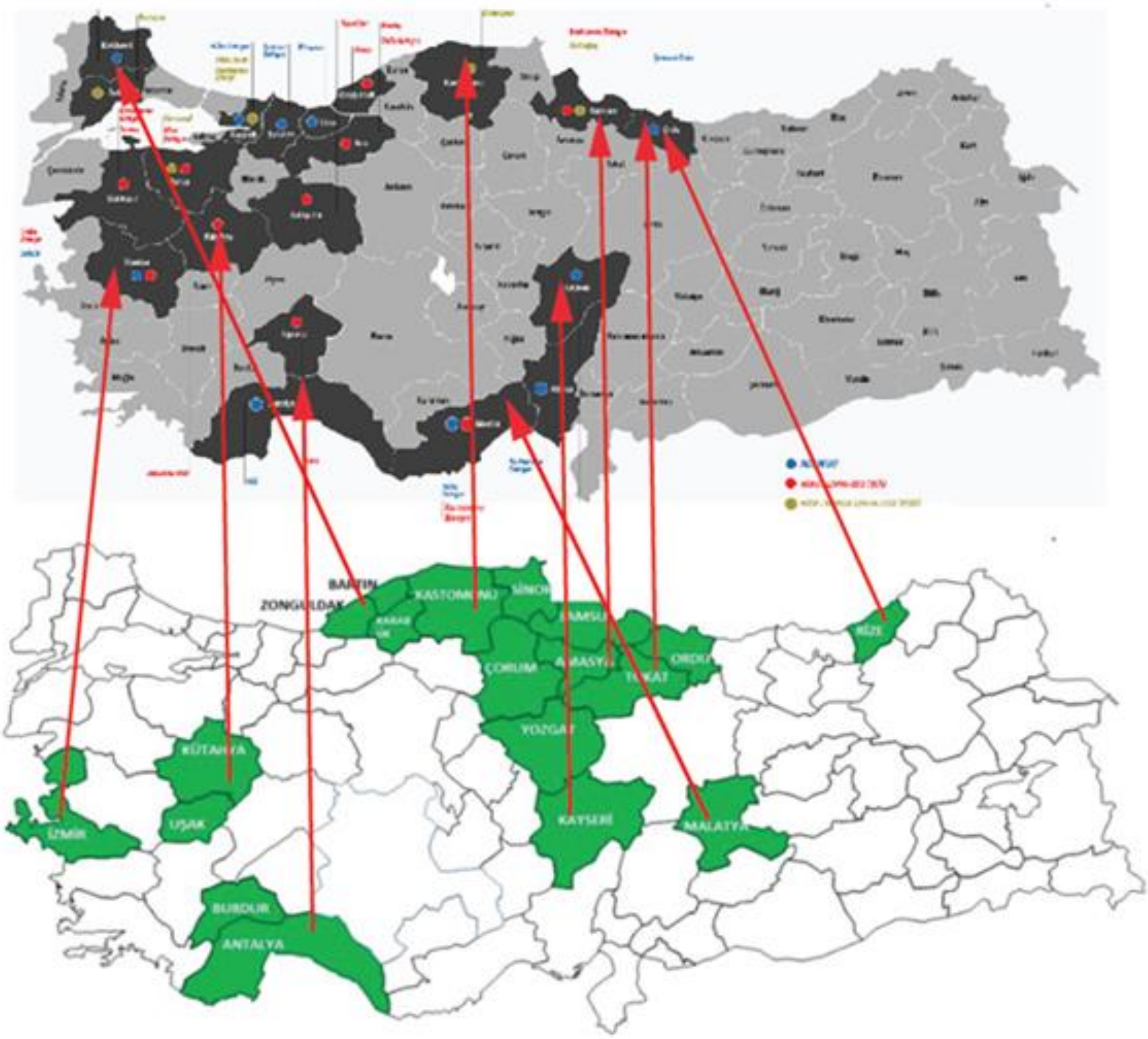
It is possible for products to be put on the market as soon as they are produced,

V. IDENTIFICATION OF INDUSTRIAL AREAS WHERE HEMP WILL BE DIRECTLY USED,

a) Particle board sector

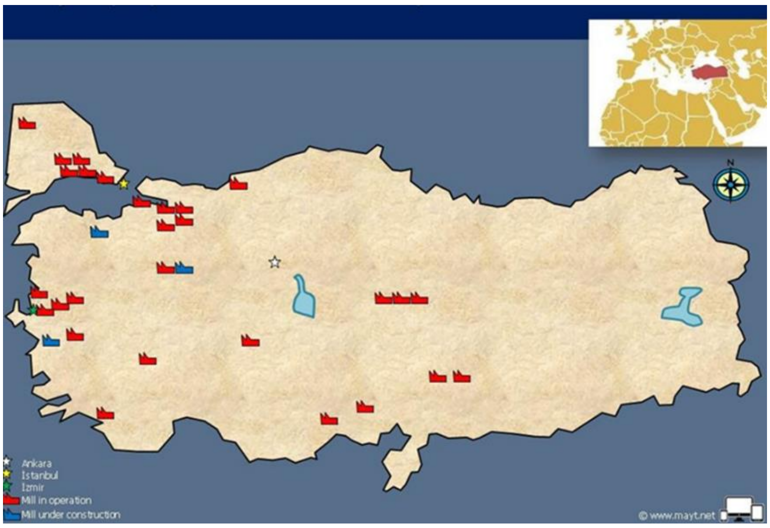
The location of particle board production facilities in Turkey [1]

Ensuring coordination of the provinces that have permission for hemp cultivation with the provinces where particle board production facilities are located.



b) Paper sector,

Locations of paper mills in Turkey [2]



c) Building material,

i) Filling material for wall manufacturing,

ii) Filling material for the screed,

iii) Insulation material for heat, water, sound, fire and radiation insulation,

iv) Plaster material for interior and exterior surfaces,

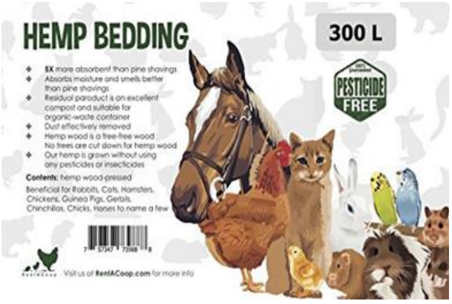
d) Fighting against erosion,

i) Fighting against erosion by planting,

ii) Making earth blankets,

e) Cleaning and rehabilitating the soil

e) Use as animal bedding and animal feed,



METHODS THAT CAN BE FOLLOWED FOR THE DEVELOPMENT OF THE HEMP INDUSTRY

1. Finding research conducted in different countries, adapting the information obtained to our country, collaborating with people and institutions that have achieved success in different countries,

2. Creating suitable environments for technology transfers from countries that are ahead of us in the hemp industry,

3. Organizing cooperatives to make the hemp industry sustainable

(Establishment and operationalization of the Akmansoy Model, which will be established jointly by industrialists and producers and is within the culture of partnership),

3.a) Cooperativeism,

3.b) Planned production,

3.c) Finding new options for cultivation,

3.d) Treatment of the soil,

3.e) Increasing product yield by alternating planting,

3.f) Using less pesticides,

f.i) Its importance in terms of soil health,

f.ii) Its importance for the health of humans and other living things,

f.iii) Its importance in terms of seed health,

f.iv) Reducing costs,

4. Since every element of hemp appeals to many industries, a sub-industry that will support the system should also be established in addition to the main industry for which work will be carried out.

CONCLUSION AND DISCUSSION

The point I am underlining here is that in order for the hemp industry to develop and get to where it needs to be, it would be more rational to direct existing industries to hemp, rather than establishing something new from scratch.

Directing companies that already have facilities, have reached a certain commercial experience, have a place in the market, have a suitable structure for new investments, need to reduce costs and have institutionalized sectoral organizations to hemp will be extremely beneficial for them, our country and the future of our economy.It is possible to list the possible developments that may occur as a result of this development of the hemp industry as follows;

1. The development of the hemp industry will accelerate and the lost time will be compensated,

2. Coordinating the provinces where the facilities are located and the provinces where production is carried out will reveal local and regional development, economic balance between the provinces will be ensured and cooperation potentials will be brought to our economy,

3. Industrialists will be free from raw material supply and producers will be free from marketing concerns. Future concerns for the parties will be eliminated,

4. Thanks to the direct and indirect benefits of hemp, the damage caused by previous wrong practices in our soil will be treated and improvements will occur in dozens of areas, from plant sociology to human health.

5. Thanks to the savings that hemp will provide, the profitability of our producers will increase and their competitiveness in the international arena will increase,

6. Thanks to the use of hemp, our external dependence in many areas will first be minimized and then reduced to zero. In this way, our foreign exchange loss will be prevented and the money given abroad will be directed to the domestic market.

7. Spreading capital to the base and making agriculture productive and profitable will prevent migration from villages or small cities to big cities.

REFERENCES

1. www.yomsad.org.tr
2. www.mayt.net

EVALUATION OF ANALGESIC ACTIVITY OF METHANOLIC EXTRACT OF *TRICHODESMA AFRICANUM* PLANT IN MICE

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Abstract

The aim of the research was to evaluate the analgesic activity of the methanolic plant extract of *Trichodesma africanumun* mice. The oral acute toxicity (LD50) test of the extract was carried out using OECD 425 (2008) Guideline. Phytochemical screening was carried out to test for the presence of chemical constituents. The analgesic activity was evaluated using Acetic acid induced writhing and Hot plate induced pain methods. The oral LD50 of the extract was found to be greater than 5000 mg/kg in mice. The methanolic extract of *Trichodesma africanumat* 250, 500, and 1000 mg/kg body weight produced significant ($p \leq 0.05$, $p \leq 0.01$) and dose dependent inhibitions of the acetic acid induced abdominal contractions and at 250 and 500 mg/kg increased pain reaction time in hot plate test in mice. The result indicates that the methanolic extract of *Trichodesma africanum* has analgesic activity and justifies its traditional use in management of pain.

Key words: Analgesic activity, *Trichodesma africanumat*

BACKGROUND

The use of medicinal plants in the treatment of ailments associated with pain is well known throughout history (Almeida *et al*., 2001). Such plants have played important roles in drug discovery. Research and studies on them are logical research strategies in the search for new drugs (Elisa *et al.*, 1995). In rural areas, medicinal plants play a vital role in primary healthcare services; they serve as therapeutic agents as well as important raw materials for manufacture of traditional and even modern medicine (Sofowora, 1993). Medicinal and aromatic plants have been used for many centuries and are still popular in today's alternative therapies. Herbal remedies and alternative medicines are used throughout the world and in the past herbs often represented the original sources of most drugs (Sa'ad *et al.,* 2005).

Pain, as defined by the International Association for the Study of Pain (IASP), is “an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage” (Cox *et al.*, 2006). It is a universal human experience that in the short term serves to protect an individual from harm, but in the long term can become a debilitating condition (Cox *et al*., 2006). Pain is an unpleasant sensory and emotional feelings suffering and emotional state of risks connected with anxiety (Domżał *et al.,* 2007). Pain has many forms. It warns against damage to the body, which is important for avoiding injuries and consequently for survival. Untreated chronic pain can cause injuries which can be unpleasant for the patient, or it can alter a persons life, reduce the quality of life, and also have an impact on the patients family (Thor *et al.,* 2007). The word “pain” for the patient means disease and suffering, for the doctor it is a symptom, and for the physiologist it is a kind of feeling that has its own anatomical and physiological system which begins with the receptors and ends up in the brain cortex. The intensity of pain is difficult to measure and an individual's perception of pain depends on the individual's emotional state, circumstances under which the pain was acquired, and whether it is perceived as a threatening signal. The perception of pain depends on such factors as arousal, attention, distraction and expectation (Domżał *et al.,* 2007).

Trichodesma africanum (L.) Sm., also known as African barbell in English and Lozeka in Arabic, belongs to the Boraginaceae family. This erect, harshly scabrid, annual, short-lived perennial herbaceous plant is of about 1 m in height. It forms branches mainly from the base and has a fistular stem which is densely covered with prickly stiff hairs of about 2 mm in length. The leaves of this plant are simple with entire margins that are covered on both surfaces with erect patent, prickles (Al-Yahya *et al.,* 1990). *T. africanum* has been reportedly used in the folk medicine of several countries for the treatment of many clinical conditions including a cough and common cold (El-Ghazali *et al.,* 2010). In Iran, roots and leaves of *T. africanum* have been used for the treatment of several clinical conditions including common cold, chest congestions, chickenpox, scarlet fever, measles, bone fractures, headache, abdominal pain, mouth ulcer, and constipation (Safa *et al.,* 2013). In Nigeria, it has been used to induce diuresis (Soladoye *et al.,* 2008). In Pakistan, it has been described for the treatment of severe respiratory tract diseases (Tareen *et al.,* 2010).

Conventional treatment of pain by synthetic drugs may cause side effects and may not be universally affordable (Daniel *et al.,* 2017). An national health survey (NHS) digital survey found that (NHS digital, 2019) the prevelence of pain among adults was 34% and it was more common in women (38%) than in men (30%). Some of the adverse effect caused by synthetic analgesics on long term use include Gastrointestinal disturbance in patients that has prior history of ulcer which is found in 10-30% of patients taking Non-steroidal antiinflammatory drugs (NSAIDs) (Sostres *et al;* 2010), cardiovascular diseases these include MI, thromboembolic events, and atrial fibrillation. Diclofenac seems to be the NSAID with the highest reported increase in adverse cardiovascular events (Harirforoosh *et al*., 2013), renal adverse effect in patient with renal dysfunction. Others include hepatic disfunction, hematologic adverse effect, anaphylactoid reaction etc (Sriuttha *et al.,* 2018; Berkes *et al.,* 2008). Common side effects of opioid administration include sedation, dizziness, nausea, vomiting, constipation, physical dependence, tolerance, and respiratory depression. Physical dependence and addiction are clinical concerns that may prevent proper prescribing and in turn inadequate pain management. Various parts of plants such as leaf, stem, bark, root, etc. are being used to prevent, alleviate symptoms or revert abnormalities back to normal. Example of plants use in the treatment of various diseases include *cryptolepis sanquinolenta* (Ghana Quinine).

Roots and leaves of *T. africanum* have been used for the treatment of several clinical conditions including common cold, chest congestions, chickenpox, scarlet fever, measles, bone fractures, headache, abdominal pain, mouth ulcer, and constipation (Safa *et al .,* 2013). However, extensive literature research reveals no published data on methanolic extracts of *Trichodesma africanum* in management of pain. This study therefore, evaluated the analgesic properties of the methanolic extract of *Trichodesma africanum* in mice as compared to the standard drugs, aspirin and morphine with a view to developing newer more efficacious, safer and affordable analgesic drugs or the discovery of lead compounds for the synthesis of new analgesic drugs. The aim of the research was to evaluate the analgesic activity produced by administration of methanol extract of *Trichodesma africanum* plant in mice.

MATERIALS AND METHOD

Reagents and Chemicals

All the reagents and chemicals used for the study were obtained from representatives of reputable chemical companies in Nigeria. The reagents and chemicals include:

Trichodesma africanum plant (*Boraginacaea*), Methanol A.R(sigma alorich, lot no 82890, Europe), Acetylsalicylic acid (Aspirin) (manufactured by Bond chemical ind. Ltd), Morphine, Dragendoffs reagent, Concentrated sulphuric acid, Concentrated Hydrochloric acid, Lead sub-acetate solution, Chloroform, 10% ammonium solution, Glacial acetic acid containing traces of ferric chloride, 10% Sodium hydroxide, Ferric chloride solution, Acetic anhydride, 1% aqueous hydrochloric acid and Molisch's reagent.

Routes of administration used: -

- ✓ Oral
- ✓ Intraperitoneal

Experimental Animals

Albino swiss mice (17-30g) of both sexes were obtained from the Animal House facility of the Department of Pharmacology and Toxicology, Kaduna state University, Kaduna. Nigeria. All animals were kept in clean dry cages maintained in a well-ventilated animal house at room temperature and a 12-hour dark/light cycle. The mice were acclimatized for one week prior to actual experiment and had *ad libitum* (when desired) access to food and water. All experimental procedures were reviewed and approved by the University Animal Ethics Committee, Faculty of Pharmaceutical Sciences, Kaduna State University, Kaduna. All experiments conformed to the principle for research involving the use of animals.

PLANT MATERIAL COLLECTION

Trichodesma africanum whole plants was collected in December, 2021 at Samaru, Zaria Local Government Area, Kaduna state. The plant was identified and authenticated by Mallam Umar S. Gallah in the Herbarium of Department of Pharmacognosy and Drugs Development, Faculty of Pharmaceutical Sciences, Kaduna State University, Kaduna, and was given a voucher specimen number of KASU/PCG/054.

1.1. PLANT PREPARATION AND EXTRACTION

The plant (*Trichodesma africanum)* was air-dried in the shade until constant weight was obtained. It was then size reduced into powder using a wooden pestle and mortar. Then 400g of the dried powder was weighed and subjected to maceration for 48 hours with 2L of 70% Methanol with occasional shaking. The mixture was filtered using a Muslin cloth followed by Whatman filter paper and then dried on a water bath at a temperature of 50^0c. The dried extract was transferred into an air-tight container for storage until required. Percentage yield was calculated as follows:

$$\% \text{ Yield} = \frac{\text{Weight of extract (g)}}{\text{Weight of powdered plant material (g)}} \times 100$$

1.2. PHYTOCHEMICAL SCREENING OF CRUDE PLANT EXTRACT

Phytochemical screening of the plant extract was carried out at the Department of Pharmacognosy and Drugs Development, Faculty of Pharmaceutical sciences, Kaduna State University, Kaduna using the method described by Trease and Evans (1996). The Extract was screened for the presence or absence of alkaloids, flavonoids, saponins, tannins, glycosides, steroids, triterpenes, anthraquinones and carbohydrates

EVALUATION OF ANALGESIC ACTIVITY
Acetic Acid Induced Writhing Test

The method described by Koster was used for the evaluation of analgesic activity in mice (Koster *et al.,* 1959). The experimental animals were weighed and randomly divided into 5 groups consisting of 5 mice in each.

- Group I (Negative control) received normal saline (10 mL/kg).
- Group II received methanol extract at doses of 250 mg/kg orally.
- Groups III received methanol extract at a dose of 500 mg/kg orally.
- Group IV received methanol extract at a dose of 1000 mg/kg orally.
- Group V (positive control) received standard drug Aspirin (300 mg/kg).

All treatments were administered orally. 1hour after administration of standard drug and test samples, each mouse was injected with 0.6% acetic acid at the dose of 10 mL/kg body weight intraperitoneally. The number of writhing responses produced by each mouse was recorded for 10 minutes commencing just 5 minutes after acetic acid injection.

$$\% \text{ inhibition} = \frac{Wc - Wt}{Wc} \times 100$$

Where W is number of writhing, c is control and t is test

Hot plate-induced Pain Test in Mice.

This is one of the most commonly used methods for evaluating central analgesic activity of a drug. In this method heat was used as a source of pain. Mice were divided into 5 groups of 5 each. First group served as negative control (10 ml/kg Distilled water), second group received methanol extract at 250 mg/kg, third group received methanol extract at 500 mg/kg, fourth group received methanol extract at 1000mg/kg and fifth group served as positive control (morphine) at 10 mg/kg. After 1 hour, animals were individually placed on a hotplate maintained at a temperature of 55± 0.5 °C, and were placed not more than 20 seconds (cut off time) on the hotplate, in order to avoid damage to the paws. The time taken to flick the hind paw or lick or jump from the hot plate was considered as the reaction time of the particular animal. The reaction time was recorded at 0, 30, 60, 90,120- and 150-min interval. An analgesic increases the reaction time. Percent decrease in reaction time was taken as index of pain perception at each interval (Kumae *et al.,* 2011).

1.3. STATISTICAL ANALYSIS

Values where expressed as mean ± standard error of mean (Mean± SEM). Difference in mean were analyzed using either one way or repeated measures ANOVA followed by Dunnette and bornferoni's post _hoc test. Values of $p \leq 0.05$ where considered significant.

RESULTS

Table 1: Phytochemical constituents of the methanolic extract of *Trichodesma africanum (Boraginacaea)*

Phytochemical constituents	Tests	Presence/Absence
Carbohydrates	Fehling's test	+
Saponins	Frothing test	+
Flavonoids	Ferric chloride test	+
	Sodium chloride test	+
Tannins	Lead sub-acetate	+
Terpenoids/steroids	Salkowski's test	+
Alkaloids	Dragendoff's test	+
Anthraquinones	Bontrager's test	-
Cardiac glycosides	Keller-killiani test	+

KEY;
+ = Present
- = Absent

Acute toxicity

No death was recorded in the mice treated orally with varying doses (2000 and 5000 mg/kg) of the methanol extract *of Trichodesma africanum*. The extract was well tolerated by the mice without any overt signs of toxicity.

Table 2: Effect of Acute oral administration of methanolic extract of *Trichodesma africanum* in mice (LD50 Determination)

S/N	Dose mg/kg	Onset of toxicity	Duration of toxicity	Signs and symptoms of toxicity	Mortality
1	2000	Nil	Nil	Nil	Nil
2	2000	Nil	Nil	Nil	Nil
3	5000	Nil	Nil	Nil	Nil

The estimated LD_{50} Value for methanolic extract of *Trichodesma africanum* is > 5,000 mg/kg

Effect of *Trichodesma africanum* on Acetic acid induced writhing test in mice

A one-way ANOVA was conducted to compare the analgesic effect of *trichodesma africanum* at different doses on the number of constriction of mice. An analysis of variance showed that the effect of *trichodesma africanum* on the number of constriction of mice was significant.

Post hoc comparisons using the Tukey test found that the mean value of number of constrictions was significantly different between extracts. At 250 mg/kg it's significant at $p \leq 0.05$, 500 mg/kg was significant at $p \leq 0.001$, and extract 1000 mg/kg at $p \leq 0.001$. There were no statistically significant differences in the mean number of constrictions among other treatment groups. Taken together, these results suggest that at a dose of 250 mg/kg and above the extract reduced the number of constrictions thus possess an analgesic effect.

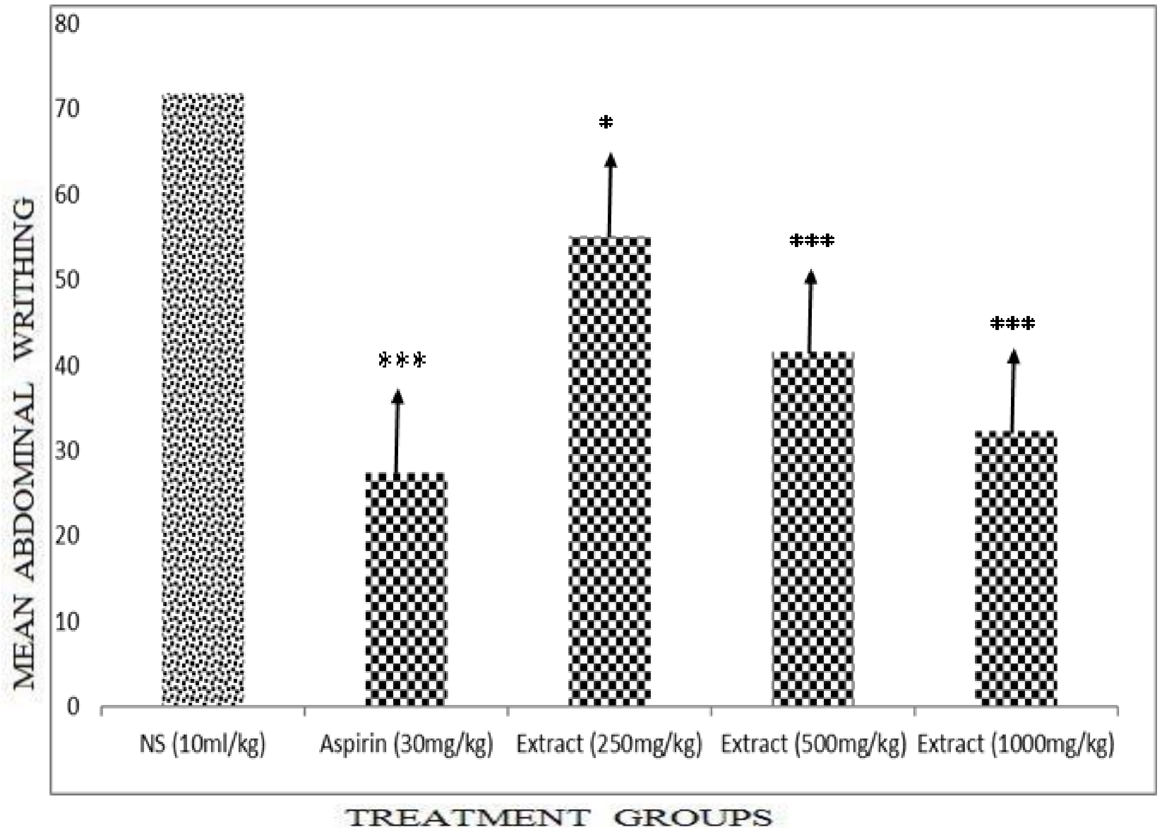

Figure 1: Acetic Acid induce writhing in Mice

Values are mean± SEM,*p≤0.05 and ***p≤0.001 are significant. NS=normal saline, ASA= Acetylsalicylic acid, TAE *trichodesma africannum* extract.

As shown in the figure above, the analgesic activity of the extract was dose dependent with the extract at a dose 1000 mg/kg observed to have the highest analgesic activity.

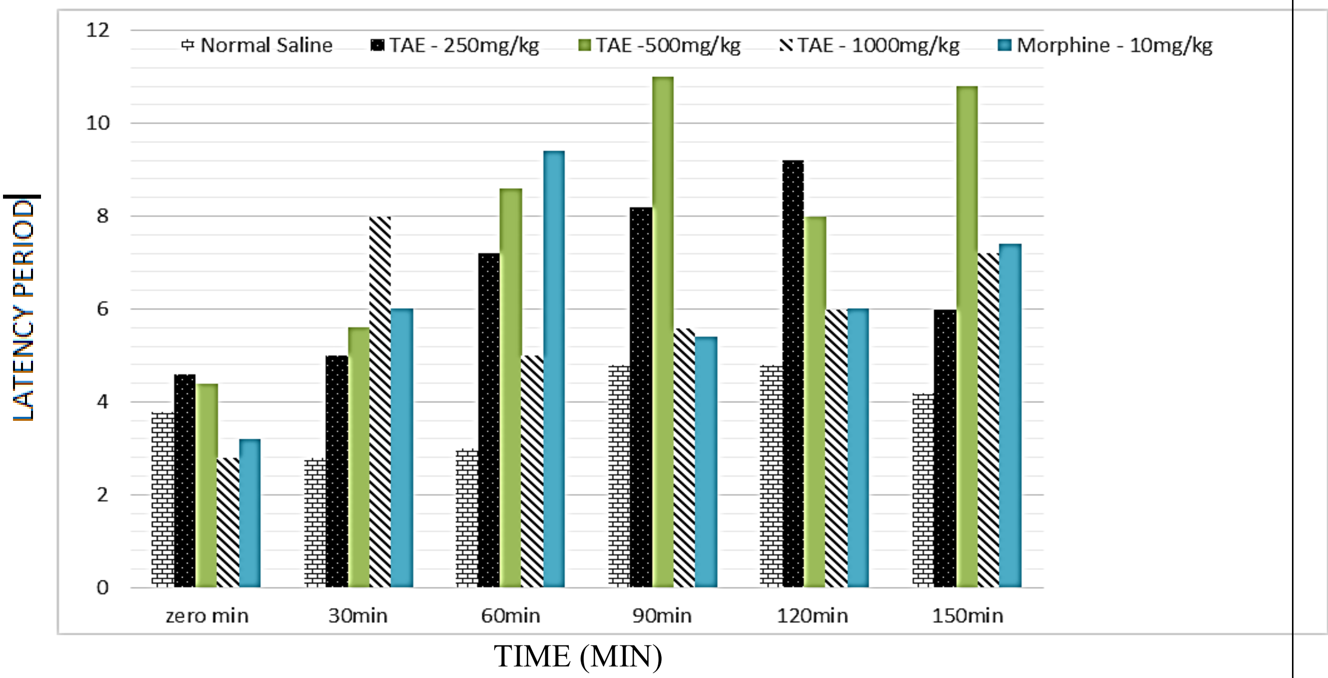

Figure 2: Hot plate induced pain in Mice

As shown in the figure above, the analgesic activity of the extract was observed to have significance at a dose of 250 mg/kg and 500 mg/kg at 60 mins and 500 mg/kg at 150 mins.

Figure 2: Effect of *Trichodesma africanum* on hot plate induced pain in mice.

Post hoc comparisons using the Burnferoni test found that Extract 250 mg/kg and 500 mg/kg showed statistically significant differences ($p<0.05$) in analgesic activity compared to the negative control (Normal Saline) after the 60th minutes. Similarly, the positive control (Morphine) showed comparative statistically significant differences in comparison with the negative control. Extract 500 mg/kg also showed statistically significant difference in analgesic activity after 150th minutes. There were no statistically significant differences among other treatment groups before and after the 60th minutes except as indicated above.

It can be concluded from the analysis and interpretation that the extract possesses an analgesic effect at a dose of 250 mg/kg and 500 mg/kg. Effect was observed more on the 500 mg/kg dose.

DISCUSSION

The therapeutic importance of medicinal plants is often attributed to the combination of their active constituents (Essien *et al.,* 2015). Different flavoniods isolated from medicinal plants have shown remarkable antipyretic, analgesic and anti-inflammatory activities (Essien *et al.,* 2015). The phytochemical screening of this plant revealed the presence of some important constituent such as carbohydrates, saponin, flavanoids, tannins, terpenoids/steroids, alkaloids, cardiac glycoside but absence of Anthraquinones. Recently discovered analgesic substances include, alkaloids, flavonoids and terpenoids. Previous studies have demonstrated that systematically administered various flavonoids, including rutin, quercetin, pectolinarin and gossypin, all produced significant anti-nociception in different pain test (Calixto *et al*., 2000).

The present study was designed to evaluate the analgesic potential of methanolic extract of *T.africanum* in Swiss albino mice. To evaluate the analgesic activity of the methanolic extract, acetic acid-induced pain test was used to induce abdominal writhing in Swiss albino mice and hot plate test was also used to induce pain in the mice. The acetic acid-induced writhing model has been widely utilized as a standard assay to explore compounds with peripheral antinociceptive activity from natural sources (Ayumi *et al.* 2020). It was widely employed to evaluate the antinociceptive activity of triterpenoid saponins (Wang *et al.* 2006; Speroni *et al.* 2007; Yang *et al.* 2008; Chen *et al*. 2018). The injection of acetic acid stimulates peripheral tissue damage, which further promotes the synthesis of eicosanoids – an important mediator in pain and inflammation, and then results in the release of various inflammatory mediators and prostaglandins – a main substance sensitizing the nociceptive neuron and inducing hyperalgesia – which plays a key role in the writhing behaviors in this test (Berkenkopf and Weichman 1988). When acetic acid is intraperitoneally injected into the experimental animal the following characteristics are observed as indicators of pain; contraction of abdominal muscle, elongation of body part and extension of the hind limbs. Therefore, such presentation is thought to be mediated by peritoneal receptors (Bentley *et al.,* 1983). It has been proposed that acetic acid acts indirectly by releasing endogenous substances responsible for exciting the nerve endings and causing pain, but also excites neurons that are sensitive to drugs (Collier *et al.,* 1968). The *T. africanum* extract in this study exhibited analgesic activity by reducing the number of abdominal writhes in acetic acid induced pain in mice after treatment with the extract. After ten minutes of the test period, the *T. africanum* extract at 250 mg/kg decreased the number of writings by 23.3% while 500 mg/kg decreased the number by 42.0% and at 1000 mg/kg of the extract, it demonstrated the highest analgesic activity by reducing the number of writhing by 55.2%. The analgesic activity of the extract was dose dependent with the extract at a dose of

1000 mg/kg observed to have the highest analgesic activity. The extract demonstrated analgesic activity by reducing the abdominal writhes by 55.2% compared to aspirin (reference drug) which caused 62.8% reduction in abdominal writhes. And this finding is supported by similar analgesic effect reported by Xishan *et al*., 2023 on antinociceptive activity of *Dolichos trilobus L* (*Leguminosae*) on acetic acid induce pain in mice.

The hot plate test involves higher brain function, and is considered to be a supraspinally organized response (Eddy *et al.*, 1953). The hot plate model has been employed extensively for the screening of compounds exhibiting analgesia by central mechanism, where elevation in pain threshold of mice towards heat is determined. It is well known fact that, the response (paw licking, jumping) by mice to noxious thermal stimuli in hot plate method is supra-spinally mediated response (Wani *et al.,* 2012). The analgesic effect exhibited by the extracts in hot plate test could be due to their interaction with various receptors present in supra-spinal sites. Both are considered to be supraspinally integrated responses. Stimulation of hot plate generates a noninflammatory and acute nociceptive response appeared as paw licking and jumping behaviors occurring at the supraspinal level (Le Bars *et al.* 2001). Therefore, a drug or substance possesses centrally mediated activity as opioids if its paw withdrawal threshold increased (Abdul Rahim *et al*. 2016). The antinociceptive activity of triterpenoid and saponins were widely evaluated by this animal model (Wang *et al.,* 2006; Speroni *et al*., 2007; Yang *et al.,* 2008; Arrau *et al.,* 2011; Chen *et al.,* 2018).118The hot plate procedure possesses an advantage over other methods of thermal stimulation, such as the tail flick (D'Amour *et al.*, 1941), in that the hot plate test can be applied repeatedly in the same animals over a short period of time (2–3 h) without causing tissue injury.

The result for the hot plate analysis showed that Extract at 250 mg/kg and 500mg/kg showed statistically significant differences in analgesic activity compared to the negative control (Normal Saline) after the 60th minutes. Similarly, the positive control (Morphine) showed comparative statistically significant differences in comparison with the negative control. Extract 500 mg/kg also showed statistically significant difference in analgesic activity after 150th minutes. There were no statistically significant differences among other treatment groups before and after the 60th minutes except as indicated above. It can be concluded from the analysis and interpretation that the extract possesses an analgesic effect at a dose of 250 mg/kg and 500 mg/kg. Effect was observed more on the 500 mg/kg dose. The analgesic effect may be attributed to some of these constituents, and this finding is supported by similar analgesic effect reported by Razafindrakoto *et al.,* 2021 on Antioxidant, analgesic, anti-inflammatory and antipyretic properties, and toxicity studies of the aerial parts of *Imperata cylindrica* (L.) Beauv.

CONCLUSION

The methanolic extract of *T. africanum* demonstrated analgesic activities on acetic acid-induced pain and hot plate induce pain in swiss albino mice. The extract reduced the number of abdominal writhings and pain sensitization significantly when compared to the reference drugs (diclofenac and morphine). This study therefore concludes that the medicinal plant possesses analgesic properties. Suppression of pain in this study could be attributed to phytochemical constituents present in the extract. Therefore, it is possible to obtain analgesic agent from the plant and serve as an alternative bio-resource in managing pain. The study thus, scientifically confirms the traditional use of the medicinal plant in management of pain.

REFERENCES

Ahmed, S., Ibrahim, M., Khalid, K. (2015); Investigation of essential oil constituents isolated from *Trichodesma africanum* (L.) grow wild in Egypt. *Res J Med Plant* 248-51.

Al-Yahya, M.A. 1990. Saudi Plants: A Phytochemical and Biological Approach. King Saud University Press, Riyadh, Saudi Arabia, Pages: 524.

Ayumi, RR., Shaik Mossadeq, WM., Zakaria, ZA., Bakhtiar, MT., Kamarudin, N., Hisamuddin, N., Talib, M., Sabar, AM. (2020). Antinociceptive activity of *asiaticoside* in mouse models of induced nociception. *Planta Med.* 86(8):548–555.

Bentley G, Newton S, Starr J (1983) Studies on the antinociceptive action of α agonist drugs and their interactions with opioid mechanisms. *British journal of pharmacology* 79: 125-34.

Berkenkopf, JW., Weichman, BM. (1988) Production of protacyclin in mice following intraperitoneal injection of acetic acid, phenylbenzoquinone and zymosan. Prostaglandins 36: 693-709

Berkes., EA. (2003). Anaphylactic and anaphylactoid reactions to aspirin and other NSAIDs. *Clin Rev Allergy Immuno*l. 137-48

Boulos, L., (2000). Flora of Egypt. Al Hadara Publishing Cairo, Egypt

Bourke, J. 2017 The story of pain: from prayer to painkillers. Springer. 180-181.

Boye, GL., Ampofo, O. (1983) Proceedings of the First International Symposium on *Cryptolepine. Kumasi*, Ghana: University of Science and Technology.

Calixto, JB., Beirith, A., Ferreira, J., Santos, ARS., Filho, VC., Yunes, RA. (2000). Naturally Occurring Antinociceptive Substances from Plants. *Phytother Res.;* 14:401–418.

Carlsson, Karl-Heinz; Jurna, Ilmar. (1987). "Depression by flupirtine, a novel analgesic agent, of motor and sensory responses of the nociceptive system in the rat spinal cord". *European Journal of Pharmacology*. 143 (1): 89–99.

Chen, S., Rong, Y., Liu, M., Cheng, S., Liu, X., Li, X., Yu, Y., Yang, G., Yang, X.(2018).Analgesic effects of triterpenoid saponins from Stauntonia chinensis via selective increase in inhibitory synaptic response in mouse cortical neurons. Front Pharmacol. 9:1302.119

Clauw DJ et al. (2019) Postgrad Med; 131(3):185–98.

Collier, HJ., Dinneen. LC., Johnson, CA., Schneider, C. (1968) The abdominal constriction response and its suppression by analgesics drugs in the mouse. *British Journal of pharmacology* 32: 295-310.

Cox, J. J., Reimann, F., Nicholas, A. K., Thornton, G., Roberts, E., Springell, K., *et al*. (2006). An SCN9A channelopathy causes congenital inability to experience pain. Nature 444, 894–898.

Eddy, NB; Leimbach, D (1953). "Synthetic analgesics. II. Dithienylbutenyl- and dithienylbutylamines". *J Pharmacol Exp Ther*. 107 (3): 385–393. PMID 13035677.

El-Gazali, GE., Al-Khalifa, KS., Saleem, GA., Abdallah, EM. (2010) Traditional medicinal plants indigenous to Al-Rass province, Saudi Arabia. *J Med Plants Res* ;4:2680-3.

El-Moaty, H.I.A. (2009). Active constituents and antimicrobial activity of *Trichodesma africanum* (L.) R.Br. var. heterotrichum Bornm. and Kneuck. Bull. Faculty Agric. Cairo Univ., 60: 357-365.

Essien, A.D., Akuodor, G.C., Essien, A.E, Asika, E.C., and Nwadum, S.K. (2015). Evaluation of Antipyretic Potential of the Ethanolic Leaf Extract of *Salacia lehmbachii* Loes. *Asian Journal of Medical Sciences* 7(2): 22-25

Essien, A. D., Essiet, G. A., Akuodor, G. C., Akpan, J. L., Chilaka, K. C., Bassey, A. L. and Nwobodo, N. N. (2016). Pharmacological Evaluation of the Aqueous Stem Bark Extract of

Bombax buonopozense in the Relief of Pain and Fever. *African Journal of Pharmacy and Pharmacology,* 10(5): 59-65.

Fujiyoshi T, Hayashi I, Ohishi S, Kuwashima M, Iida H, *et al*. (1989) Kaolin induced writhing in mice, a new model of possible bradykinin-induced pain for assessment of analgesic agents. Agent and Actions 27: 332-334

Graham, J.G., Quinn, M.L., Fabricant, D.S. and Farnsworth, N.R. (2000). Plants Used Against Cancer – an Extension of the Work of Jonathan Hartwell *Journal of Ethnopharmacology,* 73(3): 347–377

H.V, Annegowda., M.N, mordi., S-Ramathan and S.M, Mansor. (2010). Centre for drug research Malaysia 910-915.

Harirforoosh, S., Asghar, W., Jamali, F. (2013). Adverse effects of nonsteroidal antiinflammatory drugs: an update of gastrointestinal, cardiovascular and renal complications. *J Pharm Sci*.;16 (5):821-47

Kumae, G.S., Rajesh, K. and Sengottuvelu, S. (2011). Evaluation of analgesic and anti inflammatory activity of methanolic extract of Cocculus hirsutos leaves. *Int. Res. J. Pharm.* 2, 230-2

Mario, Moresca., Laura, Micheli., Barbara, Tenci., Muhammad, khatib. (2016). *Journal of ethno pharmacology* 456-465.

Matera, Carlo., Flammini, Lisa., Quadri, Marta., Vivo, Valentina., Ballabeni, Vigilio., Holzgrabe, Ulrike., Mohr, Klaus., De Amici, Marco., Barocelli, Elisabetta., Bertoni, Simona., Dallanoce, Clelia (2014). "Bis(ammonio)alkane-type agonists of muscarinic acetylcholine receptors: Synthesis, in vitro functional characterization, and in vivo evaluation of their analgesic activity". *European Journal of Medicinal Chemistry*. 75: 222–232.

Morris, DB. (1998). An invisible history of pain: early 19th-century Britain and America. *Clin J Pain*.; 14(3):191-196.

Moustafa, SM., Menshawi, BM., Wassel, GM., Mahmoud, K., Mounier, M. (2014). Screening of some plants in Egypt for their cytotoxicity against four human cancer cell lines. Screening; 6:1074-84.

Mshana, NR. (2000). Traditional Medicine and Pharmacopoeia: Contribution to the Revision of Ethnobotanical and Floristic Studies in Ghana. Accra, Ghana: Organization of African Unity/Scientific, *Technical & Research Commission.*

Organization for Economic Co-Operation and Development (OECD) Guidelines for testing of chemicals (2008). Acute oral toxicity–acute toxic class method 425, Paris, France.

Razafindrakoto, ZR., Tombozara, N., Donno, D., Gamba, G., Nalimanana, NR., et al. (2021) Antioxidant, analgesic, anti-inflammatory and antipyretic properties, and toxicity studies of the aerial parts of *Imperata cylindrica* (L.) Beauv. *South African Journal of Botany* 142(40): 222-229.

R. Koster., M. Anderson., and E. J. De Beer, (1959). "Acetic acid-induced analgesic screening," *Federation Proceedings*, vol. 18, pp. 412–417.

Retief, E. (2015). The genus *Trichodesma (Boraginaceae: Boraginoideae*) in southern Africa. Bothalia.

S, Ahmed., A, Naves., RA, khan., S, Siddiqui. pharmacology and pharmacy

Safa, O., Soltanipoor, MA., Rastegar, S., Kazemi, M., Nourbakhsh, Dehkordi, K., Ghannadi, A. (2013). An ethnobotanical survey on hormozgan province, Iran. *Avicenna J Phytomed*; 3:64

Sarkar, S., Zaidi, S., Chaturvedi, AK., Srivastava, R., Dwivedi, PK., Shukla, R. (2015). Search for a herbal medicine: Anti-asthmatic activity of methanolic extract of Curcuma longa. *Journal of Pharmacognosy and Phytochemistry*.; 3:59-72

Sharawy, SM., Alshammari, AM. (2008). Checklist of poisonous plants and animals in Aja Mountain, Hail region, Saudi Arabia. *Aust J Basic Appl Sci*;3:2217-25.

Soforoora, A. (1993). Medicinal Plants and Traditional Medicine in Africa. Spectrum Books Limited, Ibadan, Nigeria. Pp. 150-153.

Soladoye, M., Oyesiku, O. (2008) Taxonomy of Nigerian Medicinal Plants. A Textbook of Medicinal Plants from Nigeria Lagos. Nigeria: UNILAG Press.

Sostres, C., Gargallo, CJ., Arroyo, MT., Lanas, A. (2010). Adverse effects of non-steroidal anti-inflammatory drugs (NSAIDs, aspirin and coxibs) on upper gastrointestinal tract. *Best Pract Res Clin Gastroenterol :* 121-32.

Sriuttha, P., Sirichanchuen, B., Permsuwan, U. (2018). Hepatotoxicity of Nonsteroidal Anti-Inflammatory Drugs: A Systematic Review of Randomized Controlled Trials. *Int J Hepatol*; 5253623.

Sulaiman, S.K., Mohammed, H.I., Muskhazli, M., and Rusea, G. (2015). Ethnobtanical survey of medicinal plants used for traditional maternal healthcare in Katsina State, Nigeria. *South African Journal of Botany,* 97(3): 167-175.

Tareen, RB., Bibi, T., Khan, MA., Ahmad, M., Zafar, M., Hina, S. (2010). Indigenous knowledge of folk medicine by the women of Kalat and Khuzdar regions of Balochistan, Pakistan. *Pak J Bot* ; 42:146.s

Vane, JR. (1971). Inhibition of prostaglandin synthesis as a mechanism of action for aspirin-like drugs. *Nat New Biol.,* 231 (25):232-5.

Wang X, Xu J, Qiu D, Huang L. (2006). Study on the anti-inflammatory effectsand possible mechanism of total saponins of Psammosilene tunicoids. *Chin J Exper Trad Med Formulae*. 12:94–96. Wani, T.A., Kumar, D., Prasad, R. (2012). Analgesic activity of the ethanolic extract of Shorea robusta resin in experimental animals. *Indian J Pharmacol*: 493–499.

Wright, CW., Phillipson, JD., Awe, SO., Kirby, GC., Warhurst, DC., Quetin-Leclercq J, et al.(1996). Antimalarial activity of cryptolepine and some other anhydronium bases. *Phytotherapy Research*: 361-363.

Xishan Bai, Yanhong Li, Yuxiao Li, Min Li, Ming Luo, Kai Tian, Mengyuan Jiang, Yong Xiong, Ya Lu, Yukui Li, Haibo Yu & Xiangzhong Huang. (2023). Antinociceptive activity of doliroside B , *Pharmaceutical Biology,* 61:1, 201-212.

Yang L, Lin Q, Qian Z, Zhang L, Liu X, Duan X, Li Q. (2008). Isolation, extraction and activity study of the effective analgesic parts of Jintiesuo. *J Yunnan Univ Trad Chinese Med.* 31:1–3.

GEOSYNTHETICS PRODUCED FROM NATURAL FIBERS: PAST TO FUTURE

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Abstract

Geosynthetics are used for various application in geotechnical engineering to improve bearing capacity of soils, to construct more durable highway sections. Reinforced earth walls are also constructed using geosynthetics. Natural fibers such as coir, jute, sisal and flax are being used to produce geosynthetic to be used in applications in recent years. Natural geosynthetics share in the market increases day by day since they are environmental friendly than their synthetic counterparts. However, natural geosynthetics are susceptible to biodegradation which limits their service life. Hence, there are numerous studies regarding using natural geosynthetics in various applications in geotechnical engineering such as increasing soil strength, their effect to road subgrade behavior and interface characteristics with various soils. Since natural geotextiles are naturally biodegradable, several researchers attempted to increase their service life by applying natural and chemical substances to them. Then, increase in service life is determined by soil burial tests and carrying out weighing and tensile tests. However, lack of studies about hemp is seen in the literature. Therefore, hemp as a possible new natural material is introduced to produce geosynthetics in this study. Studies related to hemp fibers investigating possible production of hemp geotextiles are discussed. Advantages of hemp fibers to those such as jute and coir fibers regarding their tensile strength and biodegradation also compared with jute and coir fibers.

Keywords: Natural Geosynthetics, Hemp, Biodegradation, Tensile Strength

INTRODUCTION

Geosynthetics which are defined as a planar product manufactured from polymeric material to be used in geotechnical engineering (ASTM D4439). Geosynthetics are mainly produced from polymers which are derived from hydrocarbons. However, fiberglass and rubber might be used to produce geosynthetics (Koerner, 2005). Geosynthetics are used in numerous geotechnical engineering applications such as reinforcement, separation, filtration, drainage, fluid barrier and protection (Shukla and Yin, 2006). There are eight types of geosynthetic products such as geotextiles, geogrids, geonets, geomembranes, geosynthetic clay liners, geopipe, geofoam and geocomposites (Koerner, 2005). Those products are used in at least one of the geotechnical applications given above.

Statistical data gathered from 1970 to 1990 shows that geotextiles are the most produced type of geosynthetics in North America with a total production of 600 million of square meters in 1970. Similar trend is observed in Western Europe between 1970 to 1995. 400 million square meter geotextile consumed in 1995 in Western Europe. These numbers show that demand and consumption of geotextile increase year by year.

Beside from synthetic polymers, natural materials are also used to produce geosynthetics. Those type of materials are also called as geonaturals (Shukla and Yin, 2006). Geonaturals are mostly produced from coir and jute fibers while cotton, wool, kenaf, sisal fibers are also used in geotextile production (Shukla and Yin, 2006; Rawal and Anandjiwala, 2007; Shirazi et al., 2019; Alajmi et al., 2022). Using natural material to produce geotextile has taken attention due to increased awareness of sustainability (Lal et al., 2017). Geonatural geotextiles provides equal tensile strength and Young's modulus with respect to their synthetic counterparts. However, consumption of geonaturals covers 5-6% of total geotextile consumption (Chakravarthy et al., 2020).

It is clear that we should consider sustainability and cleaner production to control or even reduce the effects of climate change. Therefore, instead of geotextiles produced from fibers which are obtained from crude petroleum oils, geonaturals will be preferred more day by day. Therefore, this study aims to explain current state of art regarding natural geotextiles and their future with new natural fibers to be used to produce natural geotextiles.

COIR GEOSYNTHETICS

Coir geotextiles are produced from coir fibers. Coir fibers are obtained from coconut husk which is waste material (Subaida et al. 2009). Coir fibers have high lignin content which provide durability against degradation more than other fibers (Subaida et al. 2009). Coir fibers presents higher strength against tear than other natural fibers (Anusudha et al 2020).

Subaida et al. (2008) investigated behavior of woven coir geotextiles and geogrids under direct shear and pull-out conditions. Five different type of coir geonaturals were produced as geotextile and geogrid. Geonaturals were tested three different granular soil to evaluate their interactions with three different granular soils. Angle of friction of sands are reported as 41, 42, 49 degrees in the study. Direct shear tests were conducted using 60*60*50 mm direct shear box and under 100, 200 and 300 kPa normal stress. Pull – out tests were conducted under 10, 20 and 30 kPa normal stress. Direct shear test results showed that, maximum contact efficiency is provided when opening size of the geonaturals is slightly larger than the particle size of soil used in this study. Results of pull-out tests revealed two different type of behavior with respect to geonatural type. In case of geotextile, pull-out results were independent from particle diameter of soil, however largest pull-out force is obtained fine granular soil.

Lal et al. (2017) investigated contribution of geotextile and geocell to bearing capacity of sand. Sand is prepared at 60% relative density inside the loading tank with a dimension of 750*750*750 mm. Footing width is selected as 150*150*150 mm so that the boundary conditions do not affect test results. Effect of distance from the base of footing to the reinforcement, width of the geotextile and geocell, number of geotextile layer, height of geocell and distance between geotextile layers to bearing capacity were investigated in this study. Results of this study shows that geocell increases bearing capacity of sand more than geotextile reinforcement. Maximum increase of bearing capacity is observed when geocells are used as reinforcement. Maximum improvement factor is observed when distance of geocell and geotextile equals to 0.1 and 0.25 times of foundation width (B) respectively. The highest bearing capacity is achieved if the geocell height equals to 0.67B or 4 layers of coir geotextiles are used. However, it is also reported that, increasing height of geocell contributes more than increasing number of geotextile.

Subaida et al. (2009) investigated behavior of unpaved roads reinforced with woven coir geotextiles in laboratory. Their test program investigated effect of loading scheme, type of coir geotextile and location of geotextile. It is shown that inclusion of woven geotextile increased bearing capacity especially in thin sections. Permanent plastic deformations significantly lowered when geotextile is used because, geotextile prevented lateral spread of foundation soil. Geosynthetic location is found to be important in this study. Optimum depth of coir geotextile found to be 1/3 of the foundation width.

Tiwalı and Satyam (2020) used coir geotextiles treated with lime and silica fume to reduce swelling pressure of soils. Constant volume swelling pressure, CBR and large scale direct shear tests were carried out to see the influence of coir geotextiles. Placement depth of geotextiles were also changed during the study find optimum placement depth. Single and double layer geotextiles were placed at one third and half of samples. Swelling pressure decreased by introducing geotextiles in to samples. Clay sample without geotextile has swelling pressure around 70 kPa however, it decreases to around 10 kPa when two-layer geotextile treated with lime were placed. Silica fume treated geotextile did not reduce swelling pressure significantly when compared with untreated geotextile. Similarly, soaked CBR value increases with geotextile, lime treated geotextile gives higher CBR values due to pozzolanic reaction of hydrated lime. Silica fume treated caused small variation in CBR values than untreated geotextile due to higher specific surface area of silica fume. CBR value equal to 1.5% for pure clay while it increases to 6.5% for lime treated double layer geotextile application. When the authors evaluated shear strength of samples, it is seen that geotextile inclusion increased the shear strength. The increment was equal to 96% compared to untreated sample under 24.63 kPa normal stress. Similar behavior was observed for higher normal stresses. It is seen that, there is not significant difference between silica fume and lime treatment.

Saikia et al. (2019) conducted plate load tests using coir geotextiles at the interface of aggregate and sand layer. Thickness of aggregate layer varied as 10 cm, 15 cm and 20 cm, while sand layer kept constant as 80 cm. Coir geotextiles are used in single- and double-layer configuration. Results showed that coir geotextile increased bearing capacity of soil. The maximum contribution of double layer coir geotextile was observed when it is used with 15 cm aggregate layer thickness.

Lekha and Kavitha (2006) investigated strengthening clay dykes with environment friendly coir geotextiles by conducting field studies. Researchers thought that coir geotextile will function until the primary consolidation of clay which will provide safety of dykes. North Dakota penetration test is used to determine penetration resistance of geotextile protected or unprotected dykes. Penetration resistance of dykes increases with time when coir geotextile is used. As the water level increases in neighboring canal, protected and unprotected loses penetration resistance. Beside that, penetration resistance decreases faster in case of unprotected dykes. After one year of observation, it is seen that, protected dykes with geotextiles have higher penetration resistance than unprotected dykes.

Visvanathan et al. (2020) investigated behavior of a low volume road sections without or with coir geotextiles. Study covered a road section with a length of 1.736 km with two different type of coir geotextile and eight different subgrade thicknesses. Static plate loading tests, CBR tests and dynamic cone penetration tests were carried out. Tests results are compared with each other considering geotextile type and subgrade thicknesses. Coir geotextiles used in this study increased bearing capacity of all sections considered in this study. CBR test results and dynamic cone penetration test results supported those findings. Coir geotextile with a higher weight per square meter, tensile strength and less opening size outperformed the other type of coir geotextile used in this study. Both type of coir geotextile resulted reduction of aggregate layer thickness. Therefore, it is stated that, coir geotextile can be a good alternative to use under road subgrades which will reduce demand to natural resources such as aggregates.

Vinod and Bhaskar (2011) investigated effect of coir geotextile to bearing capacity of sand. Geotextiles and sand placed in test tank which have 600 mm length, 600 mm width and 500 mm depth in dimensions. Footing dimension are selected as 100 mm * 100 mm so that the test will not be affected by boundary conditions. Geotextiles were used in single layer configuration but, their length and depth of burial changed during tests. According to loading test, bearing capacity of footing increased 300% when single layer geotextile is introduced. It is found that, optimum depth of coir geotextile should be between 0.33 to 0.5 times of footing width. Beside, optimum coir geotextile width found to be two times of the footing width. When multiple coir geotextile layers are placed, the optimum layer number is found as four layers. Four layers of geotextiles maximize bearing capacity of footing when they are placed 0.5 times of footing width below the footing level.

Vinod and Minu (2010) determined contribution of coir geotextile to California Bearing Ratio (CBR). Five different types of coir geotextile were used and their contribution to four different soils such as soft clay, clay, lateritic soil and sand over soft clay. Results of this study proves that, CBR values of soils can be improved using coir geotextiles. Woven coir geotextiles provided higher CBR values than coir geogrids produced by hand.

Anusudha et al. (2019) carried out small scale plate loading test so that increase of bearing capacity of a high plastic organic soil due to effect of coir geotextile. Woven coir geotextile is used throughout the study. Loading tests were performed for only subsoil and subgrade soil over subsoil. Coir geotextile were placed at interface of subgrade and subsoil in the second case. Two types coir geotextile used in the study. Finite element method is also employed to simulate tests carried out. Vertical deformations decreased as much as 38% when coir geotextile is employed.

Sridhar and Prathapkumar (2017) used coir geotextiles to increase bearing capacity of granular soil. Bearing capacity of sand is evaluated for different coir geotextile layer configuration. Bearing capacity and settlement reduction is compared for different total depth of burial of coir geotextiles. Effect of number of coir geotextile layer was also evaluated in this study. It is seen that, increase of coir geotextile layers resulted increase in CBR values, decreased settlement reduction factors. Optimum number of coir geotextile layers are found as 3-4 with respect to bearing capacity and settlement reduction factor. Further increase of coir geotextile number results marginal changes in bearing capacity increase and settlement reduction.

Arora et al. (2019) investigated change in bearing capacity of sand when chemically treated coir geotextile is used as a reinforcement. Sodium hydroxide and sodium permanganate used for treating woven and non-woven geotextiles. Coir geotextiles were treated in three different ways. Coir geotextiles were only treated with sodium hydroxide, coir geotextiles were only treated with sodium permanganate and coir geotextiles were treated both sodium hydroxide and sodium permanganate. Chemically treated coir geotextiles were dried at room temperature. Sand and silty sand is used in the study which are compacted at optimum water contents. Woven and non-woven coir geotextiles that are placed in interface of silty sand and sand, however the highest bearing capacity is achieved when geotextile is treated with both sodium hydroxide and sodium permanganate.

Vivek et al. (2019) investigated using p-aminofenol, sodium periodate and sodium hydroxide treated and untreated coir geotextiles in unpaved roads. Monotonic loading is performed over two layer of soil placed inside a loading tank. Clay is placed beneath sand. Untreated and treated coir geotextiles are placed at interface of clay and sand. Bearing capacity of unpaved road section is improved after 9 mm and 13 mm of deformation when treated and untreated coir geotextiles were used. It is said that, coir geotextile could be useful when they are especially used in rutted road sections.

Anusudha et al. (2020) investigated effect of coir geotextile in improving unpaved low volume roads and improving subsoil's modulus by carrying out Benkelman Beam Test, static plate load test and field test. Two different coir geotextiles which have different unit area weight is used in study. Tests were conducted at different locations with different traffic, subsoil, granular soil thickness and used coir geotextile. Test results revealed that, elasticity modulus of subsoil increases significantly by adding coir geotextile. Increased elasticity modulus is used in design software (KENLAYER) to obtain design charts. It is found that, woven coir geotextiles increase elasticity modulus of road section, which reduces degradation of road section. It is stated that, using coir geotextile would reduce construction costs.

Jaswal et al. (2022) also investigated effect of untreated and treated coir geotextile into bearing capacity. Two woven and two non-woven coir geotextiles are used in study. Coir geotextiles are treated with bitumen emulsion and unsaturated polyester resin, then placed at interface between sand and clay. It is seen that, bearing capacity of soil with woven geotextile increased more than soil with nonwoven geotextile. It is also stated that, treated geotextile caused more increase in bearing capacity than untreated geotextile caused which results reduction in sand layer.

Harinder et al. (2022) carried out a study to reveal effect of coir geotextile to static and dynamic performance of embankment. California Bearing Ratio (CBR) and rut depth tests were conducted during study. Results of the study proves that addition of coir geotextile slows down settlement, reduces residual deformation and rutting depth. CBR values increases when coir geotextile is installed. Harinder et al. (2022) also states that, implementation of coir geotextile into design reduces maintenance costs of flexible pavements and increases service life of flexible pavements.

Singh et al. (2021) also investigated CBR behavior of soils reinforced with coir geotextiles with different layer arrangements. CBR tests were also carried out for soils mixed with marble dust. Marble dust inclusion increases CBR of soils while it reduces maximum dry density. Maximum CBR increase is measure when coir geotextile placed H/3 from surface of soil sample. In case of double layer reinforcement, the highest CBR is measured when coir geotextile is placed H/3 and 2H/3 depth from the soil surface.

Beena and Babu (2008) investigated effect of coir geotextiles to consolidation of clays. Coir geotextiles were placed in rectangular and circular patterns. It is seen that consolidation process becomes quicker due to coir geotextile.

JUTE GEOSYNTHETICS

Jute fibers have high tensile strength and modulus. Although jute fibers are biodegradable, they are annually renewable and available at low cost (Basu et al. 2009).

Bera et al. (2009) investigated effect of jute geotextiles to unconfined compression strength of fly ash. Different number of jute geotextile were placed inside the fly ash samples. Effect of saturation degree, sample curing time, size of samples was also investigated in the study. It is found out that the sample size effects the unconfined compression strength (UCS) of samples when jute geotextiles were used. Addition of four layers of jute geotextiles increases UCS around 525%. Researcher also proposed an equation to predict the UCS of fly ash samples depending on number of jute geotextile layers.

Basu et al. (2009) investigated performance of jute and high density blended geotextile in construction of unpaved rural roads. Road section constructed in this study consist of 100 mm compacted top layer, 100 mm compacted subgrade, 5 mm backfill, geotextile and earthen subbase. CBR tests were carried out in laboratory and in the field after 11 and 18 months after the construction. It is seen that produced hybrid geotextile increased CBR values of road section even after 18 months later. It also seen that, road surface was intact even after 18 months while rutting was observed at section without geotextile. Investigation pits showed that, jute fibers were degraded but, during degradation, a hard cake of soil seen. Hard cake soil is responsible for CBR increment and intact road surface.

Mechanical properties of jute and polypropylene hybrid nonwoven geotextiles were investigated by Rawal and Sayeed (2013). Hybrid geotextiles were produced by mixing jute fibers and polypropylene fibers at different ratios. Artificial circular and horizontal cuts were induced and then mechanical properties were evaluated by wide width tensile test and CBR puncture tests. Each tests were repeated for five times. Tensile test results showed that tensile strength and tensile modulus of produced hybrid geotextiles are higher in the cross-machine directions. It is also shown that if jute/polypropylene ratio equals to 40/60, almost equal tensile strength were determined for virgin and damaged geotextiles. It is also reported that higher tensile modulus is determined in case of 40/60 jute/polypropylene geotextile. Results prove that, natural jute fibers improved tensile modulus of hybrid geotextile while insignificant reduction is observed in tensile strength. Induced damage resulted lower tensile properties. Reduction was higher in case of horizontal cut than circular cut.

Basu et al. (2019) produced a hybrid geotextile from jute and high density polyethylene (HDPE) fibers to stabilize river embankment. HDPE fibers were employed in machine direction and jute fibers were employed in cross machine direction during production. Produced geotextile were used for slope stabilization of river embankment. Studied embankment constructed without any trench or impervious core which makes it susceptible for failure. Therefore, it is decided that the embankment will be covered with geotextile produced from jute and HDPE fibers. Six different type of hybrid geotextiles were produced whose tensile strength varies between 9.23 kN/m to 10.70 kN/m in machine direction while, it is between 17.38 kN/m to 38.11 kN/m in cross machine direction. The elongation of hybrid geotextile is higher than only HDPE geotextile. The elongation varied between 38.11% to 17.38% in machine direction while it changes from 7.25% to 18.66% in cross machine direction. CBR resistance of the hybrid geotextiles were found to be higher than pure jute and pure HDPE geotextiles. After the geotextiles were installed, river embankment was monitored for 8 years. Reinforced sectioned showed no sigh of collapse or rain cuts. Installed hybrid geotextile provided compacted hard soil layer at different section of river embankment at varying thicknesses. Those compacted soil layers has higher shear strength changing from 0.8 kg/cm2 to 4 kg/cm2. Increased shear strength resulted higher safety against slope failure.

Buragadda and Thyagaraj (2019) investigated effect of jute geotextile to sand's bearing capacity considering location of top reinforcement layer from footing, vertical spacing of geotextiles, number of reinforcement layers and width of reinforcement. Jute geotextile having 13.8 kN/m and 12.5 kN/m tensile strength at machine direction and cross machine direction respectively. 900 * 900 *900 mm loading tank is used with a footing 50, 100, 150 mm loading plate diameter, so that boundary conditions do not affect test results. The highest bearing capacity of footing is achieved when jute geotextile is placed 0.3 times the footing diameter. If more than on layer is used to reinforce sand base, optimum distance between layers is found as 0.3 times the diameter. Optimum number of reinforcement is also determined in this study with respect to bearing capacity. Increasing number of reinforcement led to higher bearing capacity, however, after four layers of geotextile, increase of bearing capacity becomes insignificant. This means that optimum number of reinforcement layer equals to in this study. Optimum reinforcement width also determined as 3.5 time of footing diameter considering bearing capacity ratio.

Muthukumar et al. (2019) produced geocell and evaluated their contribution to sand's bearing capacity by carrying out laboratory plate loading tests. Effect of thickness of sand layer between geocell and footing, width and height of geocell is investigated in this study. Steel tank and footing with dimensions 500 mm * 500 mm * 500 mm and 100 mm * 100 mm * 10 mm were used respectively in this study. Jute geocell was produced by stitching geotextile strips using yarns. Plate load test result showed that, maximum improvement in soil bearing capacity is seen if distance between footing and geocell equals to 0.1 times of footing width. It is seen that, as the width of geocell increases, bearing capacity of geocell reinforced sand increases. However, if width of geocell is more than four, insignificant increase is seen. Similar behavior is observed in case of height of geocell. Bearing capacity of geocell reinforced sand increases if the height of the geocell increases up to 0.6 times of the footing width. After this threshold value, soil bearing capacity insignificantly increases.

Gupta et al. (2021) investigated effect of Alkali Activated Binder (AAB) coated jute geotextile on subgrade stabilization. Water/solid (w/s) ratio of AAB were chosen as 0.35, 0.40, 0.45. AAB with a different water contents were applied to jute geotextiles. Tensile strength and contribution to bearing capacities of jute geotextiles were evaluated. Interface shear characteristic were also evaluated. Sand classified as poorly graded sand (SP) according to unified classification system. Bearing capacity tests were carried out using steel tank with dimensions 1.2 m length, 0.91 m width and 0.91 m depth. AAB treatment increased tensile strength of jute geotextile. Interface friction angle between sand and untreated jute geotextile is higher than sand's friction angle. Interface friction angle decreases AAB treatment along with increasing w/s ratio, while cohesion increases. Load test showed that, AAB treatment increased bearing capacity, however the highest increase is observed when jute geotextile treated with AAB if w/s ratio equals to 0.35.

Midha et al. (2017) investigated performance of chemically treated jute geotextile in unpaved roads. Unpaved road is simulated as stone aggregates while soil base is simulated with natural soil which consist of sand, silt and clay. Rain conditions are also taken into consideration which is satisfied by applying 50 mm and 100 mm/h rainfall intensity. Geotextiles are placed between natural soil and stone aggregate. Geotextiles are placed inside a sand layer in some tests. Chemical treatment of jute geotextiles is carried out by applying resorcinol, cheshewnut shell liquid and condensed tannin solution. This process is called as transesterification. Other group of geotextiles were coated by bitumen. Geotextiles were removed from the design models after 30, 60 and 90 days. Removed geotextiles were subjected to tensile test. Transesterified jute geotextiles reached tensile strength of 7000 N/m and 6500 N/m in warp and weft directions respectively. Bitumen coated geotextiles' tensile strength is measured as 9000 N/m and 8000 N/m in warp and weft directions respectively. Samples removed after 90 days and subjected to 100 mm/h rainfall intensity experienced reduction in their tensile strength. Tensile strength of transesterified jute geotextiles determined as 3235 N/m and 1590 N/m in warp and weft directions respectively. Those values correspond to 46.22% and 24.45% of initial tensile strength. In case of bitumen coated jute geotextiles retained 58.5% and 47.12% of their initial tensile strength after 90 days of burial and 100 mm/h rainfall conditions. Those values given above results when sand layer presents. If sand layer does not used in model, all geotextiles underwent higher degradation. Lower rainfall intensity resulted higher retention of tensile strength of samples. Similar results are determined for puncture diameter.

GEOSYNTHETICS FROM OTHER FIBERS

Mwasha and Petersen (2010) investigated behavior of environmental friendly geotextile produced from sisal fibers. Behavior of an embankment reinforced with sisal geotextile is observed. Embankment is constructed from quartz sand while subsoil is obtained from Caroni swamp which needs improvement. Tensile strength of sisal geotextile is investigated after it is buried under different soils for different time durations. It is concluded that, under external loads; sisal geotextile reinforced embankment, while subsoil consolidated at the same time. Therefore, even sisal geotextile is fully degradated, soft soil will consolidate and gain strength. Therefore, sisal geotextile can be used for reinforcing embankments.

PREVENTION FROM BIODEGRADATION

It is clear that the geonaturals performs as well as their synthetic counterparts, however service life of geonaturals are very limited and they biodegrade quickly. Therefore, increasing geonaturals service life has taken a lot of interest in the literature. Those studies covered and investigated variety of technics covering geonaturals by natural or synthetic substances. Those studies and their results are summarized below.

Saha et al. (2012) developed a method to increase durability of jute geotextiles against acidic solutions, alkali solutions, biological degradation and physical degradation. The new method is called as transesterification. Transesterification is a chemical treatment process to produce more durable natural geotextiles. Jute fabrics were dipped in a solution which consisted sodium hydroxide, plant tannin, cashew nut shell, liquid, resorcinol, neem oil and formaldehyde. The treatment applied to jute fabrics yielded higher tensile strengths after samples were subjected to acidic and alkali solutions. Treated samples retained 50% of their initial tensile strength while, untreated ones retained only 15% of their initial tensile strength. Chemical treatment also increased durability of jute geotextiles against salinity solutions. Treated samples retained 48% of their initial tensile strength after biological degradation for 200 days while, tensile strength of untreated samples could not be measured after 90 days due to total degradation.

Marques et al. (2014) investigated effects of climatic condition of southern Brazil on degradation of coir geotextiles. Effect of seasonal changes in weather conditions and lime treatment of coir geotextiles were evaluated by tensile tests. Untreated coir fibers retained 23% of their initial tensile strength while, treated fibers retained 19% of their initial tensile strength after 12 months of exposure to climatic conditions. Researchers are also reported that, biodegradation is faster during heavy rain season. It is also revealed by the researchers that, lime treatment of geotextile changes biodegradation in first 3 months while, it does not affect long term behavior.

Joshi and Midha (2022) conducted a study to increase serviceability life of jute geotextiles that are used in road construction. In order to do so, CA-chitosan treatment applied to jute geotextiles. Degradation of treated geotextiles were evaluated under different rainfall conditions, different road sections and different time intervals. Degradation of treated jute geotextiles were evaluated by retained tensile strength after burial. CA-chitosan treatment resulted in higher tensile strength. However, all samples lost tensile strength after burial. However, geotextiles buried inside sand layer retains higher tensile strength. Higher strength decrease observed when rainfall is higher at the same time duration. CA-Chitosan treated jute geotextile’s tensile strength is measured as 1400 kN/m in warp direction, however it decreases to 712 kN/m after 90 days of burial and 100 mm rainfall without sand layer. If the geotextile is placed within a sand layer, retained strength is measured as 786 kN/m at same conditions. Puncture diameter is also decreased due to CA-chitosan treatment, but increases as burial time increases.

Chakravarthy et al. (2021) investigated change of durability of jute geotextile when jute geotextile is treated with alkali-activated binder (AAB). Three different water to solid ration is used to produce alkali-activated binder. F type fly ash, sodium silicate, and sodium hydroxide is used to produce AAB. Jute geotextile is coated with produced alkali-activated binder and then buried into soil. Samples were remained buried for 30, 90 and 180 days. Durability of buried samples were evaluated by stereomicroscopy, FTIR, Scanning electron microscope (SEM) mass per unit area tensile strength and elongation at break. When the jute geotextiles were covered with AAB, significantly changes surface morphology. Voids of jute geotextiles are reduced by application of AAB which also affects permeability of geotextiles. Permeability of jute geotextiles decreases with the AAB treatment. The lowest permeability of treated jute geotextile is determined when the water to solid ratio equals to 0.40. SEM analysis showed that, as the water to solid ration increases formation of unreacted fly ash particle decreases. Weight loss of samples also observed in the study. Untreated jute underwent 6% of weight loss, while weight loss of treated jute geotextile was less than 1% if water to solid (w/s) ratio equals to 0.35 which is the lowest of all treated samples. Similarly, the highest tensile strength is measured when w/s equals to 0.35. It should also be noted that, initial tensile strength of samples increases if they are treated with AAB. In similar research conducted by Chakrabarthy et al. (2021) evaluated resistance of AAB treated and natural jute geotextiles against acid and alkali attack. Treated and untreated jute geotextiles were also subjected to soil burial and compost soil burial tests. Hydrolysis test were also run over all samples. Weight loss, tensile strength and elongation at break were evaluated to determine degradation of samples. The highest weight loss was observed for samples subjected to acid attack. Natural geotextile lost 80% of their initial weight if subjected to acid attack after 90 days. If the jute geotextiles coated by AAB, they retain more weight than uncoated samples. However, if w/s ratio equals to 0.35, the lowest weight loss is observed under acid attack and soil burial after 90 days. In case of alkali attack and compost burial, the lowest weight loss is observed for AAB with 0.40 w/s ratio after 90 days. However, in those cases, the lowest weight loss is calculated for other w/s coated jute geotextile for 30 day and 60 day of exposure. Tensile strength of AAB treated jute geotextile increases up to 15 kN/m from 7 kN/m. Samples can not retained their tensile strength when they subjected to acid attack for 30 days. Alkali attack also decreased tensile strength of treated samples, however tensile test can be still performed even after 90 days of exposure. AAB with 0.35 w/s ratio has the highest resistance to environment effects after 90 days.

Gosh et al. (2014) used bitumen to increase service life of non-woven jute geotextiles. Burial tests were performed by compost soil which consists of fertile garden soil, cow-dung manure and sand. Bitumen emulsion increased tensile strength of non-woven jute geotextiles, however decreased permeability, permittivity. Bitumen treated non-woven jute geotextile retained almost 60-70% of tensile strength as well as puncture resistance. Bitumen coating provided a protective barrier against microbes, soil and moisture between jute fibers.

Khan et al. (2022) investigated improvement of biodegradation of flax fibers by coating chitosan and linseed oil. Researchers states that, if correct treatment method is chosen, service life of flax fibers can be doubled.

Renourad et al. (2017) also investigated biodegradation of flax fibers. Cellulosic coating and antibacterial substance were applied to fibers. Cellulosic and antibacterial coating were applied separately and together to fibers. Cellulose coating increased resistance to biodegradability of flax yarns while antibacterial substance did not make any difference. Service life of flax yarns increased because biodegradability occurred in coating at the initial stages, then flax yarns biodegrades. Antibacterial coating did not work because, it did not provide any bonding with flax yarns. However, when antibacterial substance applied after cellulose coating, it prevented bacterial growth. It is concluded that natural subtances can be used to prevent biodegradation of flax yarns.

Renourad et al. (2014) investigated biodegradation flax fibers using Aspergillus niger cellulase and exposed to Cellvibrio bacteria. Chitosan treatment is also applied to fibers so that, its effect to biodegradation of flax yarns. Three different type of chitosan is used such as low molecular weight, medium molecular weight and high molecular weight. It is revealed that, chitosan application provided protective layer over flax fibers which reduces biodegradation. Therefore, potential flax fibers could be more resistive to biodegradation when chitosan treatment is applied. It is also said that, chitosan coating method is more environmental friendly than its synthetic counterparts.

Vivek et al. (2020) conducted durability study on coir geotextiles. Two different of woven coir geotextile and two different non-woven coir geotextile were used in the study. Chemical treatment was also employed over the samples. Paminofenol, sodium periodate and sodium hydroxide is used for chemical treatment of samples. Untreated and treated samples were buried in interface of sand-clay interface. Samples were removed from soil after 2, 6, 8 and 12 months after and subjected to tensile test. All samples lost their tensile strength after they are removed from soil. It is found out that reduction of tensile strength in weft direction is higher than tensile strength reduction in warp direction in case of woven coir geotextiles. Similar behavior is observed in case of non-woven coir geotextiles too. Reduction in tensile strength were higher in chemically treated samples than untreated samples in case of woven geotextiles. However, in case of non-woven samples, untreated samples tensile strength reduction was higher in untreated samples than treated samples.

Sayida et al. (2020) investigated biodegradation of coir geotextiles buried in five different soil types. Bio-degradation is reported as reduction in tensile strength and CBR value. Surface morphology of virgin samples and buried samples were also reported in their study. Coir geotextile samples were buried for 135 days, which resulted 30% to 95% reduction in tensile strength. Test results of samples removed earlier showed that, rate of biodegradation is lower, however, increases by time. CBR value decreases by time due to biodegradation. In their field tests, coir geotextile is found after years which proves that, laboratory tests overestimates biodegradation of sample.

Ghosh et al. (2014) used bitumen emulsion increase durability of jute geotextiles. Physical, mechanical and hydraulic properties of bitumen impregnated jute geotextiles are determined. Pure jute and bitumen impregnated jute samples are buried in soil for 21, 30, 90, 180, 270 and 365 days. Bitumen impregnated jute geotextiles retains 60% to 70% of their initial tensile strength which shows bitumen impregnation increases durability of jute geotextiles.

Thakur et al. (2021) also investigated bitumen impregnation to increase service life of jute geotextiles. Compost soil is prepared by mixing garden soil, cow dung and sand is mixed by 2:1:1. Treated and untreated soils are buried for 21 days. Bitumen impregnation increased tensile strength and elasticity of jute geotextiles. When bitumen is impregnated 0.5 kg/m2 and 0.6 kg/m2, samples lost 17.03% and 14.49% respectively.

Sumi et al. (2018) used cashew nut liquid to modify coir geotextiles surface to increase their long term performance. Untreated and treated geotextiles were placed to acidic, alkaline, salty environmental and subjected to wetting drying cycles. Biodegradation is then evaluated by carrying out tensile strength tests. Untreated and treated samples were placed at different depths during soil burial tests. Results showed that, untreated samples biodegraded faster when they are buried at lower depths of soil where microorganisms are more active. It is also seen that, treated samples retained 70% to 80% of their initial tensile strength while untreated samples retained 12% of their initial tensile strength after one-year burial duration. Alkaline conditions marginally affected biodegradation rate of samples than acidic conditions.

FUTURE: HEMP GEOSYNTHETICS

Hemp fibers were used to produce sail and ropes to be used in ships because they have high strength and durable to salty environment (Peev, 2012). Hemp fibers constitutes from cellulose, hemicellulose, lignin and pectin. Hemp fibers are resistant to heat and UV light. Hemp fibers are resistant to microorganisms and alkaline, but weak to acidic environment (Karakaya, 2021; Mangut and Karahan 2011).

It is also known that, hemp fibers have higher strength than coir, jute and cotton. Hemp fibers elasticity modulus is also higher than other natural fibers. Mechanical properties of several natural fibers provided below from Hao et al (2018).

Table 1. Mechanical properties of natural fibers.

Fiber Type	Density (g/cm^3)	Elongation (%)	Tensile Strength (MPa)	Elasticity Modulus (GPa)
Hemp	1.47	4	690	70
Cotton	1.5	7	400	12.6
Jute	1.3	1.8	773	26.5
Coir	1.2	30	593	6

Mechanical properties of hemp fibers are also compared with polypropylene (PP) fibers and high density polyethylene (HDPE) fibers in Table 2 (Ku et al. 2011).

Table 2. Comparison of mechanical properties of Hemp fibers with synthetic fibers

Fiber Type	Density (g/cm^3)	Elongation (%)	Tensile Strength (MPa)	Elasticity Modulus (GPa)
Hemp	1.47	4	690	70
PP	0.899-0.920	15-700	26-41.4	0.95-1.77
HDPE	0.94-0.96	2-130	14.5-38	0.4-1.5

It is clear from Table 2 that, hemp fibers have better mechanical strength than synthetic fibers as well. Therefore, hemp fibers can be used for production of natural geotextiles. Similar conclusions have been drawn by Ouagne et al. (2017). Hemp yarns found to have higher mechanical properties than flax yarns. When hemp yarns subjected to cellulase or bacterial attacks, hemp yarns strength were measured 2 times of coir yarns and tensile modulus was measured 3 times more than coir yarns. When hemp yarns are protected by chitosan, hemp yarns did not show significant strength and young modulus loss. Therefore, authors stated that, hemp can be used to produce geotextiles. Gregoire et al. (2021) investigated effect of hemp fiber production methods and effect of production method to mechanical properties of hemp fibers. It is reported in this study that, production method influences mechanical properties of hemp fibers. The lowest tensile strength and tensile modulus are measured as 500 MPa and 30 GPa respectively. It is concluded in this study that the hemp can produce long fibers and those fibers can be used in load bearing composites. Gregoire et al. (2020) used different process parameters to produce hemp fibers and evaluated mechanical properties. Therefore, production method that provides the highest mechanical properties is determined in this study. It is seen in this study that, the highest tensile strength and modulus is measured for raw hemp fibers, while as the process steps increases those measured properties decreases due to kinks occur during process. It is concluded in this study that, fibers from hemp can be used to produce load bearing geotextiles.

As can be seen from the literature, hemp fibers can be used to produce geotextiles. There is another aspect to be considered regarding hemp which is its environmental effects. Therefore, properties such as required amount of water to produce, CO2 footprint for primary production and fabric production, and required fabric production energy should be compared with other natural fibers. This comparison may be seen on Table 3.

Table 3. Eco-Properties of Hemp, Coir and Jute Fibers (Ashby, 2013)

Fiber Type	Embodied Energy, Primary Production (MJ/kg)	CO_2 footprint for primary production (kg/kg)	Water Usage (L/kg)	Fabric Production Energy (MJ/kg)	Fabric Production CO_2 Footprint (kg/kg)	Net Heat of Combustion (MJ/kg)	Combustion CO_2 (kg/kg)
Hemp	10-12	0.37-0.41	2,900-3,250	2.48-2.73	0.198-0.218	17-17.9	1.39-1.46
Coir	7.2-7.96	0.427-0.472	2,320-3,100	2.48-2.73	0.198-0.218	14.2-14.9	1.39-1.46
Jute	30-33	1.2-1.4	2,680-3700	2.48-2.73	0.198-0.218	16.9-17.7	1.39-1.46

It is clear from Table 3 that the coir requires the least energy to produce. It can also be said that there is insignificance difference between hemp and coir fibers for required energy to produce. However, jute requires three times more energy than hemp and coir. Although there is an insignificant difference with coir, CO2 footprint of hemp is the lowest. Required fabric production energy and fabric production CO2 is equal for all fibers. It can be concluded that, hemp geotextiles can definitely replace jute geotextiles and can be a good alternative for coir geotextiles.

CONCLUSION

This study primarily focusses on natural geotextiles considering where they are used, how they contribute to soil's shear strength, which processes are employed to prevent from bio-degradation. After that, hemp fibers are taken into consideration as an alternative fiber to produce geotextile. Following conclusions can be drawn from this study.

- Amount of natural fibers used to produce natural geotextiles increases day by day.
- Natural geotextiles increase bearing capacity of foundations.
- Natural geotextiles increase CBR of road bases.
- Natural geotextile degrades by time. Degradation differs if it is measured in field or laboratory. Natural geotextiles subjected to laboratory soil burial tests degrade faster than those buried in the field.
- Degradation of natural fibers can be slowed down by coating natural geotextile with natural and chemical substances.
- Hemp fibers shows better mechanical properties than coir fibers even after degradation.
- Although, coir and jute fibers are mostly used in geotechnical applications, hemp fiber's mechanical properties are superior to them. Therefore, hemp fiber can be an alternative to coir and jute fibers to geotextile production.
- Hemp fibers show better environment friendly properties than jute fibers, while it is estimated that, hemp is estimated as environmental friendly as coir fiber. However, since hemp fibers are superior in mechanical properties, it could still be a better option for geotextile production.

From the conclusions given above, it can be said that the hemp fibers will be a better option to produce geotextiles in the future.

REFERENCES

ASTM D4439-23 (2023). Standard Terminology for Geosynthetics

Koerner, R.M. (2005). *Designing with Geosynthetics 5th Edition*; New Jersey: Pearson Prentice Hall.

Shukla, S.K., Yin, J. H. (2006). *Fundamentals of Geosynthetic Engineering*; Leiden: Taylor&Francis

Rawal, A., Anandjiwala, R. (2007). *Comparative study between needlepunched nonwoven geotextile structures made from flax and polyester fibres.* Geotextiles and Geomembranes 25. 61 – 65

Shirazi, M.G., Rashid, A.S.A., Nazir, R.B., Rashid, A. H. A., Kassim, A., Horpibulsuk, S. (2019). *Investigation of tensile strength on alkaline treated and untreated kenaf geotextile under dry and wet conditions*. Geotextiles and Geomembranes 47. 522 – 529.

Alajmi, A., Abousnina, R., Shalwan, A., Alajmi, S., Alipour, G., Tafsirojjaman, T., Will, G. (2022). *An Experimental and Numerical Investigation into the Durability of Fibre/Polymer Composites with Synthetic and Natural Fibres.* Polymers 14.

Lal, D., Sankar, N., Chandrakaran, S. (2017). *Effect of reinforcement form on the behaviour of coir geotextile reinforced sand beds.* Soils and Foundations 57. 227 – 236.

Chakravarthy, G.S., GuhaRay, A., Kar, A. (2021). *Effect of soil burial exposure on durability of alkali-activated binder-treated jute geotextile*. Innovative Infrastructure Solutions 6:62.

Subaida, E.A., Chandrakaran, S., Sankar, N. (2009). *Laboratory performance of unpaved roads reinforced with woven coir geotextiles.* Geotextiles and Geomembranes 27. 204 – 210.

Anusudha, V., Sunitha, V., Mathew, S. (2020). *Evaluation of Coir Geotextile Reinforcement for Low-Volume Roads*. Journal of Natural Fibers.

Subaida, E.A., Chandrakaran, S., Sankar, N. (2008). *Experimental investigations on tensile and pullout behavior of woven coir geotextiles*. Geotextiles and Geomembranes 26. 384 – 392.

Tiwari, N., Satyam, N. (2020). *An experimental study on the behavior of lime and silica fume treated coir geotextile reinforced expansive soil subgrade*. Engineering Science and Technology, an International Journal 23. 1214 – 1222.

Saikia, B.D., Gogoi, B., Gogoi K., (2019). *A Behavioural Study on Two Layered Flexible Pavement Reinforced with Coconut Coir*. Mat. In: Patel S., Solanki C.H., Reddy K.R., Shukla S.K. (eds) Proceedings of the Indian Geotechnical Conference.

Lekha, K.R., Kavitha, V. (2006). *Coir geotextile reinforced clay dykes for drainage of low-lying areas*. Geotextiles and Geomembranes 24. 38 – 51.

Vinod, P., Bhaskar, A.B. (2011). *Model studies on woven coir geotextile-reinforced sand bed*. Proceedings of the ICE – Ground Improvement.

Anusudha, V., Sunitha, V., Mathew, S. (2019). *Evaluation of Coir Geotextile Reinforcement for Low-Volume Roads*. Journal of Natural Fibers.

Sridhar, R., Prathapkumar, M.T. (2017) *Behaviour of model footing resting on sand reinforced with number of layers of coir geotextile*. Innovative Infrastructure Solutions 2:50.

Singh, M., Sachin, K., Kunal, J., Singh, S.K. (2021). *Effect on CBR Values with Addition of Coir Geotextile and Marble Dust in Silty Sands*. IOP Conference Series: Earth and Environmental Science.

Beena, K.S., Babu, K. (2008). *Testing coir geotextile drains for soft ground improvement*. Proceedings of The Ice - Ground Improvement 161. 43 – 49.

Basu, G., Roy, A.N., Bhattacharyya, S.K., Ghosh, S.K. (2009). *Construction of unpaved rural road using jute–synthetic blended woven geotextile – A case study*. Geotextiles and Geomembranes 27. 506 – 512.

Bera, A.K., Chandra, S.N., Ghosh, A., Ghosh, A. (2009). *Unconfined compressive strength of fly ash reinforced with jute geotextiles*. Geotextiles and Geomembranes 27. 391 – 398.

Rawal, A., Sayeed, M.M.A. (2013). *Mechanical properties and damage analysis of jute/polypropylene hybrid nonwoven geotextiles*. Geotextiles and Geomembranes 37. 54 – 60.

Basu, G., Roy, A.N., Sanyal, P., Mitra, K., Mishra, L., Ghosh, S.K. (2019). *Bioengineering of river earth embankment using natural fibre-based composite-structured geotextiles*. Geotextiles and Geomembranes 47. 493 – 501.

Buragadda, V., Thyagaraj, T. (2019). *Bearing Capacity of Jute Geotextile-Reinforced Sand Bed*. International Journal of Geosynthetics and Ground Engineering 5:27.

Muthukumar, S., Sakthivelu, A., Shanmugasundaram, K., Mahendran, N., Ravichandran, V. (2019). *Performance Assessment of Square Footing on Jute Geocell-Reinforced Sand*. International Journal of Geosynthetics and Ground Engineering 5:25.

Gupta, S., GuhaRay, A., Kar, A., Komaravolu, V.P. (2021). *Performance of alkali-activated binder-treated jute geotextile as reinforcement for subgrade stabilization*. International Journal of Geotechnical Engineering 15:3. 299 – 312.

Midha, V.K., Joshi, S., Kumar, S.S. (2017). *Performance of Chemically Treated Jute Geotextile in Unpaved Roads at Different in situ Conditions*. J. Inst. Eng. India Ser. E 98. 47 – 54.

Mwasha, A., Petersen, A. (2010). *Thinking outside the box: The time dependent behaviour of a reinforced embankment on soft soil*. Materials and Design 31. 2360 – 2367.

Saha, P., Roy, D., Manna, S., Adhikari, B., Sen, R., Roy, S. (2012). *Durability of transesterified jute geotextiles*. Geotextiles and Geomembranes 35. 69 – 75.

Marques, A.R., Patricio, P.S.O., Santos, F.S.S., Monteiro, M.L., Urashima, D.C., Rodrigues, C.S. (2014). *Effects of the climatic conditions of the southeastern Brazil on degradation the fibers of coir-geotextile: Evaluation of mechanical and structural properties*. Geotextiles and Geomembranes 42. 76 – 82.

Joshi, S., Midha, V.K. (2022). *CA-Chitosan effect on the time dependent serviceability of jute geotextile under unpaved roads*. Journal of Natural Fibers 19:9. 3475 – 3484.

Chakravarthy, G.S., GuhaRay, A., Kar, A. (2021). *Experimental Investigations on Strength and Durability of Alkali-Activated Binder-Treated Natural Jute Geotextile*. International Journal of Geosynthetics and Ground Engineering 7:97.

Ghosh, S.K., Gupta, K.R., Bhattacharyya, R., Sahu, R.B., Mandol, S. (2014). *Improvement of Life Expectancy of Jute Based Needlepunched Geotextiles Through Bitumen Treatment*. J. Inst. Eng. India Ser. E 95. 111 – 121.

Khan, S.U., Bar, M., Evon, P., Labonne, L., Ouagne, P. (2022). *Development of 100% Linseed Flax Yarns with Improved Mechanical Properties and Durability for Geotextiles Applications*. Fibers 10:12.

Renouard, S., Hano, C., Ouagne, P., Doussot, J., Blondeau, JP.,Laine, E. (2017). *Cellulose coating and chelation of antibacterial compounds for the protection of flax yarns against natural soil degradation*. Polymer Degradation and Stability 138. 12 – 17.

Renouard, S., Hano, C., Ouagne, P., Blondeau, JP., Laine, E. (2014). *Protection of flax fiber-based yarns against natural soil degradation by chitosan*. Materials Letters 137. 269 – 273.

Vivek, Dutta, R.K., Parti, R. (2019). *Application Potential of Treated Coir Geotextiles in Unpaved Roads*. Journal of Natural Fibers.

Sayida, M.K., Evangeline, S., Vijayan, A., Girish, M.S. (2020). *Durability Study of Coir Geotextile Embedded in Different Types of Subgrade Soil*. Journal of Natural Fibers 19:6. 2288 – 2298.

Thakur, R.N., Gupta, S.K., Sinha, A., Chawla, S., Vadavadagi, S.S. (2021). *A Durability Study of Jute Geotextile Treated with Bitumen Emulsion*. Journal of Natural Fibers 18:3. 400 – 418.

Sumi, S., Unnikrishnan, N., Mathew, L. (2018). *Durability studies of surface-modified coir geotextiles*. Geotextiles and Geomembranes 46. 699 – 706.

Peev, P.I. (2012). *Is industrial hemp a sustainable construction material?* 7th semester elective assignment, VIA University College, Horsens, Denmark.

Karakaya, E. (2021). *Kenevir liflerinin ekolojik ön terbiyesi*. Yüksek Lisans Tezi, Kayseri: Erciyes Üniversitesi, Fen Bilimleri Enstitüsü.

Mangut, M., Karahan, N. (2011). *Tekstil Lifleri*. Bursa: Ekin Kitabevi, 4. Baskı

Hao, L.C., Sapuan, S.M., Hassan, M.R., Sheltami, R.M. (2018). *Natural fiber reinforced vinyl polymer composites*. Natural Fibre Reinforced Vinyl Ester and Vinyl Polymer Composites 27 – 70.

Ku, H., Wang, H., Pattarachaiyakoop, N., Trada, M. (2011). *A review on the tensile properties of natural fiber reinforced polymer composites*. Compos. Part B Eng. 42. 856 – 873.

Ouagne, P., Renouard, S., Michel, D., Laine, E. (2017). *Mechanical properties of flax and hemp yarns designed for the manufacturing of geo textiles. Improvement of the resistance to soil born microorganisms*. Journal of Textile Engineering & Fashion Technology 1(5).

Gregoire, M., Bar, M., De Luycker, E., Musio, S., Amaducci, S., Gabrion, X., Placet, V., Ouagne, P. (2021). *Comparing flax and hemp fibres yield and mechanical properties after scutching/hackling processing*. Industrial Corps & Products 72.

Gregoire, M., Barthod-Malat, B., Labonne, L., Evon, P., De Luycker, E., Ouagne, P. (2020). *Investigation of the potential of hemp fibre straws harvested using a combine machine for the production of technical load-bearing textiles*. Industrial Corps & Products 145.

Ashby, M. (2013). *Materials and the Environment 2nd Edition*. Oxford:Elsevier.

EXTENSIVE POWER OF COMMON AGRICULTURAL POLICY AND HEMP PRODUCTION IN EUROPEAN UNION: CASE OF FRANCE AND MAKING A CONTRIBUTION TO THE EUROPEAN GREEN DEAL OBJECTIVES

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Abstract

The Common Agricultural Policy (CAP) of the European Union (EU) focuses on pivotal issues surrounding the environment, the countryside, and the food. What is more, the CAP is the result of a successful partnership between the society, the environment, and the agriculture, which targets numerous vital aspects, such as: first of all, ensuring a stable supply of food, for the benefit of the individuals and the communities; second of all, supporting the farmers and finding solutions to boost their income, hence centering on encouraging more people to come and join these groups of people working in agriculture; third of all, keeping the rural areas attractive, sustainable, and vibrant, with the desire to promote at the highest levels possible the Sustainable Development Goals (SDGs); and, fourth of all, protecting the environment which implicates respect for biodiversity, great concern for ecosystems, solidarity, and support for innovating for sustainable growth. Furthermore, the current research is dedicated to analyzing today's situation of the Hemp Production in EU, while highlighting the tremendous benefits of Hemp for the EU sustainability and sustainable development. At a general level, the paper presents the immense opportunities that the Hemp Production offers to the farmers, the consumers, and the industrial sectors, mainly placing the accent on the solutions that Hemp Cultivation brings to the success of the European Green Deal Objectives. At a particular level, the current scientific work sheds a new light on the case of France – one of the largest Hemp producers in Europe, while addressing the economic situation of the top Hemp cultivating countries, namely: Canada, China, France, and United States of America (USA). One of the major objectives of this research is to focus on the great environmental effects of growing Hemp, which also reside in crucial economic benefits, given the fact that this activity is seen as an environmentally friendly one.

Keywords: Hemp; Common Agricultural Policy (CAP); Sustainable Development Goals (SDGs); Crop Rotation Patterns; Improving Health; Supporting Local Wild Plants; Sustainable Waterways; Improving Local Soil Quality; Higher Quality Harvests; Organic Growth.

INTRODUCTION

In this day and age, sustainability and sustainable development are playing crucial roles in the society (Popescu, 2023). In addition, the Sustainable Development Goals (SDGs) have shown, on far too numerous occasions until present days, the opportunities they bring to the society as a whole and the chances that they bring for a better and a safer future for all (Popescu, 2022a). In essence, it is of utmost importance for people and communities to finally understand that there is absolutely nothing more precious than health itself, peace of mind, and a clean conscious (Popescu, 2022b); additionally, in the same given context, it is of paramount necessity to finally realize that even though medicine and science have evolved rapidly and great advancements have been made in all areas in the last decades, health cannot be bought and the initial state of being (the initial state of health) once disrupted and affected (in terms of health and well-being) may only be slightly supported towards more positive outcomes, but never fully restore (never brought to the initial state of being, once affected and disrupted) (Popescu, 2022e). Besides all these, although the society and the economy have evolved at such a fast pace over the last years, it should also be acknowledged that the achievements and the developments made are not necessary in a good way and do not necessarily reflect positive effects on the people and on the environment (Popescu *et al.*, 2017). On the one hand, there is the pivotal need to address the pressing case of individuals' and communities' happiness, health, mental health, and well-being, given the importance that happiness, health, mental health, and well-being play in these days social and economic context (Wernicke, 2021). On the other hand, there is the paramount necessity to consider the health of the environment as well as the situation of ecofriendly activities and actions meant to contribute to the preservation of the resources, the biodiversity, and the ecosystems (Trbojević-Ivić, 2023). What is more, each and every time the individuals, the communities, and the environment interact the outcomes targeted should reflect care towards the Planet as well as great respect towards nature and natural habitats (Thoron & Barrick, 2023). Furthermore, it is high time to acknowledge that every single activity and every single action performed by people will sooner or later influence the environment and will ultimately be reflected one way or another in the happiness, health, mental health, and well-being status of individuals and communities (Simonovic & Vukovic, 2020). Unfortunately, today it has become clear that all those wrong decisions and/or all those steps taken without really considering the medium-term and the long-term effects of the human actions and the human activities on the Planet have ultimately come to hunt the present generations and will for sure be of great concern and worry for the future generations to come (Popescu *et al.*, 2015b).

In continuation to all the aforementioned aspects and ideas that were highlighted in the lines above, today the Common Agricultural Policy (CAP) of the European Union (EU) focuses on pivotal issues surrounding the environment, the countryside, and the food. Besides all these, there are vital connections between the success of the SDGs and the pillars and the principles that may be encountered at the basis of the CAP of the EU (Popescu & Popescu, 2019b). What is more, the CAP is the result of a successful partnership between the society, the environment, and the agriculture, which targets numerous vital aspects, such as: (a) first of all, ensuring a stable supply of food, for the benefit of the individuals and the communities; (b) second of all, supporting the farmers and finding solutions to boost their income, hence centering on encouraging more people to come and join these groups of people working in agriculture; (c) third of all, keeping the rural areas attractive, sustainable, and vibrant, with the desire to promote at the highest levels possible the SDGs; and, (d) fourth of all, protecting the environment which implicates respect for biodiversity, great concern for ecosystems, solidarity, and support for innovating for sustainable growth. Furthermore, the current research is dedicated to analyzing today's situation of the Hemp Production in EU, while highlighting the tremendous benefits of Hemp for the EU sustainability and sustainable development. At a general level, the paper presents the immense opportunities that the Hemp Production offers to the farmers, the consumers, and the industrial sectors, mainly placing the accent on the solutions that Hemp Cultivation brings to the success of the European Green Deal Objectives. At a particular level, the current scientific work sheds a new light on the case of France – one of the largest Hemp producers in Europe, while addressing the economic situation of the top Hemp cultivating countries, namely: Canada, China, France, and United States of America (USA). One of the major objectives of this research is to focus on the great environmental effects of growing Hemp, which also reside in crucial economic benefits, given the fact that this activity is seen as an environmentally friendly one.

In the history of mankind, there are far too numerous cases in which the environment has come to claim those zones that were once inhabited regions, those once prosperous regions and/or those areas which were strongly industrialized and/or where people's dwellings were found (Popescu, 2019). In essence, it ought to be emphasized that nature has always had the power to reclaim those areas once lost and to which individuals and communities have brought changes and which were transformed by humans for their economic, financial, and social purposes (Fathelrahman *et al.*, 2023). These can easily demonstrate the fact that nature has the great capacity to regenerate, it is capable to reclaim its resources and produce new ones, it possesses an immense capacity to heal and reinvent itself, and it represents a positive example of reassessing and reshaping itself depending on the circumstances (Garzilli *et al.*, 2020). First of all, a very interesting case in this matter is the one of a small Chinese fishing village named Houtouwan which was abandoned in the 1990s primarily due to its isolation from the mainland and which was reclaimed by nature with absolutely marvelous results (World Natural Heritage Nomination (WNHN) & United Nations Educational, Scientific and Cultural Organization (UNESCO), 2007). Second of all, the Angkor Archeological Park Ta Prohm in Cambodia fosters the Ta Prohm temple – which was initially known as RaJavihara (royal temple), where nature successfully reclaimed the territory and where today can be seen beautiful and gigantic trees, such as figs, banyans and kapok trees together with animals that are thriving in the nearby forests among which could be mentioned the muntjac deer, the wild boar, the leopard cats, the pileated gibbons, the silvered langurs, the smooth-coated otters, the hornbills, and the green peafowls (Authority for the Protection of the Site and Management of the Region of Angkor (APSARA or the APSARA National Authority), 2021). Interestingly, today there are numerous valuable documentaries on this particular subject and among them could be mentioned the highly captivating, extremely fascinating, and by far spellbinding documentary series very suggestively entitled Abandoned Engineering (Like a Shot Entertainment (Production Company), 2016-present days).

There are several research questions (RQ) that were chosen for this current scientific research, as follows: (a) first of all, (RQ1) targets what is hemp and what are the benefits of hemp and hemp production at a global level; (b) second of all, (RQ2) focuses on what is the power of the CAP and what are the advantages of the hemp production in the EU; and (c) third of all, (RQ3) has the intention to bring to light what is the case of France in terms of hemp and hemp production and what does making a contribution to the European Green Deal objectives in the case of France as well as in the case of other countries implicate. Also, there are several keywords or key concepts which are regarded as a main focus for this current scientific research paper, as seen in the lines below: hemp; Common Agricultural Policy (CAP); Sustainable Development Goals (SDGs); crop rotation patterns; improving health; supporting local wild plants; sustainable waterways; improving local soil quality; higher quality harvests; and organic growth.

This section represented by the introduction is followed by the conceptual framework, also known as the literature review section or the background section, the research and findings, the conclusion, and the references. It is believed that all these sections are vital for this current research and they all have the great power to show the importance and the novelty of the current scientific work performed.

CONCEPTUAL FRAMEWORK

This particular section which is represented by the conceptual framework, also known as the literature review section or the background section, having a pivotal role for the current scientific research due to the fact that it sheds a new light on several key concepts and major connections, such as: the Common Agricultural Policy (CAP) of the European Union (EU); the importance and the role of the CAP as the result of a successful partnership between the society, the environment, and the agriculture, which targets numerous vital aspects which are paramount in today's context; and the benefits of Hemp and the Hemp Production in the EU and at a global level.

First of all, it ought to be highlighted that the EU Member States are extremely preoccupied with the health and preservation of the environment, focusing ever since the beginning on creating a safer environment for all, while seeking solutions in terms of better protecting the environment with the aid of the circular economy (Council of the European Union & European Parliament, 2024). What is more, due to the fact that recent studies have shown on numerous occasions the alarming levels of pollution, the EU Member States have successfully implemented over the years numerous rules and regulations transposed, for example, in the form of Directives, which are intended to set limits of pollution as well as to find alternative solutions to the use of resources and industries believed to have caused the disastrous climatically situation in which humankind finds itself today (Akkaya, 2024; Directorate-General for Environment (European Commission) & European Commission, 2024; European Union, 2024).

Second of all, the CAP is highly centered on supporting the farmers and on ensuring Europe's food security, in times in which the SDGs play a vital role in fostering equality, while striving to ensure that everyone will have access to resources and will be able to enjoy peace and prosperity (Committee on Agriculture and Rural Development (EP Committee) *et al.*, 2024; Directorate-General for Health and Food Safety (European Commission) & European Commission, 2024a, 2024b). Moreover, the CAP was launched in 1962 and represents a bold and a vital partnership, on the one hand, between agriculture and society, and, on the other hand, between Europe and the Europe's farmers (European Commission & Directorate-General for Agriculture and Rural Development, 2024a, 2024b, 2024c; European Commission *et al*, 2024). Furthermore, the aims of the CAP are displayed in the lines below, as follows: (a) providing support to farmers and help the enhancement of agricultural productivity, essentially targeting a stable supply of food that ought to be affordable; (b) safeguarding Europe's farmers in a way in which these people will be able to reasonable living, hence being determined to continue their existence and continue working in agriculture; (c) helping tackle climate change as well as finding solutions capable to sustainably manage the natural resources; (d) maintaining the rural areas and the landscapes across the EU, so that agriculture will continue supporting life in EU and even help increase the standards of living in Europe with the help of agriculture, while caring for the environment; and (e) keeping the rural economy alive by opening and by promoting the already existing jobs in farming, agri-food industry, and other associated and important sectors which are pivotal to agriculture (European Commission & Directorate-General for Agriculture and Rural Development, 2017b, 2012, 2021; European Commission & Directorate-General for Communication, 2017a, 2018).

Third of all, a very powerful example in terms of Hemp Cultivation and Hemp Production is offered by China, given the fact that these days China is the world's largest producer of hemp, having a long and an extensive tradition in this regard, thus playing a key role due to its significant position occupied as major global hemp producer. In addition, it ought to be mentioned that Hemp Cultivation and Hemp Production can vary due to several pivotal factors among which could be emphasized the following crucial ones: agricultural methods and practices, regulations, and market demand in different countries (Akroush *et al.*, 2020; Ajaz *et al.*, 2024; Bashir & Bashir, 2023; Byrd *et al.*, 2024).

In the lines below the Table no. 1: Hemp Production in EU, while Highlighting the Tremendous Benefits of Hemp for the EU Sustainability and Sustainable Development, is placed in order to bring to the attention the vital role played by hemp and hemp production in EU as well as the advantages and the benefits hemp and hemp production which are capable to strengthen the position played by EU sustainability and sustainable development at the very core of the SDGs.

Table no. 1: Hemp Production in EU, while Highlighting the Tremendous Benefits of Hemp for the EU Sustainability and Sustainable Development

Hemp Production in EU	**Highlighting the Tremendous Benefits of Hemp for the EU Sustainability and Sustainable Development**
Hemp Production in the EU, with up-to-date general figures: Hemp Production in the EU is regarded as vital and, according to most recent figures, "the area dedicated to Hemp Cultivation has increased significantly in the EU from 20,540 hectares (ha) in 2015 to 33,020 ha in 2022" (which is regarded as a 60% increase while compared with the area dedicated to Hemp Cultivation in the year 2015) (European Commission, 2024; European Commission & Directorate-General for Agriculture and Rural Development, 2022a, 2022b, 2023);	Hemp represents a crop grown across Europe which brings numerous advantages to the society and the environment (Obayelu & Ayansina, 2022); A key example is the following one: Hemp's Nutritional Benefits are worldwide known due to the plant's richness in magnesium, phosphorus, potassium, iron, and zinc as well as the plant's abundance in vitamins B and E, which implicate that Hemp Seeds protect the brain and help with certain neurological conditions, such as Alzheimer's disease and Parkinson's disease (Dali, 2023; General Court (Court of Justice of the European Union), 2024; Grant, 2023; Gwala, 2023);
Hemp Production in the EU, with up-to-date figures showing the growth per country: According to the most recent data, between 2015 and 2022, "the production of hemp increased from 97,130 tons to 179,020 tons" (which represents, in essence, an 84.3% increase from 2015 to 2022); In addition, "France is the largest producer, accounting for more than 60% of EU production, followed by Germany (17%) and The Netherlands (5%)", which places France on a key position while compared to other global competitors, such as the top Hemp cultivating countries, namely: Canada, China, France, and United States of America (USA) (European Commission, 2024; European Commission & Directorate-General for Agriculture and Rural Development, 2022a, 2022b, 2023; Satapathy, 2020);	Another example: Hemp Seeds are abundant in vitamins, minerals, and nutrients which can provide significant health benefits in the following areas: (a) the immune system his helped by Hemp Oil which is rich in vitamin E; and (b) the body cell damage is slowed down or even stopped when the body consumes Hemp Oil which is also rich in antioxidants, which help reduce free radicals (European Commission & Directorate-General for Agriculture and Rural Development, 2000, 2011; European Commission *et al.*, 2024; Sharma *et al.*, 2023); Another example: The Hemp Plants have the ability to grow in soils poor in nutrients and have the potential to sequester carbon due to the dense canopy and the rapid growth, being more efficient than trees to sequester carbon and to produce, in turn, oxygen (Australian Government & Parliament of Australia, 2024; United Kingdom Government, 2022).
Hemp has numerous usages, such as: (a) is used to make a variety of commercial and industrial products, among which could be brought to the attention biofuel, bio-plastics, clothing, food, insulation, paper, ropes, shoes, and textiles; (b) it is a healthy addition to people's diet and as food (for instance, eating Hemp Seeds) has numerous advantages to those consuming it as long as the consumption process is done wisely, based on the fact that is high in calories and fat; and (c) Hemp Seeds consumption may interfere with some medication, which requires caution when deciding to be eaten on a regular basis (European Commission, Directorate-General for Research and Innovation, Knudsen *et al.*, 2024; European Commission & Directorate-General for Regional and Urban Policy, 2023; European Commission & European Innovation Council and SMEs Executive Agency *et al.*, 2024a; 2024b; European Commission & European Research Executive Agency, 2024; Popescu, 2017, 2022f, 2021a).	Another major example supporting the SDGs: Hemp is believed to have the capacity even eradicate deforestation and reduce carbon emissions, based on the fact that Hemp Plants have the ability to absorb at a rapid pace CO_2 from the air. The studies have shown that Hemp can capture carbon from the air and has the capacity to store it in biomass and in the soil. What is more, these researches have highlighted that the majority of the carbon is retained in the woody parts of the Hemp plant's stem which is known as "hurd", hence one hectare of Industrial Hemp can successfully absorb up to 22 tons of CO_2 per hectare. Also, it is vital to acknowledge that Hemp Plants produce a lot of oxygen since they abundance of leaves and they have a very quick growth process: one acre of hemp is known to be able to produce as much as 25 acres of forest (Australian Government & Parliament of Australia, 2024; Farooque & Abbas, 2021; Filiz Baştürk, 2023; United Kingdom Government, 2022).

Source: The Author' Own Elaboration, Based on the References Highlighted in the Table and in the Bibliography Section

In the lines below the Table no. 2: Understanding the Immense Opportunities that Hemp Production Offers to Farmers, Consumers, and Industrial Sectors, and Underlining the Solutions that Hemp Cultivation Brings to the Success of the European Green Deal Objectives points out the existing reasons why hemp production and hemp cultivation make a substantial contribution to the European Green Deal objectives.

Table no. 2: Understanding the Immense Opportunities that Hemp Production Offers to Farmers, Consumers, and Industrial Sectors, and Underlining the Solutions that Hemp Cultivation Brings to the Success of the European Green Deal Objectives

Immense Opportunities offered by Hemp Production and Paramount Solutions featured by Hemp Cultivation	**Moving towards the European Green Deal Objectives**
Hemp has numerous environmental benefits, such as, for example, those in terms of carbon storage:	According to recent data, "one hectare of hemp sequesters 9 to 15 tons of CO_2", which is believed by scientists to be "similar to the amount sequestered by a young forest"; also, hemp "only takes five months to grow", unlike other plants, especially the trees (Carikci, 2022; Erdem & Doğan, 2023; European Commission, 2024; European Commission, Joint Research Centre *et al.*, 2023a, 2023b); Biodiversity and ecosystems are crucial to the existence of humankind; hence, in this particular case, hemp has pivotal benefits to biodiversity, as follows: the flowering cycle of hemp plants "usually occurs between July and September, coinciding with a lack of pollen production from other crops", leading to the fact that, on the one hand, "hemp produces large amounts of pollen" and, on the other hand, hemp "provides shelter for birds and hemp seeds are a food for animals" (European Commission, 2024; European University Institute & Giorgio, 2024; Koshariya *et al.*, 2023; Jain *et al.*, 2023; Joint Research Centre, Institute for Prospective Technological Studies, Lefebvre *et al.*, 2012);
Hemp has numerous benefits for the people and the Planet, such as, for example, those in terms of breaking the cycle of diseases:	It has been demonstrated that hemp helps to break the cycle of diseases in those circumstances in which it is used in crop rotation, hence helping both individuals and the Planet, since it helps the preservation of soil, improves the area, and is then used by people in their day-to-day activities (European Commission, Joint Research Centre *et al.*, 2021, 2019; European Commission, 2024); In addition to the aforementioned ideas, it has been pointed out that the weeds are not able to grow, on the one hand, due to the fast growth of hemp plants and, on the other hand, due to the impressive shading capacity of hemp plants (European Committee of the Regions, 2024a-f; European Court of Auditors, 2023; European Commission, 2024);
Hemp is extremely important when addressing the sensible case of soil erosion prevention as well as the ability to grow with the aid of low or even no use of pesticides.	Soil erosion represent a very serious issue, especially in some regions severely affected by floods and gravely marked by abundant water due to heavy rain and other unforeseen methodological phenomenon; hemp is "a natural soil cover, reducing water loss and protecting against soil erosion" and, also, hemp is less affected by pests due to "the lack of natural predators", which implicates "that the use of insecticides, herbicides, and fungicides" is not really required, in this way ensuring better cultivating and production conditions for hemp (European Monitoring Centre for Drugs and Drug Addiction, Europol, 2024; European Parliament, Directorate-General for Parliamentary Research Services *et al.*, 2024a, 2024b; European Commission, 2024).

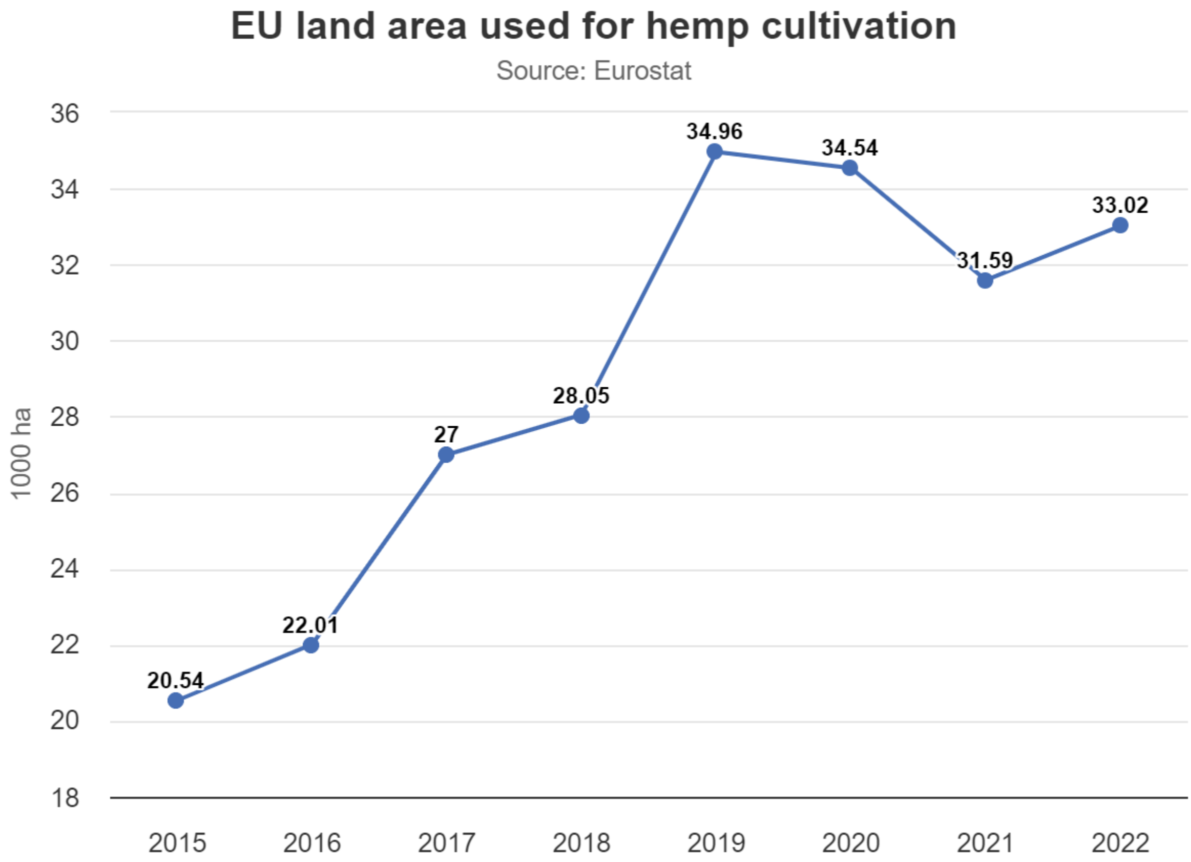
Source: The Author' Own Elaboration, Based on the References Highlighted in the Table and in the Bibliography Section

When referring to hemp and biodiversity, it needs to be pointed out that hemp boosts biodiversity and, also, hemp enables ecosystems health. As seen in the lines above, hemp plays a crucial role in terms of fostering homes for birds and offering a peaceful and nurturing habitat for small animals. Additionally, hemp plants are very important for the soils and water's health: these plants excel at phytoremediation which means that they have huge powers to absorb and to neutralize toxins from the soil and from the water. All in all, it needs to be remembered that fostering soil biodiversity is highly important in this day and age, given the high levels of pollution all around the world, which implicates that hemp plants have the capacity to detoxify the land and create a more welcoming environment for a wide variety of organisms – hence, promoting life, seeking well-being and a healthy environment, and fostering healthier environments for all.

Additionally, fortunately almost the entire body of the hemp plant can be used these days, which means that the hemp plant may be used in a large variety of activities, having wide arias of utility, such as the following major ones: the hemp plant can be used in the industrial production of food; the hemp plant may be a valuable source of fiber; and, the hemp plant might serve as a great construction material, being safe for the environment as well as for the individuals and the communities, unlike other construction materials that have controversial histories. In terms of construction materials that have controversial histories a notable example – and, by far, not the only one example available – is based on the European Environment Agency (EEA) data: several EU Member States have banned Asbestos in the 1990's, while Asbestos has been banned in the EU since 2005, given the fact that according to extensive studies it has been displayed that all forms of Asbestos are known carcinogens leading mainly (but not only) to mesothelioma, asbestos-related lung cancer, and asbestosis (European Environment Agency (EEA), 2022).

In the lines below there is Figure no. 1: EU Land Area Used for Hemp Cultivation, During the Years 2015-2022 which is based on EUROSTAT data gathered between the years 2015-2022. Based on the figure below, it can be remarked that EU land area used for hemp cultivation reached a peak in 2019 afterwards slowly declining until 2021 and later on registering an increase between 2021 and 2022 due to the immense potential that hemp offers in terms of health as well as industrial use.

Figure no. 1: EU Land Area Used for Hemp Cultivation, During the Years 2015-2022



Source: European Commission based on Agriculture and Rural Development, the document on Hemp and Hemp production in the EU (European Commission, 2024, which makes reference to EUROSTAT data)

RESEARCH AND FINDINGS

This particular section which is represented by the research and findings sheds a new light on the importance of the hemp plants, the hemp cultivation, and the hemp production. Essentially, it needs to be brought to light that the hemp plant is a resilient and sustainable plant, having a vigorous growth, with the ability to successfully live in unfriendly environments, with heavily polluted water sources as well as not so nutritious soils. In addition, the hemp plant has a high industrial value and plays a crucial role in food processing chains.

When referring to hemp and biodiversity, it needs to be pointed out that hemp boosts biodiversity and, also, hemp enables ecosystems health. As seen in the lines above, hemp plays a crucial role in terms of fostering homes for birds and offering a peaceful and nurturing habitat for small animals. Additionally, hemp plants are very important for the soils and water's health: these plants excel at phytoremediation which means that they have huge powers to absorb and to neutralize toxins from the soil and from the water. All in all, it needs to be remembered that fostering soil biodiversity is highly important in this day and age, given the high levels of pollution all around the world, which implicates that hemp plants have the capacity to detoxify the land and create a more welcoming environment for a wide variety of organisms – hence, promoting life, seeking well-being and a healthy environment, and fostering healthier environments for all.

To begin with, ever since the beginning of mankind, there have been controversies and there still are controversies in using certain plants (Martinho, 2023; Nabi *et al.*, 2023a; Nabi *et al.*, 2023b). Of course, in some cases, these controversies might have been linked with the side effects of using certain plants in specific moments in time and in given circumstances (Popescu *et al.*, 2015a-2015e; Popescu *et al.*, 2014). Also, these controversies could have had their origins in some rituals that usually accompanied the use of these plants in specific cultures and in particular contexts, especially when associated with magical powers or apparently inexplicable phenomenon. The history of mankind is filled with such moments and such circumstances that have been associated with times of distress, times of worry, and times that called for action in a way in which individuals' mind was not able to cope with occasions of such grander and importance. Nevertheless, these controversies should not be linked with the history of hemp and the hemp production since the benefits of hemp have long been known ever since ancient Chinese practices. Besides these, the use of hemp for industrial benefits is worldwide acknowledged and known, while the properties of hemp products are renown all over the Globe and are highly praised by specialists. In addition, some specialists referred to in this current paper are going that far too even wonder how would the history of mankind looked in the absence of such beneficial plants for the health of the individuals, the communities, and the environment.

For instance, it needs to be brought to the attention the fact that, although they are small, hemp seeds (which have a hard exterior regarded as being nut-like as well as a soft interior which contain the "hemp hearts") and "hemp hearts" (which are the seed's soft-inside) are extremely precious for the human body and they have numerous benefits for people and among these benefits could be mentioned the following key ones: (a) first of all, hemp seeds and "hemp hearts" are known for their healing properties since they have the power to regenerate the skin and accelerate the healing of the skin, while hemp seeds are also highly beneficial for the brain since they protect the brain and feed the brain; (b) second of all, hemp seeds and "hemp hearts" have the capacity to boost heart health and are filled with protein, fiber, and health fatty acids – among which can be mentioned omega-3s and omega-6s; and (c) third of all, although they come from the Cannabis Sativa Plant these hemp seeds and "hemp hearts" do not produce mind-altering effects and they are extremely nutritional and rich in alpha-linoleic acid (ALA), gamma-linoleic acid (GLA), fiber, iron, magnesium, phosphorus, potassium, sodium, calcium, iron, zinc, vitamin E, minerals, and B vitamins, and so on. Likewise, for example, due to the fact that hemp seeds are so rich in fiber they help enormously people to regulate the bowel functions, to reduce the need to eat sugar and sweet products, and to reduce appetite due to their property to prolong the feeling of being sated. In the same time, another very important example of advantages of consuming hemp seeds is reflected in these lines below: due to the hemp seeds high content of gamma-linoleic acid (GLA), the symptoms of menopause and the Premenstrual syndrome (PMS) may be alleviated. The aspects presented in the lines above, in synthetic form, are just a few cases in which hemp and hemp production are becoming useful for people. However, besides all these elements, hemp and hemp production are highly beneficial for the environment. For instance, hemp has the capacity to absorb toxins, has the property to absorb heavy metals, and has the power to regenerate the environment and help the environment in the best way possible. That is the reason why hemp helps soil to regenerate and to gain its properties over the years and even to gain new properties when being used.

CONCLUSION

This part of this research study is dedicated to the conclusion and discussion section. This part of this paper is regarded as crucial by the author since it offers the opportunity to highlight the most important aspects that ought to be taken into consideration when analyzing the scientific work on "Extensive power of Common Agricultural Policy and hemp production in European

Union: Case of France and making a contribution to the European Green Deal objectives". In like manner, this study is extremely complex and has the power to shed a new light on the importance of hemp and hemp production not only in EU countries but also all around the Globe, having in mind that nature plays a special role in individuals' and communities' lives and day-to-day activities.

In the end, there is no wonder that there are even cases in which reputed specialists could ask themselves how life would look on Earth without plants having such healing and beneficial properties as hemp do (Quendler *et al.*, 2020; Popescu, 2022c; Popescu, 2022d; Popescu, 2021b; Popescu, 2021c; Popescu, 2020a-2020d; Popescu & Popescu, 2019a). In addition, the question could be extended to those situations in which researchers would ask themselves what new attributes could be soon associated with hemp and in what manner would hemp come to support health and well-being in the near future to come if new properties would be discovered over the next years with the aid of new technologies. Likewise, given the fact that there is such a fragile equilibrium between people's desire to have access to unimagined reaches although in so many cases useless, corporations' willingness to have the highest profits without considering the costs although in so many cases without clear justification and with no ethical and moral support whatsoever, and environment's utmost need to be preserved and avidly supported in order to be preserved and regenerated, there are always new and pressing issues to be taken into account and into consideration, such as, for instance: how should this equilibrium look like and how can it be obtained in order to be afterwards successfully maintained on the long-term; is there a viable reason why the health and the well-being of individuals and communities be sacrificed in the name of profitability and economic growth; and will the environment always have the capacity to regenerate each time in history when people and/or entities will fail to seek to preserve the nature, the natural habitats, the biodiversity, and the ecosystems or, in fact, at one moment in time an earthshattering event will finally help individuals and communities open their eyes and realize what is truly and ultimately important for them and the future generations to come – in the spirit of the SDGs and the CAP.

In the end, positioning the hemp plants in the spotlight – with the aid of this research paper, represents a marvelous idea and a paramount decision, based on the fact that by zeroing in on the benefits offered by cultivating and producing the hemp plants the attention will not only be placed on these particular plants but, also, on the great power that can be found in preserving the environment for the medium-term and long-term benefit of the Planet and the individuals and the communities.

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The Author declares that there are no conflicts of interest. The Author declares that has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this.

AUTHOR CONTRIBUTIONS

Conceptualization, Cristina Raluca Gh. Popescu (C.R.G.P.); methodology, C.R.G.P.; software, C.R.G.P.; validation, C.R.G.P.; formal analysis, C.R.G.P.; investigation, C.R.G.P.; resources, C.R.G.P.; data curation, C.R.G.P.; writing—original draft preparation, C.R.G.P.; writing—review and editing, C.R.G.P. The Author fully contributed to this manuscript. The Author has read and agreed to the published version of the manuscript.

REFERENCES

Akkaya, Ş. (2024). The European Union's Border Carbon Tax Regulation and Its Possible Effects on Turkey's Exports in the Short Term. In R. Castanho (Ed.), *Green Economy and Renewable Energy Transitions for Sustainable Development* (pp. 29-43). IGI Global. https://doi.org/10.4018/979-8-3693-1297-1.ch003.

Akroush, S. N., Dhehibi, B., & Aw-Hassan, A. (2020). Agricultural Growth Accounting and Total Factor Productivity in Jordan: Trends, Determinants, and Future Challenges. In I. Management Association (Ed.), *Environmental and Agricultural Informatics: Concepts, Methodologies, Tools, and Applications* (pp. 1709-1723). IGI Global. https://doi.org/10.4018/978-1-5225-9621-9.ch079.

Ajaz, M. A., Jamshaid, S., Ali, S., & Khan, K. S. (2024). Role of Green Corporate Social Responsibility and Corporate Social Responsibility in Enterprises: Evidence From Europe. In E. Shaikh (Ed.), *Strategies and Approaches of Corporate Social Responsibility Toward Multinational Enterprises* (pp. 242-262). IGI Global. https://doi.org/10.4018/979-8-3693-0363-4.ch014.

Australian Government & Parliament of Australia. (2024). The Role of Industrial Hemp in Carbon Farming. Name: James Vosper BSCHons, FRGS Company: GoodEarth Resources PTY Ltd (ABN 79 124 022 859). pp. 1-6.

Authority for the Protection of the Site and Management of the Region of Angkor (APSARA or the APSARA National Authority). (2021). Angkor Archeological Park Ta Prohm. Retrieved from: https://apsaraauthority.gov.kh/2021/08/12/ta-prohm/. Accessed on the 1st of May 2024.

Bashir, I. & Bashir, S. (2023). Historical Evolution of Cannabis sativa Transmogrifying Utilizations. In R. Lone, A. Mir, & J. Manzoor (Eds.), *Cannabis sativa Cultivation, Production, and Applications in Pharmaceuticals and Cosmetics* (pp. 29-42). IGI Global. https://doi.org/10.4018/978-1-6684-5718-4.ch002.

Byrd, A. P., Edgar, D. W., Granberry, T., & Anderson, R. G. (2024). Agricultural Mechanics in SBAE Teacher Preparation. In R. Barrick & A. Thoron (Eds.), *Emerging Research in Agricultural Teacher Education* (pp. 79-97). IGI Global. https://doi.org/10.4018/979-8-3693-2766-1.ch005.

Carikci, C. (2022). Green Economy Policies and Financing the Green New Deal. In Ş. Akkaya & B. Ergüder (Eds.), *Handbook of Research on Challenges in Public Economics in the Era of Globalization* (pp. 207-216). IGI Global. https://doi.org/10.4018/978-1-7998-9083-6.ch012.

Committee on Agriculture and Rural Development (EP Committee), Committee on Fisheries (EP Committee), European Parliament. (2024). P9_TA(2023)0375 – European protein strategy European Parliament resolution of 19 October 2023 European protein strategy (2023/2015(INI)). (2024). *Official Journal*, C 2657, ELI: http://data.europa.eu/eli/C/2024/2657/oj[legislation].

Council of the European Union, European Parliament. (2024). Regulation (EU) 2024/1157 of the European Parliament and of the Council of 11 April 2024 on shipments of waste, amending Regulations (EU) No 1257/2013 and (EU) 2020/1056 and repealing Regulation (EC) No 1013/2006Text with EEA relevance.. (2024). *Official Journal*, L 1157, ELI: http://data.europa.eu/eli/reg/2024/1157/oj[legislation].

Dali, T. P. (2023). Analysis of Lessons That Can Be Learnt by South African Government Leaders in Their Role in Advancements Within the Cannabis Industry of South Africa. In P. Mashau & J. Nyawo (Eds.), *Rapid Innovation and Development in the Global Cannabis Market* (pp. 159-175). IGI Global. https://doi.org/10.4018/978-1-6684-6346-8.ch009.

Directorate-General for Environment (European Commission), European Commission. (2024). Commission Implementing Decision (EU) 2024/367 of 23 January 2024 laying down rules for the application of Directive (EU) 2020/2184 of the European Parliament and of the Council by establishing the European positive lists of starting substances, compositions and constituents authorised for use in the manufacture of materials or products that come into contact with water intended for human consumption. (2024). *Official Journal*, L 367, ELI: http://data.europa.eu/eli/dec_impl/2024/367/oj[legislation].

Directorate-General for Health and Food Safety (European Commission), European Commission. (2024a). Commission Regulation (EU) 2024/1076 of 15 April 2024 amending Annexes II and V to Regulation (EC) No 396/2005 of the European Parliament and of the Council as regards maximum residue levels for bispyribac, metosulam, oryzalin, oxasulfuron and triazoxide in or on certain products. (2024). *Official Journal*, L 1076, ELI: http://data.europa.eu/eli/reg/2024/1076/oj[legislation].

Directorate-General for Health and Food Safety (European Commission), European Commission. (2024b). Commission Regulation (EU) 2024/1077 of 15 April 2024 amending Annex II to Regulation (EC) No 396/2005 of the European Parliament and of the Council as regards maximum residue levels for 2,4-DB, iodosulfuron-methyl, mesotrione and pyraflufen-ethyl in or on certain products. (2024). *Official Journal*, L 1077, ELI: http://data.europa.eu/eli/reg/2024/1077/oj[legislation].

Garzilli, F., Mazzarella, C., & Vittiglio, V. (2020). Integrated Approaches for Peri-Urban Wastescapes: Eco-Innovative Strategies of the REPAiR Project in the Naples Case Study. *International Journal of Urban Planning and Smart Cities (IJUPSC), 1*(2), 43-58. http://doi.org/10.4018/IJUPSC.2020070104.

General Court (Court of Justice of the European Union). (2024). Case T-206/23: Judgment of the General Court of 13 March 2024 – Laboratorios Ern v EUIPO – Cannabinoids Spain (Sanoid). (2024). *Official Journal*, C 2763, ELI: http://data.europa.eu/eli/C/2024/2763/oj[legislation].

Grant, J. (2023). The Role of the South African Government in Advancing the Cannabis Industry to Assist the Ailing Economy and Improve Unemployment. In P. Mashau & J. Nyawo (Eds.), *Rapid Innovation and Development in the Global Cannabis Market* (pp. 123-138). IGI Global. https://doi.org/10.4018/978-1-6684-6346-8.ch007.

Gwala, R. S. (2023). The Legalisation of Cannabis in South Africa: Proposing an Economic Value Chain Model for South Africa. In P. Mashau & J. Nyawo (Eds.), *Rapid Innovation and*

Development in the Global Cannabis Market (pp. 98-122). IGI Global. https://doi.org/10.4018/978-1-6684-6346-8.ch006.

Erdem, M. B. & Doğan, N. Ö. (2023). Green Transformation in Logistics Within the Scope of the European Green Deal. In U. Akkucuk (Ed.), *Managing Inflation and Supply Chain Disruptions in the Global Economy* (pp. 179-198). IGI Global. https://doi.org/10.4018/978-1-6684-5876-1.ch012.

European Commission, Directorate-General for Agriculture and Rural Development, (2024a). Commission Regulation (EU) 2024/1314 of 15 May 2024 amending Annex III to Regulation (EC) No 396/2005 of the European Parliament and of the Council as regards maximum residue levels for dithianon in or on certain products. (2024). *Official Journal*, L 1314, ELI: http://data.europa.eu/eli/reg/2024/1314/oj[legislation].

European Commission, Directorate-General for Agriculture and Rural Development, (2024b). Commission Regulation (EU) 2024/1318 of 15 May 2024 amending Annex II to Regulation (EC) No 396/2005 of the European Parliament and of the Council as regards maximum residue levels prothioconazole in or on certain products. (2024). *Official Journal*, L 1318, ELI: http://data.europa.eu/eli/reg/2024/1318/oj[legislation].

European Commission, Directorate-General for Agriculture and Rural Development, (2024c). Common catalogue of varieties of agricultural plant species Supplement A 2024/4. (2024). *Official Journal*, C 2699, ELI: http://data.europa.eu/eli/C/2024/2699/oj[legislation].

European Commission, Directorate-General for Agriculture and Rural Development, Aramyan, L., van Galen, M., Logatcheva, K. (2024). *Comparative analysis of the socio-economic developments and competitiveness of the agri-food sector at a sectoral and macro level in the pre-accession countries: annex, country factsheets*, Publications Office of the European Union. https://data.europa.eu/doi/10.2762/649475.

European Commission (2024). Agriculture and Rural Development. Hemp. Retrieved from: https://agriculture.ec.europa.eu/farming/crop-productions-and-plant-based-products/hemp_en. Accessed on the 1st of May 2024.

European Commission, Directorate-General for Agriculture and Rural Development, (2023). Commission notice clarifying the applicable legislation to the conditions for import of hemp and hemp seeds under Article 189 of Regulation (EU) No 1308/2013 of the European Parliament and the Council. (2023). *Official Journal*, C 1365, ELI: http://data.europa.eu/eli/C/2023/1365/oj[legislation].

European Commission, Directorate-General for Agriculture and Rural Development, (2022a). Case T-653/21: Order of the General Court of 20 October 2022 — Callaway v Commission (Action for annulment — Common agricultural policy — Common catalogue of varieties of agricultural plant species — Plant varieties — Producer of the hemp variety Finola — Areas cultivated in Poland — Hemp varieties eligible for financial support under the common agricultural policy — Tetrahydrocannabinol (THC) content — Authorisation given to Poland to prohibit the marketing of the Finola variety in its territory — Not directly concerned — Inadmissibility). (2022). *Official Journal*, C 463, 46-47. CELEX: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:62021TB0653[legislation].

European Commission, Directorate-General for Agriculture and Rural Development, (2022b). Commission Regulation (EU) 2022/1393 of 11 August 2022 amending Regulation (EC) No 1881/2006 as regards maximum levels of delta-9-tetrahydrocannabinol (Δ9-THC) in hemp seeds and products derived therefrom (Text with EEA relevance). (2022). *Official Journal*, L 211, 83-85. ELI: http://data.europa.eu/eli/reg/2022/1393/oj[legislation].

European Commission, Directorate-General for Agriculture and Rural Development, (2021). *Evaluation support study on the information policy on the Common Agricultural Policy: leaflet*, Publications Office. https://data.europa.eu/doi/10.2762/531675.

European Commission, Directorate-General for Communication, (2018). *EU budget for the future: the common agricultural policy*, Publications Office of the European Union. https://data.europa.eu/doi/10.2775/9738.

European Commission, Directorate-General for Communication, (2017a). *Agriculture: a partnership between Europe and farmers*, Publications Office. https://data.europa.eu/doi/10.2775/64508.

European Commission, Directorate-General for Agriculture and Rural Development, (2017b). *CAP explained: direct payments for farmers 2015-2020*, Publications Office. https://data.europa.eu/doi/10.2762/572019.

European Commission, Directorate-General for Agriculture and Rural Development, (2012). *The Common Agricultural Policy: a partnership between Europe and farmers*, Publications Office. https://data.europa.eu/doi/10.2762/31102.

European Commission, Directorate-General for Agriculture and Rural Development, (2011). *After 2013: a common agricultural policy for food, natural resources and the regions*, Publications Office.

European Commission, Directorate-General for Agriculture and Rural Development, (2000). *The common agricultural policy: 1999 review*, Publications Office of the European Union.

European Commission, Directorate-General for Environment, Le Den, X., Steinmann, J., Kovacs, A. (2024). *Supporting the development of a roadmap for the reduction of whole life carbon of buildings: final technical report*, Publications Office of the European Union. https://data.europa.eu/doi/10.2779/849252.

European Commission, Directorate-General for Research and Innovation, Knudsen, M., Caniëls, M., Dickinson, P. (2024). *Futures of green skills and jobs in Europe in 2050: scenarios and policy implications*, Publications Office of the European Union. https://data.europa.eu/doi/10.2777/36430.

European Commission, Directorate-General for Regional and Urban Policy, (2023). *Approaches for biomass projects: a summary fiche*, Publications Office of the European Union. https://data.europa.eu/doi/10.2776/145048.

European Commission, European Innovation Council and SMEs Executive Agency, Izsak, K., Moreno, C. (2024a). *Monitoring the twin transition of industrial ecosystems: textiles: analytical report*, Publications Office of the European Union. https://data.europa.eu/doi/10.2826/308561.

European Commission, European Innovation Council and SMEs Executive Agency, Vuijlsteke, C., Voldere, I., Izsak, K. (2024b). *Monitoring the twin transition of industrial ecosystems: cultural and creative industries: analytical report*, Publications Office of the European Union. https://data.europa.eu/doi/10.2826/74386.

European Commission, European Research Executive Agency, (2024). *Leading the transition towards healthy soils: guidelines for living labs proposals*, Publications Office of the European Union. https://data.europa.eu/doi/10.2848/473377.

European Commission, Joint Research Centre, Duboz, L., Ciuffo, B. (2023a). *10th International Symposium on Transportation Data & Modelling (ISTDM2023): Ispra, 19-22 June 2023: booklet of abstracts*, (L.Duboz,editor,B.Ciuffo,edito) Publications Office of the European Union. https://data.europa.eu/doi/10.2760/135735.

European Commission, Joint Research Centre, Huygens, D., Foschi, J., Caro, D. (2023b). *Techno-scientific assessment of the management options for used and waste textiles in the European Union*, Publications Office of the European Union. https://data.europa.eu/doi/10.2760/6292.

European Commission, Joint Research Centre, Rommel, J., Barreiro-Hurlé, J., Thomas, F. (2021). *Farmers and the new green architecture of the EU common agricultural policy: a behavioural experiment*, Publications Office of the European Union. https://data.europa.eu/doi/10.2760/718383.

European Commission, Joint Research Centre, Dessart, F. (2019). *Farmers' views on EU agri-environmental policies : contributing to the Common Agricultural Policy impact assessment with evidence from focus groups*, Publications Office. https://data.europa.eu/doi/10.2760/049327.

European Committee of the Regions, (2024a). *Background note on partnerships for regional innovation (PRI)*, European Committee of the Regions. https://data.europa.eu/doi/10.2863/235687.

European Committee of the Regions, (2024b). *Background note on sustainable energy policy*, European Committee of the Regions. https://data.europa.eu/doi/10.2863/55038.

European Committee of the Regions, (2024c). *Annual activity report for 2023 : European Committee of the Regions*, European Committee of the Regions. https://data.europa.eu/doi/10.2863/216773.

European Committee of the Regions, (2024d). *Background note on cohesion policy*, European Committee of the Regions. https://data.europa.eu/doi/10.2863/518077.

European Committee of the Regions, (2024e). *Background note on the future of rural areas*, European Committee of the Regions. https://data.europa.eu/doi/10.2863/406658

European Committee of the Regions, (2024f). *Background note on resilience and quality of the EU healthcare system*, European Committee of the Regions. https://data.europa.eu/doi/10.2863/597828.

European Court of Auditors, (2023). *The EU's support for sustainable biofuels in transport : an unclear route ahead. Special report 29, 2023*, Publications Office of the European Union. https://data.europa.eu/doi/10.2865/795929.

European Environment Agency (EEA). (2022). Asbestos. Retrieved from: https://www.eea.europa.eu/publications/environmental-burden-of-cancer/asbestos. Accessed on the 1st of May 2024.

European Monitoring Centre for Drugs and Drug Addiction, Europol, (2024). *EU drug markets analysis 2024: key insights for policy and practice*, Publications Office of the European Union. https://data.europa.eu/doi/10.2810/137611.

European Parliament, Directorate-General for Parliamentary Research Services, Smith, E., Etienne, J., Montanari, F. (2024a). *Alternative protein sources for food and feed*, European Parliament. https://data.europa.eu/doi/10.2861/999488.

European Parliament, Directorate-General for Internal Policies of the Union, Beck, M., Van Bunnen, P., Bodart, S. (2024b). *Rural areas: levels of support and impact on competitiveness of farms: final report: research for AGRI Committee*, European Parliament. https://data.europa.eu/doi/10.2861/216818.

European Union Intellectual Property Office, (2023). *EU enforcement of intellectual property rights: results at the EU border and in the EU internal market 2022*, European Union Intellectual Property Office. https://data.europa.eu/doi/10.2814/762823.

European Union. (2024). Commission Regulation (EU) 2023/915 of 25 April 2023 on maximum levels for certain contaminants in food and repealing Regulation (EC) No 1881/2006 (Text with EEA relevance) Text with EEA relevance. Published: 2024-04-25. Corporate author(s): Provisional data. CONSOLIDATION: 2023R0915/20240425. CELEX: 02023R0915-20240425. ELI: reg/2023/915/2024-04-25. Latest edition. https://op.europa.eu/en/publication-detail/-/publication/0a155499-0186-11ef-a251-01aa75ed71a1/language-en.

European University Institute, Giorgio, J. (2024). *What are the consequences for middle powers, such as the Kingdom of Saudi Arabia, of a multi-order future?*, European University Institute. https://data.europa.eu/doi/10.2870/89038.

Fathelrahman, E. M., Faulkner, P. E., & Al Breiki, G. A. (2023). The Perspectives of Higher Agricultural Education in the Gulf Cooperation Council Countries. In M. Samy & R. Barrick (Eds.), *Agricultural Education for Development in the Arab Countries* (pp. 306-329). IGI Global. https://doi.org/10.4018/978-1-6684-4050-6.ch012.

Farooque, A. A. & Abbas, F. (2021). Precision Management Practices for Legal Cultivation of Cannabis (Cannabis sativa L.): Precision Management Practices for Cannabis Cultivation. In S. Abd El-Kader & B. Mohammad El-Basioni (Eds.), *Precision Agriculture Technologies for Food Security and Sustainability* (pp. 187-209). IGI Global. https://doi.org/10.4018/978-1-7998-5000-7.ch008.

Filiz Baştürk, M. (2023). Turkey's Financial Alignment With the European Green Deal. In A. Pego (Ed.), *Climate Change, World Consequences, and the Sustainable Development Goals for 2030* (pp. 229-242). IGI Global. https://doi.org/10.4018/978-1-6684-4829-8.ch012.

Like a Shot Entertainment (Production Company). (2016-present days). Abandoned Engineering. Retrieved from: https://www.imdb.com/title/tt6667634/. Accessed on the 1st of May 2024.

Koshariya, A. K., Madhusudhanan, J., Jinnah Sheik Mohamed, M., Kerur, S. S., Valeti, S. V., & Haribalaji, V. (2023). Bioethanol Production From Biomass Extracted From Sunn Hemp Seed: A Case Study. In P. Vasant, R. Rodríguez-Aguilar, I. Litvinchev, & J. Marmolejo-Saucedo (Eds.), *Human Agro-Energy Optimization for Business and Industry* (pp. 241-263). IGI Global. https://doi.org/10.4018/978-1-6684-4118-3.ch012.

Jain, P. J., Rajnani, N. P., & Kurup, N. S. (2023). Cannabis sativa: A Versatile Herb – An Overview on Pharmaceutical and Cosmetic Applications. In R. Lone, A. Mir, & J. Manzoor (Eds.), *Cannabis sativa Cultivation, Production, and Applications in Pharmaceuticals and Cosmetics* (pp. 63-80). IGI Global. https://doi.org/10.4018/978-1-6684-5718-4.ch005.

Joint Research Centre, Institute for Prospective Technological Studies, Lefebvre, M., Gomez y Paloma, S., Espinosa, M. (2012). *The influence of the Common Agricultural Policy on agricultural landscapes*, Publications Office. https://data.europa.eu/doi/10.2791/94269.

Martinho, V. (2023). *Global Agricultural Policy After COVID-19*. IGI Global. https://doi.org/10.4018/978-1-6684-8923-9.ch005.

Nabi, Z., Kundan, S., Verma, N., & Kumar, D. (2023a). Cannabis sativa and Its Ability to Combat Climate Change: Unravelling Sustainable Benefits of Cannabis and Its Derivatives. In R. Lone, A. Mir, & J. Manzoor (Eds.), *Cannabis sativa Cultivation, Production, and*

Applications in Pharmaceuticals and Cosmetics (pp. 143-152). IGI Global. https://doi.org/10.4018/978-1-6684-5718-4.ch010.

Nabi, Z., Lone, J. M., & Sharma, A. (2023b). Medicinal Uses of Cannabis sativa and Its Derivatives. In R. Lone, A. Mir, & J. Manzoor (Eds.), *Cannabis sativa Cultivation, Production, and Applications in Pharmaceuticals and Cosmetics* (pp. 52-62). IGI Global. https://doi.org/10.4018/978-1-6684-5718-4.ch004.

Obayelu, A. E. & Ayansina, S. O. (2022). Agricultural and Food Policy: Pathways to Sustainable Food Systems and Food Security. In I. Management Association (Ed.), *Research Anthology on Strategies for Achieving Agricultural Sustainability* (pp. 63-77). IGI Global. https://doi.org/10.4018/978-1-6684-5352-0.ch004.

Quendler, E., Mayer, C., & Ortner, K. M. (2020). Economic Transformation of Austrian Agriculture Since EU Accession. In I. Management Association (Ed.), *Environmental and Agricultural Informatics: Concepts, Methodologies, Tools, and Applications* (pp. 875-905). IGI Global. https://doi.org/10.4018/978-1-5225-9621-9.ch039.

Popescu, C. R. G. (2023). Artificial Intelligence and Sustainability in a Game-Changing Post-COVID-19 Era: Key Drivers for Economic Development, Social Development, and Environmental Protection. In C. Popescu (Ed.), *Positive and Constructive Contributions for Sustainable Development Goals* (pp. 1-20). IGI Global. https://doi.org/10.4018/978-1-6684-7499-0.ch001.

Popescu, C. R. G. (2022a). Impressive, Inspiring, and Profound Mindfulness Movement in Organizations: Boosting Productivity, Cultivating Joy, and Sharping Awareness. In C. Popescu (Ed.), *Handbook of Research on Building Inclusive Global Knowledge Societies for Sustainable Development* (pp. 60-96). IGI Global. https://doi.org/10.4018/978-1-6684-5109-0.ch003.

Popescu, C. R. G. (2022b). Mindfulness at Work, a Sound Business Investment: Focusing on the Employee Well-Being While Increasing Creativity and Innovation. In C. Popescu (Ed.), *Handbook of Research on Changing Dynamics in Responsible and Sustainable Business in the Post-COVID-19 Era* (pp. 1-34). IGI Global. https://doi.org/10.4018/978-1-6684-2523-7.ch001.

Popescu, C. R. G. (2022c). Mindfulness Business Principles: Producing Outstanding Value and Encouraging Community Connections. In C. Popescu (Ed.), *COVID-19 Pandemic Impact on New Economy Development and Societal Change* (pp. 196-228). IGI Global. https://doi.org/10.4018/978-1-6684-3374-4.ch010.

Popescu, C. R. G. (2022d). Environmental, Social, and Corporate Governance by Avoiding Management Bias and Tax Minimization: Reaching a General Consensus Regarding a Minimum Global Tax Rate. In C. Popescu (Ed.), *COVID-19 Pandemic Impact on New Economy Development and Societal Change* (pp. 94-132). IGI Global. https://doi.org/10.4018/978-1-6684-3374-4.ch006.

Popescu, C. R. G. (2022e). Fostering Creativity in Business: Empowering Strong Transformational Leaders. In C. Popescu (Ed.), *Handbook of Research on Changing Dynamics in Responsible and Sustainable Business in the Post-COVID-19 Era* (pp. 349-381). IGI Global. https://doi.org/10.4018/978-1-6684-2523-7.ch017.

Popescu, C. R. G. (2022f). Analyzing the Impact of Green Marketing Strategies on the Financial and Non-Financial Performance of Organizations: The Intellectual Capital Factor. In I. Management Association (Ed.), *Research Anthology on Business Continuity and Navigating Times of Crisis* (pp. 202-226). IGI Global. https://doi.org/10.4018/978-1-6684-4503-7.ch011.

Popescu, C. R. G. (2021a). Sustainable and Responsible Entrepreneurship for Value-Based Cultures, Economies, and Societies: Increasing Performance Through Intellectual Capital in

Challenging Times. In C. Popescu & R. Verma (Eds.), *Sustainable and Responsible Entrepreneurship and Key Drivers of Performance* (pp. 33-58). IGI Global. https://doi.org/10.4018/978-1-7998-7951-0.ch002.

Popescu, C. R. G. (2021b). Impact of Innovative Capital on the Global Performance of the European Union: Implications on Sustainability Assessment. In C. Popescu (Ed.), *Handbook of Research on Novel Practices and Current Successes in Achieving the Sustainable Development Goals* (pp. 90-124). IGI Global. https://doi.org/10.4018/978-1-7998-8426-2.ch005.

Popescu, C. R. (2021c). Measuring Progress Towards the Sustainable Development Goals: Creativity, Intellectual Capital, and Innovation. In C. Popescu (Ed.), *Handbook of Research on Novel Practices and Current Successes in Achieving the Sustainable Development Goals* (pp. 125-136). IGI Global. https://doi.org/10.4018/978-1-7998-8426-2.ch006.

Popescu, C. R. G. (2020a). Approaches to Sustainable and Responsible Entrepreneurship: Creativity, Innovation, and Intellectual Capital as Drivers for Organization Performance. In B. Hernández-Sánchez, J. Sánchez-García, & A. Moreira (Eds.), *Building an Entrepreneurial and Sustainable Society* (pp. 75-95). IGI Global. https://doi.org/10.4018/978-1-7998-2704-7.ch004.

Popescu, C. R. G. (2020b). Developing a Model for Entrepreneurship Competencies: Innovation, Knowledge Management, and Intellectual Capital – Success Competences for Building Inclusive Entrepreneurship and Organizational Performance. In J. Šebestová (Ed.), *Developing Entrepreneurial Competencies for Start-Ups and Small Business* (pp. 1-22). IGI Global. https://doi.org/10.4018/978-1-7998-2714-6.ch001.

Popescu, C. R. G. (2020c). Analyzing the Impact of Green Marketing Strategies on the Financial and Non-Financial Performance of Organizations: The Intellectual Capital Factor. In V. Naidoo & R. Verma (Eds.), *Green Marketing as a Positive Driver Toward Business Sustainability* (pp. 186-218). IGI Global. https://doi.org/10.4018/978-1-5225-9558-8.ch008.

Popescu, C. R. G. (2020d). Sustainability Assessment: Does the OECD/G20 Inclusive Framework for BEPS (Base Erosion and Profit Shifting Project) Put an End to Disputes Over The Recognition and Measurement of Intellectual Capital? *Sustainability*, *12*, 10004. https://doi.org/10.3390/su122310004.

Popescu, C. R. G. (2019). Corporate Social Responsibility, Corporate Governance and Business Performance: Limits and Challenges Imposed by the Implementation of Directive 2013/34/EU in Romania. *Sustainability*, *11*, 5146. https://doi.org/10.3390/su11195146.

Popescu, C. R. G. & Popescu, G. N. (2019a). The Social, Economic, and Environmental Impact of Ecological Beekeeping in Romania. In G. Popescu (Ed.), *Agrifood Economics and Sustainable Development in Contemporary Society* (pp. 75-96). IGI Global. https://doi.org/10.4018/978-1-5225-5739-5.ch004.

Popescu, C. R. G. & Popescu, G. N. (2019b). An Exploratory Study Based on a Questionnaire Concerning Green and Sustainable Finance, Corporate Social Responsibility, and Performance: Evidence from the Romanian Business Environment. *J. Risk Financial Manag.*, *12*, 162. https://doi.org/10.3390/jrfm12040162.

Popescu, C. R. G. (2017). The Role Of Total Quality Management In Developing The Concept Of Social Responsibility To Protect Public Interest In Associations Of Liberal Professions. *Amfiteatru Economic*. Editura ASE. Volume: 19. pp. 1091-1106. Special Issue: 11. WOS:000413858500012. ISSN: 1582-9146. eISSN: 2247-9104.

Popescu, C. R. G., Popescu, G. N., Popescu, V. A. (2017). Assessment Of The State Of Implementation Of Excellence Model Common Assessment Framework (CAF) 2013 By The National Institutes Of Research - Development - Innovation In Romania. *Amfiteatru Economic*.

Editura ASE. Volume: 19. Issue: 44. pp. 41-60. WOS:000395746900004. ISSN: 1582-9146. eISSN: 2247-9104.

Popescu, C. R. G., Popescu, G. N., Popescu, V. A. (2015a). Corporate Governance in Romania: Theories and Practices. In Boubaker, S., Nguyen, D.K. (Eds.), *Corporate Governance And Corporate Social Responsibility: Emerging Markets Focus* (pp. 375-401). WORLD SCIENTIFIC PUBL CO PTE LTDPO BOX 128 FARRER RD, SINGAPORE 9128, SINGAPORE. WOS:000349291300016. ISBN: 978-981-4520-37-9. https://doi.org/10.1142/9789814520386_0014. https://www.worldscientific.com/doi/abs/10.1142/9789814520386_0014.

Popescu, C. R. G., Popescu, V. A., Popescu, G. N. (2015b). The Entrepreneur's Role In The Performance Growth Of The Financial Audit Activity In Romania. *Amfiteatru Economic*. Editura ASE. Volume: 17. Issue: 38. pp. 228-246. WOS:000352213800015. ISSN: 1582-9146. eISSN: 2247-9104.

Popescu, V. A., Popescu, G. N., Popescu, C. R. G. (2015c). The Relation Productivity - Environment In The Context Of Sustainable Development - Case Study On The Romanian Industry. *Metalurgija*. CROATIAN METALLURGICAL SOCBERISLAVICEVA 6, ZAGREB, CROATIA. Volume: 54. Issue: 1. pp. 286-288. WOS:000341740000075. ISSN:0543-5846. eISSN:1334-2576.

Popescu, V. A., Popescu, G. N., Popescu, C. R. G. (2015d). Competitiveness And Sustainability - A Modern Economic Approach To The Industrial Policy. *Metalurgija*. CROATIAN METALLURGICAL SOCBERISLAVICEVA 6, ZAGREB, CROATIA. Volume: 54. Issue: 2. pp. 426-428. WOS:000343781300031. ISSN:0543-5846. eISSN:1334-2576.

Popescu, V. A., Popescu, G. N., Popescu, C. R. G. (2015e). The Impact Of Global Crisis On The Dominant Sectors Of The Economy At The Romanian Industry. *Metalurgija*. CROATIAN METALLURGICAL SOCBERISLAVICEVA 6, ZAGREB, CROATIA. Volume: 54. Issue: 2. pp. 289-291. WOS:000341740000076. ISSN:0543-5846. eISSN:1334-2576.

Popescu, V. A., Popescu, G. N., Popescu, C. R. G. (2014). The Economic And Social Dimensions Of Romania's Metallurgical Industry. *Metalurgija*. CROATIAN METALLURGICAL SOCBERISLAVICEVA 6, ZAGREB, CROATIA. Volume: 53. Issue: 1. pp. 113-115. WOS:000320481400029. ISSN:0543-5846. eISSN:1334-2576.

Satapathy, S. (2020). Risk Factor in Agricultural Sector: Prioritizing Indian Agricultural Risk Factor by MAUT Method. In M. Mellal (Ed.), *Soft Computing Methods for System Dependability* (pp. 249-263). IGI Global. https://doi.org/10.4018/978-1-7998-1718-5.ch009.

Sharma, A., Rajput, M., & Manzoor, J. (2023). Cannabis sativa: History, Cultivation, and Medicine. In R. Lone, A. Mir, & J. Manzoor (Eds.), *Cannabis sativa Cultivation, Production, and Applications in Pharmaceuticals and Cosmetics* (pp. 1-28). IGI Global. https://doi.org/10.4018/978-1-6684-5718-4.ch001.

Simonovic, Z. & Vukovic, P. (2020). Characteristics Development of Agriculture and Agricultural Policy Southeast European Countries. In I. Management Association (Ed.), *Environmental and Agricultural Informatics: Concepts, Methodologies, Tools, and Applications* (pp. 948-966). IGI Global. https://doi.org/10.4018/978-1-5225-9621-9.ch042.

Thoron, A. C. & Barrick, R. K. (2023). Education, Community, Industry: Partnerships for Agricultural Development. In M. Samy & R. Barrick (Eds.), *Agricultural Education for Development in the Arab Countries* (pp. 166-212). IGI Global. https://doi.org/10.4018/978-1-6684-4050-6.ch007.

Trbojević-Ivić, J. (2023). Microbial Cellulase in the Production of Second Generation Biofuels: State-of-the-Art and Beyond. In A. Rathoure & S. Khade (Eds.), *Biomass and Bioenergy Solutions for Climate Change Mitigation and Sustainability* (pp. 233-257). IGI Global. https://doi.org/10.4018/978-1-6684-5269-1.ch014.

United Kingdom Government. (2022). University of York. Hemp-30 Phase I. Final Report. Retrieved from: https://assets.publishing.service.gov.uk/media/62cd011fd3bf7f2ffaa4aa34/Phase_1_report_-_University_of_York_-_HEMP-30_catalysing_a_step_change_in_the_production.pdf. Accessed on the 1st of May 2024.

Wernicke, I. H. (2021). Agriculture 4.0 and Bioeconomy: Strategies of the European Union and Germany to Promote the Agricultural Sector – Opportunities and Strains of Digitization and the Use of Bio-Based Innovations. In M. Khosrow-Pour D.B.A. (Ed.), *Encyclopedia of Information Science and Technology, Fifth Edition* (pp. 1323-1335). IGI Global. https://doi.org/10.4018/978-1-7998-3479-3.ch090.

World Natural Heritage Nomination (WNHN) & United Nations Educational, Scientific and Cultural Organization (UNESCO). (2007). Ministry of Construction of People's Republic of China. Convention Concerning the Protection of the World Cultural and Natural Heritage Natural Heritage: China South China Karst Shilin Karst (Yunnan) Libo Karst (Guizhou) Wulong Karst (Chongqing). Retrieved from: https://whc.unesco.org/uploads/nominations/1248.pdf. Accessed on the 1st of May 2024.

THE HEALTH-ENVIRONMENT NEXUS: TACKLING VITAL HEMP POLICIES, ADDRESSING CUTTING-EDGE RESEARCH FOR SUSTAINABLE DEVELOPMENT, AND MANAGING DECISIVE HUMAN RIGHTS

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Abstract

These days, the outcomes derived from closely analyzing and better understanding the health-environment nexus brings to light the unimagined consequences of the global changes: on the hand, there is a growing awareness among the individuals, the communities, the governments, and the organizations regarding the health impacts that climate crisis and biodiversity loss implicate; and, on the other hand, there is a growing need for researchers and policymakers to support the health of the Planet, by fostering interdisciplinary work, by enabling health-policy experts joint projects, and by supporting common environmental agreements. What is more, according to the European Industrial Hemp Association (EIHA) there is a paramount need to focus on the advantages and the benefits of Hemp, in order to create strong and long-lasting connections between the social and the economic transformation, and the circular economy goals. Furthermore, the purpose of this ground-breaking study is to display, on the one hand, the benefits of the Sustainable Hemp in all major areas and the role of the Hemp in the Green Economy, and, on the other hand, to address the conscious shopper's dilemma when faced with vital aspects, such as: the need to be part of the sustainable performance processes; the desire to make the right choices based on informed decisions; and, learning how to harness Hemp's sustainability potential. All in all, the current paper tackles the case of Hemp and its growing popularity for the following main reasons: the sustainability potential and the sustainable development properties; the biodiversity protection capacities; the opportunity to scale Hemp production; the wide-ranging advantages of the fibers coming from the Hemp Plants; and, the chance to consider in a responsible manner the measurable beneficial outcomes of growing and using Hemp, with the aid of programs supporting Hemp research and development towards a resilient future.

Keywords: Hemp; European Industrial Hemp Association (EIHA); World Health Organization (WHO); Cost-Efficient Hemp; Hemp Market Trends; Hemp Regulations; Collaborative Research; Global Biodiversity Framework; Environment, Health, and Well-Being Nexus.

INTRODUCTION

Today, it is commonly believed that the society has very high expectations when it comes to sustainability and sustainable development. Most certainly, it can be easily acknowledged that these extremely high hopes have arisen in the last years in particular due to the abrupt changes faced by people as well as due to the unprecedented challenges that the environment has come to confront itself with (Popescu, 2022c-2022f). These are times in which the Sustainable Development Goals (SDGs) are widely promoted at all levels of the society, accompanied by great hope that these Global Goals (GG) will have the capacity to restore the broken equilibrium that was encountered, from time to time, in a fragile manner, over the decades, in the tumultuous relationship built between people and nature (Popescu, 2023; Popescu, 2022a; Popescu, 2022b). Although in the very beginning humans had a great respect towards the environment and were acting with humility and caution when seeking new means of living in order to support themselves and their families – a type of behavior usually seen in smaller communities that mainly depended on their natural habitat and on the resources limitedly offered by their surroundings, the behavioral patterns of individuals started to change once some of them realized that by trying to forcefully impose their strength upon the environment and even upon other people they would ultimately end up in better positions and become much wealthier than the rest of the community members. That is precisely why these ideas that dreams should be followed at all costs and that plans ought to be put in practice no matter of the consequences are usually turning abruptly and dangerously against those who boldly initiated and forcefully supported them (Popescu *et al.*, 2015a-2015e; Popescu *et al.*, 2014).

Given the above mentioned aspects, it is high time for the environment to regain its (almost) lost importance and it is of great concern these days to focus on restoring those sites that were badly neglected by the individuals and the communities that lost their way in the relationship with nature as well as by the entities that forgot to give something good back to the environment that supported their activities and their businesses. In these turbulent times, the hemp cultivation and the hemp production seem to successfully tackle the new challenges faced by the health-environment nexus in moments in which economic growth, profit, and performance ought to be changed with accountability, equilibrium, happiness, health, mental health, mindfulness, responsibility, sustainability, and well-being.

In this day and age, the scientific paper entitled The Health-Environment Nexus: Tackling Vital Hemp Policies, Addressing Cutting-Edge Research for Sustainable Development, and Managing Decisive Human Rights plays a paramount role in better acknowledging the existing links between health and nature, starting from the powerful idea according to which a very precious plant, namely the hemp plant, has the capacity to restore the balance between health and environment, providing support for a better and a more secure future not only for the present generations but, also, for the next generations.

In the middle of all these novel and even somewhat original situations in the history of mankind, the European Industrial Hemp Association (EIHA) plays a vital role for several reasons. First of all, due to its ongoing activities and efforts, the EIHA sheds a new light on defining and better and more effectively understanding hemp, with the particular aim of enabling those willing to know more about hemp to have access to information and knowledge related to hemp (European Industrial Hemp Association (EIHA), 2024a-2024d). Second of all, the EIHA has a very powerful voice when it comes to the European hemp sector, having the objective of representing the common interests of the hemp farmers, the hemp cultivators, the hemp producers, and the hemp traders that have as field of activity issues closely related to hemp, such as, for example, hemp fibers, hemp seeds, hemp leaves, and cannabinoids (European Industrial Hemp Association (EIHA), 2024a-2024d). All in all, taking into account that all the activities related to the hemp plant are extremely complex and make reference to a wide range of issues, it seems that the EIHA aims are very important, namely: to serve, to protect, and to represent the hemp sector in the European Union (EU) as well as the international policy-making processes. Currently, the EIHA has a wide network formed out of more than 250 members, hence bringing together operators from 25 EU Member States as well as 12 non-EU countries – which include members from North America and Asia Pacific (European Industrial Hemp Association (EIHA), 2024a-2024d).

These days, the outcomes derived from closely analyzing and better understanding the health-environment nexus brings to light the unimagined consequences of the global changes: on the hand, there is a growing awareness among the individuals, the communities, the governments, and the organizations regarding the health impacts that climate crisis and biodiversity loss implicate; and, on the other hand, there is a growing need for researchers and policymakers to support the health of the Planet, by fostering interdisciplinary work, by enabling health-policy experts joint projects, and by supporting common environmental agreements. What is more, according to the EIHA there is a paramount need to focus on the advantages and the benefits of hemp, in order to create strong and long-lasting connections between the social and the economic transformation, and the circular economy goals. Furthermore, the purpose of this ground-breaking study is to display, on the one hand, the benefits of the Sustainable Hemp in all major areas and the role of the hemp in the Green Economy, and, on the other hand, to address the conscious shopper's dilemma when faced with vital aspects, such as: the need to be part of the sustainable performance processes; the desire to make the right choices based on informed decisions; and, learning how to harness hemp's sustainability potential. All in all, the current paper tackles the case of hemp and its growing popularity for the following main reasons: the sustainability potential and the sustainable development properties; the biodiversity protection capacities; the opportunity to scale hemp production; the wide-ranging advantages of the fibers coming from the hemp plants; and, the chance to consider in a responsible manner the measurable beneficial outcomes of growing and using hemp, with the aid of programs supporting hemp research and development towards a resilient future. There are several keywords that require specific attention, such as, for example: hemp; European Industrial Hemp Association (EIHA); World Health Organization (WHO); cost-efficient hemp; hemp market trends; hemp regulations; collaborative research; global biodiversity framework; environment, health, and well-being nexus.

There are several powerful research questions (RQ) that were tackled by the authors of this valuable study, as follows: first of all, (RQ1) is what is hemp and what is the role played by the hemp plants in today's uncertain context so that sustainability and sustainable development are being fostered; second of all, (RQ2) is what is the importance of hemp for the success of the circular economy goals; and, third of all, (RQ3) is how to harness hemp's sustainability potential and should the focus be on sustainable hemp. These are three very important research questions, especially in the context in which specialists have demonstrated in their most recent studies that hemp possesses very powerful regenerative characteristics for the soils, the waters, and the environment, and can survive and prosper in harsh and unfriendly conditions. By becoming mindful of all the advantages and the benefits comprised in cultivating the hemp plants and in producing hemp products, it is believed that communities and businesses are getting significantly closer to becoming more sustainable and more centered on fostering the health-environment nexus which is pivotal.

This section represented by the introduction is followed by the conceptual framework, also known as the literature review section or the background section, the research and findings, the conclusion, and the references. The study is novel and highly original due to the way in which the ideas are displayed, due to the manner in which the entire text manages to promote the importance and the role of the hemp plants for the individuals, the communities, and the environment, due to the interesting selection of references that come to support the ideas fostered, and due to the valuable contribution that is able to make in terms of painting the necessity to unite forces for the SDGs achievement.

CONCEPTUAL FRAMEWORK

In this day and age, the hemp plants are very good in supporting the SDGs (with a special accent placed on sustainable development and sustainability, while having in mind the tremendous implications of green economy and circular economy) having the possibility to offer paramount help in the process of combating climate change, based on the fact that the hemp plants are good for global warming due to their countless benefits (Popescu, 2021a, 2021b, 2021c; United Nations & United Nations Conference on Trade and Development, 2024a). In this matter, the hemp plants have many product alternatives as well as many product uses. What is more, according to studies the hemp plants are far more sustainable than cotton and bamboo and flex, and hemp is 100% biodegradable which means that hemp materials have the property of being 100% biodegradable in the soil, hence enriching the soil with numerous microelements that lead to more nutritious soils, more protected soils, and more robust surroundings (United Nations & United Nations Conference on Trade and Development, 2024b). Furthermore, specialists have displayed that the manufacturing processes that are specific to hemp are far more sustainable far more easier and beneficial for the environment while compared to other manufacturing processes that can be associated to cotton and bamboo and flex (United Nations & United Nations Conference on Trade and Development, 2023a). All in all, it had to be taken into consideration that hemp plants are processed manually with little or even with no chemicals, while other plants, such as, for instance, cotton and bamboo have to undergo rigorous processes (United Nations & United Nations Conference on Trade and Development, 2023b). A good and valuable example in this matter is represented by the bamboo plants, where the process the cellulose from the stalk is highly complex and rigorous and takes numerous steps in order to transform the bamboo into soft fabric.

According to Special Issue No. 16 published in the year 2022 by the United Nations and the United Nations Conference on Trade and Development which is entitled very suggestively "Commodities at a Glance. Special Issue on Industrial Hemp" the following major aspects are noted from the very beginning: "Industrial hemp does not have intoxicating properties. Nonetheless, it remains a controversial plant, as it is still often mistakenly associated with use as an intoxicant. A negative connotation still prevails despite a history, over several millennia, of its industrial and medicinal applications. Such a connotation is due in part to confusion about the botanical characteristics and chemo-type of the plant" (United Nations & United Nations Conference on Trade and Development, 2022a, p.2). In continuation, in the same document the following ideas are highlighted: "Industrial hemp belongs to the *Cannabis L. genus*. Despite a long history of botanical research, no consensus on its taxonomy has emerged yet. The only consensus reached is about the current existence of a unique species in the genus, namely the *Cannabis sativa L. species*" (United Nations & United Nations Conference on Trade and Development, 2022a, p.2).

Interestingly, the same aforementioned document continues with the following pivotal aspects: "From a botanical point of view, industrial hemp does not uniquely correspond to any subspecies of *Cannabis sativa L*. All recognized subspecies encompass several varieties and cultivars, some having intoxicating properties" (with the special note at the end of the page that states: "In the taxonomic hierarchy, the genus splits into species, then into subspecies and finally into varieties or cultivars. A variety is a type of plant grown from seed that has the same characteristics as the parent plant. A cultivar is a lithe parent plant. Growing a plant from one of these plant's seeds may not produce the same plant as the parent."). A clear distinction between intoxicating properties and intoxicant plant varieties should be made, as is done, using a practical approach adopted by the hemp industry. This is also the approach adopted in this report, even though it does not perfectly correspond to any taxonomic or phylogenetic classification" (with the special note at the end of the page that states: "Hereafter, non-intoxicant plants are referred to as industrial hemp or hemp. Intoxicant plants are referred to as cannabis with "c" in lower case. References to *C. sativa L.* or *Cannabis*, with "C" in upper case, may or may not have intoxicating properties.") (United Nations & United Nations Conference on Trade and Development, 2022a, p.2).

In the lines below the Table no. 1: The European Industrial Hemp Association (EIHA), the Sustainable Hemp, the Role of the Hemp in the Green Economy and the Focus on the Advantages and the Benefits of Hemp centers on showing the importance of the hemp plants and the pivotal role played the green economy.

Table no. 1: The European Industrial Hemp Association (EIHA), the Sustainable Hemp, the Role of the Hemp in the Green Economy and the Focus on the Advantages and the Benefits of Hemp

Amazing Benefits of Hemp Plant:	**Sustainable Hemp Plant and its Versatility that Offer New Opportunities for SDGs and Sustainability:**
Hemp is regarded as an amazing plant that has all its parts useful, uses just a fraction of the water required to grow cotton plants and, additionally, possesses the capacity to absorb more carbon dioxide per hectare than most trees as well as than other plants (Hemp Federation Ireland (HFI), 2024; Popescu, 2020a, 2020b, 2020c, 2020d; United Nations & United Nations Conference on Trade and Development, 2022b, 2022c).	Hemp is an eco-friendly plant that has been cultivated for thousands of years (Cerino *et al.*, 2021). Hemp is extremely versatile, being used in food products, textiles, biofuels, and building materials (Popescu, 2019; United Nations & United Nations Conference on Trade and Development, 2022d).
Hemp is an efficient crop to grow, known for its cost-efficiency while compared to other plants (such as, for example, cotton) (Popescu & Popescu, 2019a, 2019b; United Nations & United Nations Conference on Trade and Development, 2022b, 2022c).	Hemp is highly resilient, robust, and sustainable (while compared to other plants, such as, for example, to cotton), having as main qualities in this matter the following attributes: (a) firstly, requires less water than other plants; (b) secondly, needs less pesticides or even no pesticides in order to grow and become useful in several ways possible; and (c) thirdly, is more resilient to diseases and pests, which represents a great advantage for farmers since they can use less or even no chemicals or treatments (Mayo Clinic Organization, 2019; Popescu, 2017; United Nations & United Nations Conference on Trade and Development, 2022d).
Hemp has a wide array of utility, it can be used as a representative fiber plant for the textile industry and for construction materials, based on its abundance in fibers, but it can also be encountered in the industrial production of food (United Nations & United Nations Conference on Trade and Development, 2022b, 2022c; United Nations & United Nations Conference on Trade and Development, 2022d).	Hemp supports environmental sustainability, due to the fact that industrial hemp may have numerous environmental benefits, such as: (a) may offer a more efficient use of energy; (b) may have less reliance fossil fuels; (c) may support forest conservation, foster agriculture, and can be good for global warming since it can combat climate change (Popescu *et al.*, 2017; United Nations & United Nations Conference on Trade and Development, 2022b, 2022c; United Nations & United Nations Conference on Trade and Development, 2022d).

Source: The Author' Own Elaboration, Based on the References Highlighted in the Table and in the Bibliography Section

In the lines below the Table no. 2: Understanding the Case of Hemp and its Growing Popularity, while Addressing the Circular Economy Opportunities, centers on the relationship between hemp and the World Health Organization (WHO), cost-efficient hemp, hemp market trends, hemp regulations, collaborative research, global biodiversity framework, and environment, health, and well-being nexus.

Table no. 2: Understanding the Case of Hemp and its Growing Popularity, while Addressing the Circular Economy Opportunities

Understanding the Case of Hemp and its Growing Popularity:	Addressing the Circular Economy Opportunities:
Hemp can be a vital substitute for plastic, as acknowledged in numerous documents and as debated at numerous scientific events (United Nations & United Nations Conference on Trade and Development, 2023c):	In a document published in the year 2023 and suggestively entitled "Trade regulations for climate action? New insights from the global non-tariff measures database", the United Nations Conference on Trade and Development and United Nations Economic and Social Commission for Asia and the Pacific states the following aspects when offering answers to the key question: "What are plastic substitutes?" "Plastic substitutes are made of natural materials derived from minerals, plants, animals, the marine environment, or forestry resources, possessing comparable properties to plastics (e.g., strength, flexibility, lightness, and malleability). These do not include petroleum-based or synthetic polymers, bio-plastics, and biodegradable plastics. Examples include hemp, bamboo, agricultural residues, seaweed, aluminum and glass. Plastic substitutes should demonstrate a reduced environmental footprint throughout their life cycle and should also either be biodegradable, compostable, or erodible, and compliant with definitions for reuse, recycling, or responsible waste disposal." (United Nations, United Nations Conference on Trade and Development, United Nations Conference on Trade and Development and United Nations Economic and Social Commission for Asia and the Pacific, 2023, p.11).
Between hemp and heavy metals there is a strong relationship due to hemp plant's great capacity to regenerate contaminated soils (United Nations & United Nations Conference on Trade and Development, 2021):	In metal-contaminated environments as the ones that can be found in the case of abandoned mines, the hemp plants can absorb high concentrations of potentially harmful metals, heavy metals, such as: arsenic, cadmium, chromium, lead, mercury, and nickel; these heavy metals will be then found in the leaves of the hemp plants (Adhikary *et al.*, 2021; Farinon *et al.*, 2020; Morales *et al.*, 2022; Placido & Lee, 2022; Rizzo *et al.*, 2023); With the aid of the process of phytoremediation, the roots of the hemp plants have the capacity to remove (to absolve) the dangerous, harmful, and polluting chemicals from the environment, by digging deep into those areas that are contaminated (for instance, into the contaminated soils) and absorb not only the beneficial nutrients that can be encountered in the soil but also the harmful chemicals which are afterwards stored in the plants – most often in the leaves, stalk, or stems (United Nations & United Nations Conference on Trade and Development, 2021).
Between hemp and radiation there is a strong relationship due to hemp plant's great capacity to absorb toxins mainly through the roots and stems (United Nations & United Nations Conference on Trade and Development, 2022e; United Nations & United Nations Conference on Trade and Development, 2018)	In continuation to the already mentioned benefits, the hemp plants not only absorb heavy metals, but they also remove other contaminants such as radiation, crude oil, landfill leachate, and pesticides (Punja *et al.*, 2023; Punja, 2021; Rupasinghe *et al.*, 2020; Vandenhove & Van Hees, 2005).

Source: The Author' Own Elaboration, Based on the References Highlighted in the Table and in the Bibliography Section

When referring to the hemp plants and their great accomplishments, advantages, and benefits for the individuals, the communities, and the environment there are numerous aspects that can be brought into discussion and that can be brought to the attention, especially when considering key concepts such as: the circular economy, biodiversity, ecosystems, and the equilibrium that needs to be maintained and supported between people's aspirations and environmental needs.

These days, besides all the processes mentioned already there is another facet of the hemp plants that requires attention: the process of rhizofiltration which is a form of phytoremediation that implicates filtering contaminated groundwater, surface water, and waste water with the aid of and through a mass of roots – and the root zone is named rhizosphere (Babalola *et al.*, 2021; Brunel *et al.*, 2020; Ignatius *et al.*, 2014).

RESEARCH AND FINDINGS

This particular section which is represented by the research and findings sheds a new light on the importance of the hemp plants with the intention of drawing attention to the relationship that can be encountered between health and environment, while painting a positive image of the cultivation and production processes of the hemp plants – as a very powerful solution these days in case of regions characterized by heavily polluted air, soils, water, and so on and so forth.

What is more, it is believed that the powerful research questions (RQ) that were tackled in the paper by the authors of this valuable study were adequately and thoroughly answered. First of all, the first research question (RQ1) was what hemp is and what role is played by the hemp plants in today's uncertain context so that sustainability and sustainable development are being fostered. In this matter, the current study has shown that the hemp plants have most unfortunately been associated, over the years, with other plants which are believed to have mind-altering effects – such as, for instance, the marihuana plants or the cannabis plants, unlike the hemp plants which, according to researchers, do not have mind-altering effects. Over the years, these associations between plants led to numerous misunderstandings and decisions that untimely led to banning the cultivation of hemp plants. In addition, it is believed that due to its valuable nutritious properties and environmentally healing characteristics, the hemp plants cultivation is essentially supporting sustainability and sustainable development; hence the hemp plants may be considered promoters of the SDGs. Second of all, the next research question (RQ2) was what the importance of the hemp plants is for the success of the circular economy goals; this question is extremely important, since there are numerous links between the great power embodied in the circular economy goals and the circular economy pillars and the SDGs. The circular economy plays a vital part these days: on the one hand, after so many years in which the society promoted a model (the linear model of economy) based on simply consuming the products and then discarding them without any additional thoughts and, in most situations, without even trying to find an alternative use for them, it has become clear that the rhythm of consumption is so high and the number of the products that are being left behind with no clear use is so big that the Planet has no longer the possibility to cope with the waste generated; and, on the other hand, the idea of offering a new alternative to the products used has the power of preserving the Planet's limited and vital resources, in this way giving the opportunity to waste (in different forms and stages) to be part of a new life cycle. The power of the circular economy is immense and this new economic model seems to support in a better and in a healthier manner the aims represented by the SDGs. In continuation, third of all, the last research question (RQ3) is how to harness hemp's sustainability potential and should the focus be on sustainable hemp. The aspects that can be encountered when realizing that the hemp plants support sustainability and the SDGs are the following ones: (a) the hemp plants support sustainability and the SDGs due to their capacity to absorb heavy metals that can be found in soils and water, which helps the cleaning process of the environment even if this particular process takes time; (b) the hemp plants support sustainability and the SDGs due to the fact that they can survive in harsh conditions and in not so friendly environments, but they are environmentally friendly, being able to successfully grow with less and even no pesticides, they help better fix the soil since they have roots capable to support the areas on which it is planted, they produce a lot of oxygen (far more than trees can on a similar area that has been planted); and (c) the hemp plants support sustainability and the SDGs due to the fact that they help people with different health problems (such as, the mental problems) and not only.

In essence, the three very important research questions embodied in this current study were successfully addressed and it ought to be taken into account that the specialists have demonstrated in their most recent studies that hemp possesses very powerful regenerative characteristics for the soils, the waters, and the environment, and can survive and prosper in harsh and unfriendly conditions. Under these specific conditions, by becoming mindful of all the advantages and the benefits comprised in cultivating the hemp plants and in producing hemp products, it is believed that communities and businesses are getting significantly closer to becoming more sustainable and more centered on fostering the health-environment nexus which is pivotal. Also, mindfulness represents a very powerful state of mind in the case of individuals and communities. Accordingly, people and communities are encouraged to become mindful of their surroundings while focusing on their daily tasks as well as while trying to create connections between their day-to-day routine and the environment. The outcomes of people and communities becoming more mindful would be that people and communities need to be fully aware of the results of their actions on the short-term, on the medium-term, and on the long-term, seeking equilibrium between their aspirations and objectives and the needs of the Planet. By not becoming mindful of the implications that human actions and activities have on the environment, further damage will be done to the environment and the nature will continue to be destroyed and to suffer. Hence, an ill environment will lead to ill individuals, to communities that will confront themselves with highly challenging health problems that will be passed even to the next generations to come. That is the reason why now it is high time for business owners, governmental officials, and country leaders to understand the consequences of the actions that take place at the level of the economies and the industries, and to respond in consequence by supporting the health-environment nexus, by tackling vital hemp policies, by addressing cutting-edge research for sustainable development, and by managing decisive human rights in the spirit of the SDGs and of the circular economy.

CONCLUSION

This part of this research study is dedicated to the conclusion and discussion section. In particular, this section is seen as vital to this research paper due to the fact that it summarizes the most relevant aspects that need to be highlighted on The Health-Environment Nexus: Tackling Vital Hemp Policies, Addressing Cutting-Edge Research for Sustainable Development, and Managing Decisive Human Rights. On the one hand, while referring to the health-environment nexus there are several issues that ought to be emphasized: firstly, health and environment are profoundly linked, which implicate that both rely on each other for the future of the individuals, the communities, the biodiversity, and the ecosystems; secondly, there is no such thing as being healthy in the absence of a well-balanced and safe environment, governed by equilibrium, rationality, and a sense of security; and, thirdly, the ideas that nature can be drastically changed in order to fully support mankind dreams and aspirations and, also, that the natural habitats are unimportant or less important for human life represent aspects that require immediate and urgent consideration, based on the fact that they do not reflect the reality of these times and, ultimately, they were never able to reflect any reality no matter of the place or time in the history of humanity. On the other hand, when thinking about the health-environment nexus only positive aspects should come to mind and only constructive thoughts ought to ultimately accompany this particular type of relationship, as follows in the lines below: firstly, with nature and the natural habitats life has begun on this Planet, which means that nature should represent a priority on the agenda of everyone, no matter what other aims, aspirations, goals, and objectives one might have; secondly, health and well-being have their roots in the status of the environment and an affected, a damaged, a “sick” environment will have long-term implications on everybody; and, thirdly, people should learn to become more mindful of their own actions and activities in order to protect the biodiversity, the ecosystems, the natural habitats due to the fact that everything on the Planet and in the Universe is interconnected.

In other words, it is a utopia to believe that humans can life peaceful and healthy lives in a polluted environment, no matter of the advancements of science and technology. Likewise, it represents a utopia to think that by building a better future for all can be done otherwise than with constructive and positive way of thinking and by making compromises that will lead to the disappearance of cultures, natural habitats, plants, and animals. Given the fact that these relationships exist everywhere in nature, by sacrificing a few specifies and with their disappearance everyone will be affected on the medium-term and on the long-term. A very good example in this situation is provided by the lives of bees without which specialists have come to believe that life of Earth will no longer be possible, due to the fact that bees are the ones that ensure plants pollination processes which lead to the facilitation of the rest of the steps that are specific to plants lives (after pollination leading to their capacity to have fruits, and so on). Interestingly, there are numerous voices suggesting that live bees can easily be replaced by Artificial Intelligence (AI) combined with other new forms of technology, hence creating artificial bees with the capacity to perform more or less similar tasks as the living bees are able to do. Nevertheless, it should be taken into account that there are numerous cases in history in which the creators of certain devices and technologies initially thought that their creations would lead to something good for their countries, for the communities and/or for the environment and, ultimately, ended up by doing something completely wrong and with grave consequences for many, many years to come (hundreds and, maybe, even thousands of years from that moment on). Hence, out of these bad experiences people should learn and should acknowledge that it is better to rely on what there is already in place and what is already functioning successfully rather than believing that nature is unimportant and can be easily restored with the aid of science and technology.

Going even further with this analysis, from the health-environment nexus the next step targeted is represented by the position of the hemp plants and the hemp cultivation in today’s general context. It is of great importance to understand that by tackling vital hemp policies, by addressing cutting-edge research for sustainable development, and by managing decisive human rights life will be brighter and the idea of a better future for all will come to life. The hemp plants are the ones being able to live in unfriendly environments, with soils less rich in nutrients and with an unbelievable capacity to grow that can help nature restore and habitats regenerate. According to studies, the hemp plants can produce oxygen in higher quantities that tress might be able to do and, also, the hemp plants can absorb CO_2 which means that they can be of great aid in polluted areas and regions. What is more, the hemp plants can survive in the areas affected by heavy metals, which makes them extremely robust and resilient. Furthermore, almost all the parts of the hemp plants may ultimately have a place in the consumption or production process, being extremely useful for people’s health since they are so nutritious, being highly valuable for the industry since they can be used, for example, in the textile industry, and not only.

By supporting the development of the hemp plants, the intention of the specialists worldwide is to facilitate access to a better understanding of these plants and a better way to be part of the healing process of the environment, which leads to tackling vital hemp policies, by addressing cutting-edge research for sustainable development, and by managing decisive human rights. All in all, the hemp policies ought to be updated and ought to comprise the latest technological advancements in terms of nature and soil preservation, the purification of the air and of the water. In other words, specialists need to make sure that the benefits of the hemp plants are known and recognized at a global level, in order to offer alternatives and solutions, for example, to other plants that may be encountered in the environment and that probably require different living and cultivating conditions than the hemp plants.

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AUTHOR CONTRIBUTIONS

Conceptualization, Cristina Raluca Gh. Popescu (C.R.G.P.) and Gheorghe N. Popescu (G.N.P.); methodology, C.R.G.P. and G.N.P.; software, C.R.G.P. and G.N.P.; validation, C.R.G.P. and G.N.P.; formal analysis, C.R.G.P. and G.N.P.; investigation, C.R.G.P. and G.N.P.; resources, C.R.G.P. and G.N.P.; data curation, C.R.G.P. and G.N.P.; writing—original draft preparation, C.R.G.P. and G.N.P.; writing—review and editing, C.R.G.P. and G.N.P. All Authors have equally contributed to this manuscript. All Authors have read and agreed to the published version of the manuscript.

REFERENCES

Adhikary, D., Kulkarni, M., El-Mezawy, A., Mobini, S., Elhiti, M., Gjuric, R., Ray, A., Polowick, P., Slaski, J. J., Jones, M. P., & Bhowmik, P. (2021). Medical Cannabis and Industrial Hemp Tissue Culture: Present Status and Future Potential. *Frontiers in plant science*, *12*, 627240. https://doi.org/10.3389/fpls.2021.627240.

Babalola, O. O., Emmanuel, O. C., Adeleke, B. S., Odelade, K. A., Nwachukwu, B. C., Ayiti, O. E., Adegboyega, T. T., & Igiehon, N. O. (2021). Rhizosphere Microbiome Cooperations: Strategies for Sustainable Crop Production. *Current microbiology*, *78*(4), 1069–1085. https://doi.org/10.1007/s00284-021-02375-2.

Brunel, C., Pouteau, R., Dawson, W., Pester, M., Ramirez, K. S., & van Kleunen, M. (2020). Towards Unraveling Macroecological Patterns in Rhizosphere Microbiomes. *Trends in plant science*, *25*(10), 1017–1029. https://doi.org/10.1016/j.tplants.2020.04.015.

Cerino, P., Buonerba, C., Cannazza, G., D'Auria, J., Ottoni, E., Fulgione, A., Di Stasio, A., Pierri, B., & Gallo, A. (2021). A Review of Hemp as Food and Nutritional Supplement. *Cannabis and cannabinoid research*, *6*(1), 19–27. https://doi.org/10.1089/can.2020.0001.

European Industrial Hemp Association (EIHA). (2024a). About EIHA. Retrieved from: https://eiha.org/introducing-ourselves/. Accessed on the 1st of May 2024.

European Industrial Hemp Association (EIHA). (2024b). About Hemp. Retrieved from: https://eiha.org/about-hemp-definition/. Accessed on the 1st of May 2024.

European Industrial Hemp Association (EIHA). (2024c). Members Directory. Retrieved from: https://members.eiha.org/#/members-directory. Accessed on the 1st of May 2024.

European Industrial Hemp Association (EIHA). (2024d). Identity Manual. Retrieved from: https://eiha.org/wp-content/uploads/2021/01/Com_CA_identitymanual_01012021.pdf. Accessed on the 1st of May 2024.

Farinon, B., Molinari, R., Costantini, L., & Merendino, N. (2020). The seed of industrial hemp (*Cannabis sativa* L.): Nutritional Quality and Potential Functionality for Human Health and Nutrition. *Nutrients*, *12*(7), 1935. https://doi.org/10.3390/nu12071935.

Hemp Federation Ireland (HFI). (2024). EU Commission Clarifies the Legality of THC in Hemp Food. Retrieved from: https://www.drugsandalcohol.ie/36033/1/EU%20Commission%20Clarifies%20the%20Legality%20of%20THC%20in%20Hemp%20Food.pdf. Accessed on the 1st of May 2024.

Ignatius, A., Arunbabu, V., Neethu, J., & Ramasamy, E. V. (2014). Rhizofiltration of lead using an aromatic medicinal plant Plectranthus amboinicus cultured in a hydroponic nutrient film technique (NFT) system. *Environmental science and pollution research international*, *21*(22), 13007–13016. https://doi.org/10.1007/s11356-014-3204-1.

Mayo Clinic Organization. (2019). CBD products, hemp oil may be helpful but more research is needed, Mayo Clinic review says. Retrieved from: https://newsnetwork.mayoclinic.org/discussion/cbd-products-hemp-oil-may-be-helpful-but-more-research-is-needed-mayo-clinic-review-says/. Accessed on the 1st of May 2024.

Morales, M. B., Díaz, M., Giralt, D., Sardà-Palomera, F., Traba, J., Mougeot, F., Serrano, D., Mañosa, S., Gaba, S., Moreira, F., Pärt, T., Concepción, E. D., Tarjuelo, R., Arroyo, B., & Bota, G. (2022). Protect European green agricultural policies for future food security. *Communications earth & environment*, *3*(1), 217. https://doi.org/10.1038/s43247-022-00550-2.

Placido, D. F., & Lee, C. C. (2022). Potential of Industrial Hemp for Phytoremediation of Heavy Metals. *Plants (Basel, Switzerland)*, *11*(5), 595. https://doi.org/10.3390/plants11050595.

Popescu, C. R. G. (2023). Artificial Intelligence and Sustainability in a Game-Changing Post-COVID-19 Era: Key Drivers for Economic Development, Social Development, and Environmental Protection. In C. Popescu (Ed.), *Positive and Constructive Contributions for Sustainable Development Goals* (pp. 1-20). IGI Global. https://doi.org/10.4018/978-1-6684-7499-0.ch001.

Popescu, C. R. G. (2022a). Impressive, Inspiring, and Profound Mindfulness Movement in Organizations: Boosting Productivity, Cultivating Joy, and Sharping Awareness. In C. Popescu

(Ed.), *Handbook of Research on Building Inclusive Global Knowledge Societies for Sustainable Development* (pp. 60-96). IGI Global. https://doi.org/10.4018/978-1-6684-5109-0.ch003.

Popescu, C. R. G. (2022b). Mindfulness at Work, a Sound Business Investment: Focusing on the Employee Well-Being While Increasing Creativity and Innovation. In C. Popescu (Ed.), *Handbook of Research on Changing Dynamics in Responsible and Sustainable Business in the Post-COVID-19 Era* (pp. 1-34). IGI Global. https://doi.org/10.4018/978-1-6684-2523-7.ch001.

Popescu, C. R. G. (2022c). Mindfulness Business Principles: Producing Outstanding Value and Encouraging Community Connections. In C. Popescu (Ed.), *COVID-19 Pandemic Impact on New Economy Development and Societal Change* (pp. 196-228). IGI Global. https://doi.org/10.4018/978-1-6684-3374-4.ch010.

Popescu, C. R. G. (2022d). Environmental, Social, and Corporate Governance by Avoiding Management Bias and Tax Minimization: Reaching a General Consensus Regarding a Minimum Global Tax Rate. In C. Popescu (Ed.), *COVID-19 Pandemic Impact on New Economy Development and Societal Change* (pp. 94-132). IGI Global. https://doi.org/10.4018/978-1-6684-3374-4.ch006.

Popescu, C. R. G. (2022e). Fostering Creativity in Business: Empowering Strong Transformational Leaders. In C. Popescu (Ed.), *Handbook of Research on Changing Dynamics in Responsible and Sustainable Business in the Post-COVID-19 Era* (pp. 349-381). IGI Global. https://doi.org/10.4018/978-1-6684-2523-7.ch017.

Popescu, C. R. G. (2022f). Analyzing the Impact of Green Marketing Strategies on the Financial and Non-Financial Performance of Organizations: The Intellectual Capital Factor. In I. Management Association (Ed.), *Research Anthology on Business Continuity and Navigating Times of Crisis* (pp. 202-226). IGI Global. https://doi.org/10.4018/978-1-6684-4503-7.ch011.

Popescu, C. R. G. (2021a). Sustainable and Responsible Entrepreneurship for Value-Based Cultures, Economies, and Societies: Increasing Performance Through Intellectual Capital in Challenging Times. In C. Popescu & R. Verma (Eds.), *Sustainable and Responsible Entrepreneurship and Key Drivers of Performance* (pp. 33-58). IGI Global. https://doi.org/10.4018/978-1-7998-7951-0.ch002.

Popescu, C. R. G. (2021b). Impact of Innovative Capital on the Global Performance of the European Union: Implications on Sustainability Assessment. In C. Popescu (Ed.), *Handbook of Research on Novel Practices and Current Successes in Achieving the Sustainable Development Goals* (pp. 90-124). IGI Global. https://doi.org/10.4018/978-1-7998-8426-2.ch005.

Popescu, C. R. (2021c). Measuring Progress Towards the Sustainable Development Goals: Creativity, Intellectual Capital, and Innovation. In C. Popescu (Ed.), *Handbook of Research on Novel Practices and Current Successes in Achieving the Sustainable Development Goals* (pp. 125-136). IGI Global. https://doi.org/10.4018/978-1-7998-8426-2.ch006.

Popescu, C. R. G. (2020a). Approaches to Sustainable and Responsible Entrepreneurship: Creativity, Innovation, and Intellectual Capital as Drivers for Organization Performance. In B. Hernández-Sánchez, J. Sánchez-García, & A. Moreira (Eds.), *Building an Entrepreneurial and Sustainable Society* (pp. 75-95). IGI Global. https://doi.org/10.4018/978-1-7998-2704-7.ch004.

Popescu, C. R. G. (2020b). Developing a Model for Entrepreneurship Competencies: Innovation, Knowledge Management, and Intellectual Capital – Success Competences for Building Inclusive Entrepreneurship and Organizational Performance. In J. Šebestová (Ed.), *Developing Entrepreneurial Competencies for Start-Ups and Small Business* (pp. 1-22). IGI Global. https://doi.org/10.4018/978-1-7998-2714-6.ch001.

Popescu, C. R. G. (2020c). Analyzing the Impact of Green Marketing Strategies on the Financial and Non-Financial Performance of Organizations: The Intellectual Capital Factor. In V. Naidoo & R. Verma (Eds.), *Green Marketing as a Positive Driver Toward Business Sustainability* (pp. 186-218). IGI Global. https://doi.org/10.4018/978-1-5225-9558-8.ch008.

Popescu, C. R. G. (2020d). Sustainability Assessment: Does the OECD/G20 Inclusive Framework for BEPS (Base Erosion and Profit Shifting Project) Put an End to Disputes Over The Recognition and Measurement of Intellectual Capital? *Sustainability*, *12*, 10004. https://doi.org/10.3390/su122310004.

Popescu, C. R. G. (2019). Corporate Social Responsibility, Corporate Governance and Business Performance: Limits and Challenges Imposed by the Implementation of Directive 2013/34/EU in Romania. *Sustainability*, *11*, 5146. https://doi.org/10.3390/su11195146.

Popescu, C. R. G. & Popescu, G. N. (2019a). The Social, Economic, and Environmental Impact of Ecological Beekeeping in Romania. In G. Popescu (Ed.), *Agrifood Economics and Sustainable Development in Contemporary Society* (pp. 75-96). IGI Global. https://doi.org/10.4018/978-1-5225-5739-5.ch004.

Popescu, C. R. G. & Popescu, G. N. (2019b). An Exploratory Study Based on a Questionnaire Concerning Green and Sustainable Finance, Corporate Social Responsibility, and Performance: Evidence from the Romanian Business Environment. *J. Risk Financial Manag.*, *12*, 162. https://doi.org/10.3390/jrfm12040162.

Popescu, C. R. G. (2017). The Role Of Total Quality Management In Developing The Concept Of Social Responsibility To Protect Public Interest In Associations Of Liberal Professions. *Amfiteatru Economic*. Editura ASE. Volume: 19. pp. 1091-1106. Special Issue: 11. WOS:000413858500012. ISSN: 1582-9146. eISSN: 2247-9104.

Popescu, C. R. G., Popescu, G. N., Popescu, V. A. (2017). Assessment Of The State Of Implementation Of Excellence Model Common Assessment Framework (CAF) 2013 By The National Institutes Of Research - Development - Innovation In Romania. *Amfiteatru Economic*. Editura ASE. Volume: 19. Issue: 44. pp. 41-60. WOS:000395746900004. ISSN: 1582-9146. eISSN: 2247-9104.

Popescu, C. R. G., Popescu, G. N., Popescu, V. A. (2015a). Corporate Governance in Romania: Theories and Practices. In Boubaker, S., Nguyen, D.K. (Eds.), *Corporate Governance And Corporate Social Responsibility: Emerging Markets Focus* (pp. 375-401). WORLD SCIENTIFIC PUBL CO PTE LTDPO BOX 128 FARRER RD, SINGAPORE 9128, SINGAPORE. WOS:000349291300016. ISBN: 978-981-4520-37-9. https://doi.org/10.1142/9789814520386_0014. https://www.worldscientific.com/doi/abs/10.1142/9789814520386_0014.

Popescu, C. R. G., Popescu, V. A., Popescu, G. N. (2015b). The Entrepreneur's Role In The Performance Growth Of The Financial Audit Activity In Romania. *Amfiteatru Economic*. Editura ASE. Volume: 17. Issue: 38. pp. 228-246. WOS:000352213800015. ISSN: 1582-9146. eISSN: 2247-9104.

Popescu, V. A., Popescu, G. N., Popescu, C. R. G. (2015c). The Relation Productivity - Environment In The Context Of Sustainable Development - Case Study On The Romanian Industry. *Metalurgija*. CROATIAN METALLURGICAL SOCBERISLAVICEVA 6, ZAGREB, CROATIA. Volume: 54. Issue: 1. pp. 286-288. WOS:000341740000075. ISSN:0543-5846. eISSN:1334-2576.

Popescu, V. A., Popescu, G. N., Popescu, C. R. G. (2015d). Competitiveness And Sustainability - A Modern Economic Approach To The Industrial Policy. *Metalurgija*. CROATIAN

METALLURGICAL SOCBERISLAVICEVA 6, ZAGREB, CROATIA. Volume: 54. Issue: 2. pp. 426-428. WOS:000343781300031. ISSN:0543-5846. eISSN:1334-2576.

Popescu, V. A., Popescu, G. N., Popescu, C. R. G. (2015e). The Impact Of Global Crisis On The Dominant Sectors Of The Economy At The Romanian Industry. *Metalurgija*. CROATIAN METALLURGICAL SOCBERISLAVICEVA 6, ZAGREB, CROATIA. Volume: 54. Issue: 2. pp. 289-291. WOS:000341740000076. ISSN:0543-5846. eISSN:1334-2576.

Popescu, V. A., Popescu, G. N., Popescu, C. R. G. (2014). The Economic And Social Dimensions Of Romania's Metallurgical Industry. *Metalurgija*. CROATIAN METALLURGICAL SOCBERISLAVICEVA 6, ZAGREB, CROATIA. Volume: 53. Issue: 1. pp. 113-115. WOS:000320481400029. ISSN:0543-5846. eISSN:1334-2576.

Punja, Z. K., Kahl, D., Reade, R., Xiang, Y., Munz, J., & Nachappa, P. (2023). Challenges to *Cannabis sativa* Production from Pathogens and Microbes-The Role of Molecular Diagnostics and Bioinformatics. *International journal of molecular sciences*, *25*(1), 14. https://doi.org/10.3390/ijms25010014.

Punja Z. K. (2021). Emerging diseases of Cannabis sativa and sustainable management. *Pest management science*, *77*(9), 3857–3870. https://doi.org/10.1002/ps.6307.

Rizzo, G., Storz, M. A., & Calapai, G. (2023). The Role of Hemp (*Cannabis sativa* L.) as a Functional Food in Vegetarian Nutrition. *Foods (Basel, Switzerland)*, *12*(18), 3505. https://doi.org/10.3390/foods12183505.

Rupasinghe, H. P. V., Davis, A., Kumar, S. K., Murray, B., & Zheljazkov, V. D. (2020). Industrial Hemp (*Cannabis sativa* subsp. *sativa*) as an Emerging Source for Value-Added Functional Food Ingredients and Nutraceuticals. *Molecules (Basel, Switzerland)*, *25*(18), 4078. https://doi.org/10.3390/molecules25184078.

United Nations & United Nations Conference on Trade and Development. (2024a). Measuring Trade in Hemp Products: Why it Matters and What Needs to Change. Retrieved from: https://unctad.org/news/measuring-trade-hemp-products-why-it-matters-and-what-needs-change. Accessed on the 15th of May 2024.

United Nations & United Nations Conference on Trade and Development. (2024b). Measuring Global Exports Of İndustrial Hemp Products Insights From National Product Classifications. Geneva. Retrieved from: https://unctad.org/system/files/official-document/ditccom2024d1_en.pdf. Accessed on the 1st of May 2024.

United Nations & United Nations Conference on Trade and Development. (2023a). Workshop on İndustrial Hemp. Retrieved from: https://unctad.org/meeting/workshop-industrial-hemp. Accessed on the 1st of May 2024.

United Nations & United Nations Conference on Trade and Development. (2023b). Polıcy Brıef. No. 110. Retrieved from: https://unctad.org/system/files/official-document/presspb2023d4_en.pdf. Accessed on the 1st of May 2024.

United Nations & United Nations Conference on Trade and Development. (2023c). Plastic Pollution. The pressing case for natural and environmentally friendly substitutes to plastics. ISBN: 978-92-1-101475-4 eISBN: 978-92-1-002722-9 Sales No. E.23.II.D.11. Retrieved https://unctad.org/system/files/official-document/ditcted2023d2_en.pdf. Accessed on the 1st of May 2024.

United Nations & United Nations Conference on Trade and Development. (2022a). Commodities at a Glance. Special Issue on Industrial Hemp. No. 16. eISBN: 978-92-1-001995-8. eISSN: 2522-7866. Retrieved from: https://unctad.org/system/files/official-document/ditccom2022d1_en.pdf. Accessed on the 1st of May 2024.

United Nations & United Nations Conference on Trade and Development. (2022b). Hemp's versatility and sustainability offer huge opportunities for developing countries. A new UNCTAD report examines the plant's economic, environmental and social potential. Retrieved from: https://unctad.org/news/hemps-versatility-and-sustainability-offer-huge-opportunities-developing-countries. Accessed on the 1st of May 2024.

United Nations & United Nations Conference on Trade and Development. (2022c). Substitutes for Single-Use Plastics in Sub-Saharan Africa and South Asia. Annexes. Retrieved from: https://unctad.org/system/files/official-document/tcsditcinf2022d3_annexes_en.pdf. Accessed on the 1st of May 2024.

United Nations & United Nations Conference on Trade and Development. (2022d). Substitutes for Single-Use Plastics in Sub-Saharan Africa and South Asia Case Studies from Bangladesh, Kenya and Nigeria. Retrieved from: https://unctad.org/system/files/information-document/tcsditcinf2022d3_en_0.pdf. Accessed on the 1st of May 2024.

United Nations & United Nations Conference on Trade and Development. (2022e). Bamboo as alternate structural material. United Nations Conference on Trade and Development 13th Multi-Year Expert Meeting on Commodities and Development 10-12 October 2022, Geneva. Retrieved from: https://unctad.org/system/files/non-official-document/MYEM-ITEM_3c-Molari-12.10.22.pdf. Accessed on the 1st of May 2024.

United Nations & United Nations Conference on Trade and Development. (2021). Material Substitutes to Address Marine Plastic Pollution and Support a Circular Economy: Issues and Options for Trade Policymakers. Retrieved from: https://unctad.org/system/files/official-document/ditctedinf2021d5_en.pdf. Accessed on the 1st of May 2024.

United Nations & United Nations Conference on Trade and Development. (2018). UNCTAD TRAINS: The Global Database on Non-Tariff Measures User Guide (2017, Version 2). Retrieved from: https://unctad.org/system/files/official-document/ditctab2017d3_en.pdf. Accessed on the 1st of May 2024.

United Nations, United Nations Conference on Trade and Development, & United Nations Conference on Trade and Development and United Nations Economic and Social Commission for Asia and the Pacific. (2023). Trade regulations for climate action? New insights from the global non-tariff measures database. eISBN: 978-92-1-358649-5. Retrieved https://unctad.org/system/files/official-document/ditctab2023d5_en.pdf. Accessed on the 1st of May 2024.

Vandenhove, H., & Van Hees, M. (2005). Fibre crops as alternative land use for radioactively contaminated arable land. *Journal of environmental radioactivity*, *81*(2-3), 131–141. https://doi.org/10.1016/j.jenvrad.2005.01.002.

GREEN ARCHITECTURE: DESIGNING ZERO-CARBON BUILDINGS FOR ENHANCED PUBLIC HEALTH

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Abstract

As escalating climate change dangers and swelling public health issues loom larger, zero-carbon structures stand out as a pivotal answer, heralding a change of framework toward sustainable progress and ecological guardianship. The scientific article explores the notion of zero-carbon structures as a revolutionary means of decreasing worldwide greenhouse gas emissions and shielding communal wellbeing, delving into how optimizing structures to generate no carbon footprints could significantly lessen health-harming discharges and slow the pace of climate alteration. Through a wide-ranging, cross-disciplinary evaluation, we deconstruct the processes by which zero-carbon structures accomplish net-zero emissions, drawing from innovative architectural plans, cutting-edge energy efficiency technologies, and the amalgamation of renewable energy sources. We explore the multifaceted benefits these buildings offer, including substantial decreases in carbon footprints, enhancement of indoor environmental quality, and promotion of occupants' health and productivity, thereby contributing to the broader goals of environmental protection and sustainability.

The challenges impeding the widespread adoption of zero-carbon buildings are critically examined, encompassing technological hurdles, economic barriers, and socio-cultural resistance, alongside strategies to navigate these obstacles. The role of policy frameworks, financial incentives, and educational outreach in facilitating the transition to zero-carbon construction practices is thoroughly analyzed, highlighting successful global initiatives and case studies that exemplify the practicality and effectiveness of these solutions.

We propose that future work in this domain must call for interdisciplinary teamwork between architects, engineers, policymakers, and the community to pioneer and apply solutions on a large scale to achieve carbon neutrality. The article proposes adopting a comprehensive tactic that combines urban planning, green infrastructure development, and behavioral modification cultivation to cultivate communities that are resilient, health-enhancing, and ecologically sustainable.

Conclusively, this article posits zero-carbon buildings at the forefront of the movement towards a sustainable future, underscoring the urgency for collective action among stakeholders across sectors to embrace and advance this green revolution. By aligning efforts to promote zero-carbon buildings, we can achieve significant strides in public health improvement, environmental preservation, and climate change mitigation, ensuring a viable, thriving planet for future generations.

Keywords: Zero-Carbon Buildings; Sustainable Architecture; Environmental Protection; Public Health; Climate Change Mitigation.

EXAMINATION OF HEMP-BASED GARMENT FABRICS AS FORENSIC EVIDENCE AND COMPARISON WITH OTHER TYPE FABRIC

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Abstract

With the advancement of technology, fabrics meeting the dressing and body preservation needs of individuals can be obtained from various raw materials. Fabric types may include cotton, wool, linen, polyester, hemp, and others. Fabrics made from hemp, due to their organic farming, sustainability, and biodegradability, are used by many people. However, hemp is also the raw material for marijuana, a psychoactive substance, and as a result, its production and cultivation are banned in some countries.

In this study, the characterization of garments produced from hemp-type fabrics commercially available in our country has been carried out. The first stage involves collecting samples of commercially available hemp-based fabric and researching the properties of the products. By comparing different producers and products, the usage density of hemp-based fabrics has been investigated. In the next stage, the determination of hemp-based fabric products was carried out using FTIR (Fourier-transform infrared) spectroscopic methods. The physical appearance of the fabrics was investigated using macroscopy. Moreover, hemp-based garments were compared with other types of commercially available garments (cotton, polyester, hybrid, acrylic). The unique value of this study lies in the spectroscopic examination of washed garments containing hemp-based evidence, comparing the behavior of hemp fabrics towards different liquids with other fabric types, and the possibility of encountering hemp-based evidence at crime scenes.

Keywords: Hemp fiber, Forensic evidence, FTIR, crime scene.

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ECO-FRIENDLY INDUSTRIAL HEMP SUPPORTING THE CIRCULAR ECONOMY

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Abstract

The circular economy is an economic paradigm that prioritizes continuity and environmental preservation throughout the entire process, from the extraction of raw materials for production to waste generation. Protocols, including alternatives, technologies, and practices, facilitating the substitution of non-renewable natural resources with resources recovered from waste, fulfill the socioeconomic and environmental objectives of the circular economy concept. Given the escalating interest in industrial hemp and the implementation of legalization policies, there has been significant research into the diverse applications of this valuable crop in recent years. Following plant breeding, industrial hemp should be reconsidered as a 'resource' rather than a 'waste' within the framework of a more comprehensive circular economy model. The efficacy of hemp in phytoremediation and its role in mitigating air pollution during growth are well-documented. Following harvest, the plant's fibers can be utilized to produce textile and biopolymer products. Furthermore, the residual harvest waste can be utilized in biomethane production, while biochar derived through pyrolysis can serve as activated carbon in water treatment applications. This study aims to assess the environmentally beneficial aspects of industrial hemp and its contributions to the circular economy. Numerous studies suggest that the utilization of industrial hemp holds promise for fostering a sustainable, environmentally friendly, and economically viable future.

Keywords: Hemp, environment, circular economy, phytoremediation

EVALUATION THE POTENTIAL OF INDUSTRIAL HEMP (*CANNABIS SATIVA* L.) AS A FORAGE SOURCE IN RUMINANT NUTRITION

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Abstract

Hemp (*Cannabis* subsp.) is a very old cultivated plant that is generally grown for the oil obtained from its seeds and the fiber obtained from its stems. Various parts of this plant have been used for thousands of years in different sectors such as food, feed, medicine, cosmetics, textile, shipping and construction. In many countries of the world, the cultivation of cannabis plants is limited due to the naturally occurring psychoactive substance called tetrahydrocannabinol (THC). Hemp containing trace amounts (<1%) of THC compared to other cannabis species; it is scientifically classified under the name of cultivated, commercial or industrial genus (*Cannabis sativa* L.).

There is no THC component in the seeds of the industrial hemp plant. Hemp seeds, which are rich in protein and energy as well as their high oil content, are used in the nutrition of many animal species, especially poultry, ornamental birds, horses and cattle. Hemp seeds are also rich in omega-3 and omega-6 fatty acids, which can support the health of animals. However, the use of the vegetative parts of industrial hemp as roughage is not very common due to its high fiber and low protein content. Questions such as appropriate processing techniques to eliminate these known disadvantages, maximum usage amounts, substitution rates, whether grazing is possible or whether grazing has an effect on live weight gain and productivity performances are still not fully answered. However, there are almost no studies on how the nutritional values of industrial hemp, which is known to grow quite quickly, change over time during the vegetation periods and whether there are differences between existing varieties.

In this study, research conducted to evaluate the potential of using industrial hemp as an alternative forage source, especially in the nutrition of ruminant animals, was examined and compiled and solutions to some problems were suggested.

Keywords: hemp, forage, roughage, silage, ruminant, nutrition, cannabis sativa

ZEMİN İYİLEŞTİRİLMESİNDE DOĞAL LİFLERİN KULLANIMININ DEĞERLENDİRİLMESİ

EVALUATION OF THE USE OF NATURAL FIBERS IN SOIL IMPROVEMENT

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Özet

Geoteknik mühendisleri çalışma sahalarında sıklıkla problemli zeminler ile karşılaşmaktadır. Problemli zeminler düşük taşıma gücü, aşırı ve farklı oturma, sıvılaşma gibi olumsuz özellikler göstermektedir. Bu zeminlerin yapılaşmaya uygun hale getirilmesi için çeşitli zemin iyileştirme teknikleri kullanılmaktadır. Son zamanlarda araştırmacılar tarafından sıkça tercih edilen zemin iyileştirme yöntemlerinden biri zemine ayrık lif eklenmesidir. Lif katkılı zemin iyileştirme yöntemlerinde tercih edilen liflerin başında sentetik lifler bulunmaktadır. Sentetik lifler petrol esaslı malzemelerden oluşan yüksek basınç ve çekme mukavemetine sahip liflerdir. Ancak dünya çapında çevre dostu ve sürdürülebilirlik kavramlarına olan ilgi zemin iyileştirilmesinde doğal lif kullanımına yönelik araştırmaları ortaya çıkarmıştır. Bu doğrultuda zemin iyileştirmesinde kullanılan doğal liflerin başında Hindistan cevizi, mısır, küspe, hurma, kenevir lifleri bulunmaktadır.

Bu çalışmada sentetik ve doğal lifler ile yapılan zemin iyileştirme çalışmaları incelenmiştir. Doğal liflerin sentetik liflere alternatif olarak kullanılabilirliği değerlendirilmiştir. Literatürde araştırmacıların zeminlerin basınç dayanımının belirlenmesi için serbest basınç ve üç eksenli basınç deneyleri gerçekleştirdiği ayrıca Yol alt tabakasının iyileştirilmesinde lif katkısının değerlendirilmesi için ise CBR deneylerinin yapıldığı görülmektedir. Bu deneylerde zemin iyileştirmesinde %0,15-2,50 oranında ve 5-40 mm arasında değişen uzunluklarda lifleri kullanılmıştır.

Elde edilen veriler doğrultusunda doğal liflerin zeminin basınç dayanımını ve CBR değerlerini arttırdığı görülmüş ve sentetik liflere alternatif olarak kullanılabileceği belirlenmiştir. Doğal lifler içerisinde bulunan kenevir liflerinin yüksek çekme mukavemeti ve yüzey yapısı ile zeminde mukavemeti 3 kata kadar arttırdığı gözlemlenmiştir.

Anahtar Kelimeler: Doğal Lifler, Kenevir Lifi, Zemin Stabilizasyonu

Abstract

Geotechnical engineers often encounter problematic soils in their work areas. Problematic soils show negative characteristics such as low bearing capacity, excessive and uneven settlement, and liquefaction. Various ground improvement techniques are used to make these grounds suitable for construction. One of the soil improvement methods frequently preferred by researchers recently is the addition of split fibers to the soil. Synthetic fibers are the most preferred fibers in fiber-added soil improvement methods. Synthetic fibers are fibers with high pressure and tensile strength consisting of petroleum-based materials. However, worldwide interest in environmentally friendly and sustainability concepts has led to research on the use of natural fibers in soil improvement. In this regard, the main natural fibers used in soil improvement are coconut, corn, oil pulp, date palm and hemp fibers.

In this study, ground improvement studies using synthetic and natural fibers were examined. The usability of natural fibers as an alternative to synthetic fibers has been evaluated. In the literature, it is seen that researchers carried out unconfined pressure and triaxial pressure tests to determine the compressive strength of soils, and CBR tests were carried out to evaluate the fiber contribution in improving the road sublayer. In these experiments, fibers of 0.15-2.50% and lengths varying between 5-40 mm were used in soil improvement.

In line with the data obtained, it was seen that natural fibers increased the compressive strength and CBR values of the soil and it was determined that they could be used as an alternative to synthetic fibers. It has been observed that hemp fibers, which are among natural fibers, increase the strength in the ground up to 3 times with their high tensile strength and surface structure.

Key Words: Natural Fibers, Hemp Fiber, Ground Stabilization

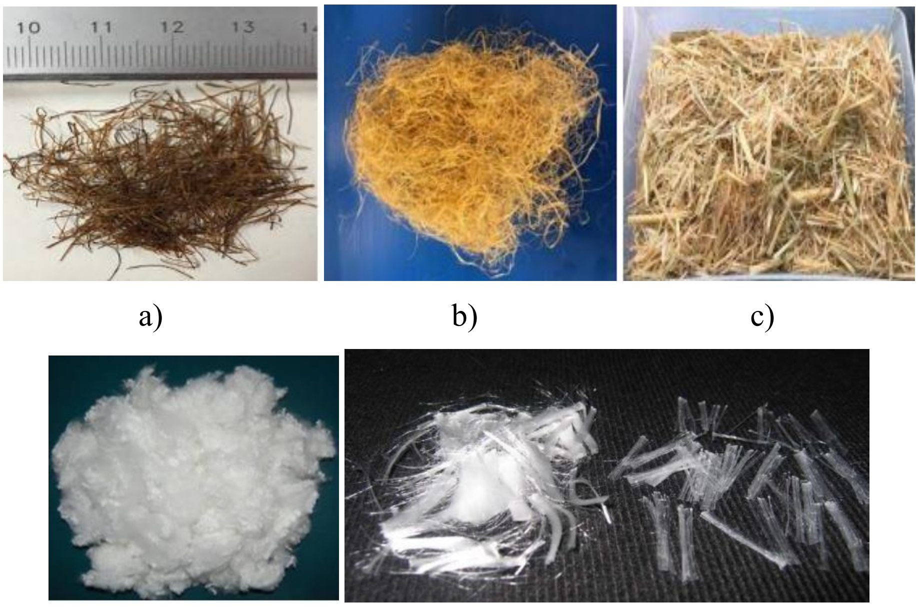
GİRİŞ

Yapılaşmaya uygun sağlam zemin alanları nüfus artışının da etkisiyle azalmıştır. Dolayısıyla problemli zemin alanlarının yapılaşmaya açılması bir zorunluluk haline gelmiştir. Düşük taşıma gücü, aşırı ve farklı oturma değerleri, yer altı suyuna ve dinamik bir etkiye bağlı sıvılaşma potansiyeli gibi durumlara sahip bu zeminler, zemin iyileştirme metotları ile iyileştirilmektedir. Zemin iyileştirmesinde pek çok farklı yöntem kullanılmaktadır. Bu yöntemler arasında taş kolon, jet grout, derin karıştırma, kompaksiyon, kireç, bitüm, çimento uçucu kül, lif vb. malzemeler ile stabilizasyon gibi teknikler bulunmaktadır. Son dönemde teknolojik ve malzeme alanındaki gelişmelere bağlı olarak zeminlerin güçlendirilmesinde sentetik ve doğal liflerin kullanımı yaygınlaşmıştır (Najjar vd., (2014); Cai vd., (2006)). Zeminlere lif ilavesi, maliyet açısından uygunluğu, esnekliği ve çevre dostu olması gibi olumlu özellikleri ile başarılı bir zemin iyileştirme tekniği olarak görülmektedir (Ahmad vd., (2019); Ammar vd., (2019); Najjar vd., (2014); Sharma vd., (2015); Choobbasti vd., (2018); Wei vd., (2018); Sravani vd., (2019); Tajdini vd., (2017); Gümüşer ve Şenol (2013)). Zemin iyileştirmede kullanılan liflerin başında sentetik lifler bulunmaktadır. Sentetik lifler polipropilen, polyester, polietilen, poliamid, taş yünü gibi ham maddelerden oluşmaktadır (Sravani vd., (2019); Tajdini vd., (2017); Gümüşer ve Şenol (2013)). Ancak, son zamanlarda dünya çapında farkındalık ve sürdürülebilirlik kavramlarına olan ilginin artması ile küresel ısınma, iklim değişikliği ve çevre kirliliğini önleyici uygulamalar üzerine çalışmalar yapılmaktadır. Bu durum geoteknik mühendisliği de dâhil olmak üzere çeşitli alanlarda daha çevre dostu ve sürdürülebilir malzeme arayışına yol açmıştır (Diab vd., (2016)). Bu doğrultuda araştırmacılar sentetik liflere alternatif olabilecek doğal lifler üzerine çalışmalar gerçekleştirmektedir. Literatürde incelenen doğal lifler arasında hurma, keten, Hindistan cevizi, kenevir gibi pek çok lif bulunmaktadır. Doğal liflerle yapılan çalışmalarda, genellikle lifli zeminlerin basınç dayanımı ve yol dolgusunda kullanılabilirliği incelenmiştir (Sharma vd., (2015); Butt vd., (2016); Diab vd., (2016); Hazra vd., (2017)). Bu amaçla araştırmacılar serbest basınç, üç eksenli basınç, CBR gibi deneyler gerçekleştirmektedir. Yapılan tüm araştırmalarda lif katkısının zemin mukavemetinde önemli bir iyileştirme gerçekleştirdiği belirlenmiştir.

Bu çalışmada sentetik ve doğal lifler ile yapılan zemin iyileştirme çalışmaları incelenmiştir. Doğal liflerin sentetik liflere alternatif olarak kullanılabilmesi karşılaştırmalı olarak değerlendirilmiştir. Bu amaç doğrultusunda literatürde gerçekleştirilen çalışmalarda yapılan deneyler, kullanılan lifler ve değişen deneysel parametreler incelenmiştir.

ARAŞTIRMA VE BULGULAR

Araştırmacılar çalışmalarında lif katkısının zemin iyileştirmeye etkisinin belirlenebilmesi amacıyla bir dizi üç eksenli basınç, serbest basınç, Kaliforniya Taşıma Oranı (CBR), doğrudan kesme ve çekme dayanımı deneyleri gerçekleştirmişlerdir. Çalışmalar neticesinde, zemine lif takviyesinin oturmayı azalttığı ve taşıma gücünü arttırdığı görülmektedir. Literatürde düşük ve yüksek plastisiteli kil zeminler, kötü derecelendirilmiş kum zeminler, killi ve siltli kumlar üzerinde çeşitli araştırmalar yapılmıştır. Lifler zemine ağırlıkça %0,15-2,5 oranlarında değişen aralıklarda katılmıştır. Tercih edilen lif uzunlukları ise 5-40 mm arasında değişmektedir. Araştırmalarda lif katkısı ile zemin iyileştirmesine zeminlerin su içeriklerinin, lif cinsinin, lif oranlarının ve lif uzunluklarının etkileri incelenmiştir (Şekil 1.).



a) b) c)

d) e)

***Şekil 1**. a) Mısır ipeği lifleri, b) kenevir lifleri, c) Buğday samanı lifleri, d) Polyester elyaf, e) Polipropilen lif*

Gümüşer ve Şenol (2013) yüksek plastisiteli kil zeminlerin iyileştirilmesinde uçucu kül ve 2 tip polipropilen lif kullanımını araştırmışlardır. Çalışmada yüksek plastisiteli kil zemine %0.5, %1 ve %1,5 oranında polipropilen lif ve multiflament polipropilen lif; %10, %15 oranında uçucu kül eklemişlerdir. Lif uzunlukları 6-12-24-34 mm olarak belirlenmiştir. Deneysel çalışma kapsamında CBR deneyleri gerçekleştirmişlerdir. Deney sonuçlarında %15 uçucu kül katkılı zemine %0,5 lif içeriği eklenmesi ile CBR değerlerinde 3 kata varan iyileştirmeler elde etmişlerdir. Benzer şekilde **Sravani vd., (2019)** yüksek plastisiteli kil zeminlerin iyileştirilmesinde silis dumanı ve sentetik liflerin (polipropilen ve polyester) etkisini incelemişlerdir. Çalışmada katkı olarak %4, %6, %8 ve %10 oranında silis dumanı; %0.2, %0.4, %0.6 ve %0.8 oranlarında polipropilen ve polyester elyaflar kullanmışlardır. Deneysel çalışma kapsamında konsolidasyon, serbest basınç ve CBR deneyleri gerçekleştirmişlerdir. Araştırma sonucunda silis dumanı katkılı kil zemine %0,8 polyester lif eklenmesi ile serbest basınç dayanımında 3 kata varan ve CBR değerlerinde 4 kata varan iyileşmeler gözlemlemişlerdir. **Rabab'ah vd., (2021)** şişen zeminler (yüksek plastisiteli silt) üzerinde cam elyaf katkısını araştırmışlardır. Çalışmalarında kil zemine katkı olarak %0.25, 0.5, 0.75 ve 1 oranlarında cam elyaf katkısı eklemişlerdir. Deneysel çalışma kapsamında serbest şişme, serbest basınç ve CBR deneyleri gerçekleştirmişlerdir. Araştırma sonucunda deney verileri %1 lif katkısının zeminin serbest basınç değerlerinde 5 kata varan ve CBR değerlerlerinde 5 kata varan iyileştirmeler olduğu gözlemlenmiştir. Aynı zamanda sentetik lif katkılı zeminlerin şişme yüzdesi değerleri katkısız zemine oranla düşmüştür. Literatürde sentetik liflerle yapılan zemin iyileştirme çalışmalarının yanında doğal liflerle gerçekleştirilen zemin iyileştirme çalışmaları da bulunmaktadır. Yapılan çalışmalarda mısır lifleri, Hindistan cevizi lifleri, kenevir lifleri ve çeşitli yerel bitkisel lifler tercih edilmektedir. **Maity vd., (2018)** farklı doğal liflerin zemin iyileştirmesinde kullanılabilirliğini karşılaştırmalı olarak incelemişlerdir. Çalışmalarında orta plastisiteli kil zemine Jüt lifi, Hindistan cevizi lifi ve Sabai otu lifi katkısı ilave etmişlerdir. Lifleri 5, 10, 20 mm uzunluklarda ve %1, %1.5, %2, %2.5 oranlarında zemin ile karıştırmışlardır. Deneysel çalışma kapsamında serbest basınç ve CBR deneyleri gerçekleştirmişlerdir. Araştırma verilerine göre 20 mm Hindistan cevizi lifi katkılı zeminin serbest basınç dayanımında 3 kata varan ve CBR değerlerinde 2 kata varan iyileşmeler elde etmişlerdir. **Sharma vd., (2015)** %2,5 oranında çimento ile stabilize edilen siltli zeminlerin Grewia Optivia (Beul) ve Pinus Roxburghii (Chir Pine) isimli Hindistan'da yetişen yerel bitkilerin lifleri ile iyileştirilmesini araştırmışlardır. Çalışmalarında 7, 14, 28, 56, 90 günlük kür sürelerinden sonra serbest basınç deneyleri gerçekleştirmişlerdir. 90 günlük %2 Grewia Optivia (Beul) lifi katkılı zeminlerin serbest basınç dayanımında katkısız zemine oranla 10 kata varan iyileştirmeler elde etmişlerdir. Benzer şekilde siltli zeminlerin iyileştirmesi üzerine **Zhang vd., (2021)** kireç ile stabilize edilen zeminlerin iyileştirilmesinde jüt liflerinin etkisini incelemişlerdir. Çalışmalarında siltli zemine ağırlıkça %3, %6 ve %9 kireç eklenirken %0.5, %1 ve %1.5 oranlarında jüt lifi eklemişlerdir. Deneysel çalışmalarda 7 ve 28 günlük kür süreleri dikkate alınmış ve serbest basınç deneyleri gerçekleştirmişlerdir. Deneysel çalışmadan elde ettikleri verilere göre 28 günlük ağırlıkça %9 kireç katkılı zeminlere %1 jüt lifi eklenmesi ile serbest basınç dayanımında 2 kata varan mukavemet artışı elde etmişlerdir. Literatürde kenevir lifleri ile yapılan zemin iyileştirme çalışmaları incelendiğinde, farklı lif oranları ve lif uzunlukları kullanıldığı görülmektedir. **Najjar vd., (2014)** düşük plastisiteli kil zeminlerin kenevir lifleri ile güçlendirilmesini araştırmışlardır. Çalışmalarında zemine 25 mm uzunluğunda ve %0.15, %0.3, %0.4, %0.5 ve %1 oranlarında kenevir lifi ekleyerek üç eksenli basınç deneyleri (UU) gerçekleştirmişlerdir. Deneysel çalışma sonucunda %1 lif katkılı zeminin mukavemetinde 3 kata varan iyileştirmeler elde etmişlerdir. **Diab vd., (2016)** değişen su içeriklerinde (%14, %18 ve %20) kenevir lifleri ile güçlendirilmiş düşük plastisiteli kil zeminlerin mukavemetlerini üç eksenli basınç deneyleri (UU) yaparak incelemişlerdir. Çalışmalarında zemine 40 mm uzunluğunda ve %0.5, %0.75, %1, %1.25 ve %1.5 oranlarında kenevir lifi katkısı eklemişlerdir. Araştırma verilerine göre %14 su içeriğinde ve %1.25 lif içeriğinde hazırlanan zemin numunelerinin mukavemetinde katkısız zemine oranla 3 kata varan iyileştirmeler elde edilmiştir. **Hazra vd., (2017)** zemin iyileştirmesinde kenevir elyafı kullanılmasını araştırmışlardır. Çalışmalarında düşük plastisiteli kil zemin farklı uzunluklarda (10, 20 ve 30 mm) ve farklı oranlarda (%0,5, %1, %1,5 ve %2) kenevir lifi ilave etmişlerdir. Deneysel çalışma kapsamında CBR deneyleri gerçekleştirmişlerdir. Elde edilen sonuçlar incelendiğinde 30 mm ve %1,5 lif içeriğine sahip zeminin CBR değerinde katkısız zeminin CBR değerine oranla 2 kata varan iyileştirmeler olduğu gözlemlenmiştir. **Ahmad vd., (2019)** kenevir lifi ile güçlendirilmiş düşük plastisiteli kil zeminlerin dayanımını değişen su içeriklerinde (%18,%20) konsolidasyonlu drenajlı üç eksenli basınç deneyleri yaparak incelemişlerdir. Araştırmada killi zeminlere lif katkısı olarak 40 mm uzunluğunda %1.25

oranında kenevir lifi eklemişlerdir. Deneysel çalışmada %18 su içeriğinde lif katkılı zeminlerin kohezyon ve içsel sürtünme açısı değerlerinde artış gözlemlenmiştir. Araştırmacılar sentetik ve doğal liflerin zemin iyileştirilmesinde kullanıldığı ve karşılaştırılmalı incelendiği çalışmalar da gerçekleştirmiştir. **Özdemir, (2019)** uçucu kül katkılı killi zeminlerin doğal (saman, kendir) ve sentetik (polyester iplik) lif türleri geoteknik özelliklerinin değişimini araştırmıştır. Kil zemine, %0.5, %1 ve %1.5 oranlarında ve 2 mm, 5 mm uzunluğunda lif eklenerek serbest basınç deneyleri gerçekleştirilmiştir. Deney sonuçlarından elde edilen verilere göre %10 uçucu kül, %1.5 kendir katkısının ve %10 uçucu kül, %1.5 polyester lif katkısının katkısız zeminin basınç dayanımına oranla 3 kata varan iyileştirmeler sağladığı belirlenmiştir. **Nezhad vd., (2021)** düşük plastisiteli kil zeminlerin doğal ve sentetik liflerle iyileştirmesini araştırmışlardır. Çalışmalarında doğal liflerden küspe ve bazaltı; sentetik liflerden polyesteri kullanmışlardır. Deneysel çalışmalarda %0.5, %1 ve %2 lif içeriklerini ve 2.5, 5, 7.5 mm lif uzunluklarını tercih etmişlerdir. Araştırma kapsamında CBR ve üç eksenli basınç deneyleri gerçekleştirmişlerdir. Deney sonuçlarına göre, ağırlıkça %2 ve 7.5 mm liflerle hazırlanan zemin numunelerinin CBR verilerinin en yüksek olduğunu belirlemişlerdir. CBR deneylerinde polyester liflerin doğal liflere göre daha yüksek katkı sağladığını tespit etmişlerdir. Üç eksenli basınç deney sonuçlarına göre bazalt liflerinin içsel sürtünme açısını 2 kat arttırdığını ve polyester liflerin kohezyonu %71 arttırdığını belirlemişlerdir.

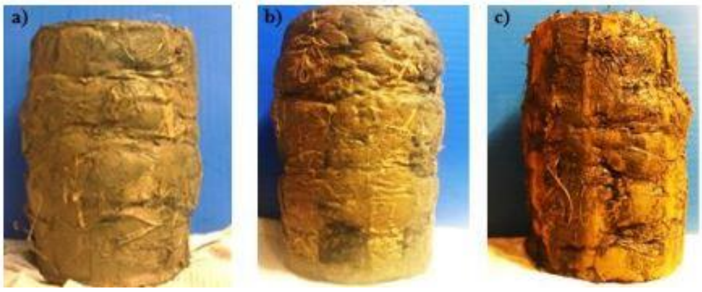
Lif katkısı ile (doğal ve sentetik) zemin iyileştirmesi üzerine yapılan araştırmalar Tablo 1.'de özet olarak verilmiştir.

Tablo 1. *Literatürde lif katkısı ile zemin iyileştirmesi üzerine yapılan çalışmaların özeti*

Zemin Cinsi	Kullanılan Lif Türü	Lif Uzunluğu, mm	Lif Oranı	Gerçekleştirilen Deneyler	Elde Edilen İyileşme Oranı	Araştırmacı
CH	Polipropilen Multiflament Polipropilen	6-12-24-34	%0.5, %1, %1.5	CBR	3 Kat	Gümüşer ve Şenol (2013)
CL	Kenevir	25	%0.15, %0.3, %0.4, %0.5, %1	Üç Eksenli Basınç Deneyi (UU)	3 Kat	Najjar vd. (2014)
CL	Kenevir	10, 20, 30	%0,5, %1, %1,5, %2	CBR	2 Kat	Hazra vd. (2017)
CL	Jüt, Hindistan Cevizi, Sabai Otu	5, 10 ,20	%1, %1.5, %2, %2.5	Serbest Basınç (SB), CBR	SB= 3 Kat CBR= 2 Kat	Maity vd. (2018)
CL	Kenevir	40	%1.25	Üç Eksenli Basınç Deneyi (CD)	2 Kat	Ahmad vd. (2019)
CH	Kendir, Polyester	2, 5	%0.5, %1, %1.5	Serbest Basınç	3 Kat	Özdemir (2019)
MH	Cam Elyafı	-	%0.25, %0.5, %0.75, %1	Serbest Basınç, CBR	SB= 5 Kat CBR= 5 Kat	Rabab'ah vd. (2021)
MH	Jüt	-	%0.5, %1, %1.5	Serbest Basınç	2 Kat	Zhang vd. (2021)

Araştırmacılar, lif katkısı ile zemin iyileştirme yöntemi için çeşitli zemin tiplerinde gerçekleştirdikleri serbest basınç ve üç eksenli basınç deneylerinin sonuçlarından liflerin zemin dayanımını ve şekil değiştirme yeteneğini arttırdığını gözlemlemişlerdir (Özdemir, (2019); Najjar vd., (2014); Ahmad vd., (2019)). Bu durum liflerin zemin daneleri arasında bağlantı sağlayarak zemine süneklik kazandırması ile açıklanabilmektedir. Şekil 2.'de Ahmad vd. (2019)'nin üç eksenli basınç deneyi uyguladığı kenevir lifi katkılı zemin numuneleri ve Şekil 3.'te Özdemir (2023)'in serbest basınç deneyi uyguladığı kenevir lifi katkılı numunelerin basınç kuvveti altında sünek davranış gösterdiği fark edilmektedir. Doğal liflerle yapılan çalışmalarda liflerin yüzey yapısına bağlı olarak zemin-lif arasındaki sürtünme kuvvetinin sentetik liflere göre daha fazla olduğu gözlemlenmiştir (Anggraini, (2016); Ammar vd., (2018)). Doğal liflerin yüzey yapısının zemin ile aderansının yüksek olması liflerin zeminden sıyrılmasını güçleştirmektedir. Araştırmacı elde ettiği bu sonuç üzerinde kenevir liflerinin zemin ile aderansının fazla olmasının etkili olduğunu belirtmektedir. Lif katkılı zeminlerin yol alt temel tabakasında kullanılabilirliğinin incelendiği araştırmalar da literatürde yer almaktadır. Bu çalışmalarda lif katkısının belli bir orana kadar CBR değerlerini arttırdığı gözlemlenmiştir. CBR deneylerinde optimum değeri aşan lif oranı zemin içerisinde zayıf yüzeyler oluşmasına sebep olarak dayanımı düşürmektedir. Bu durum Şekil 4.'te verilen Hazra, D., vd. (2017)'nin kenevir lifi katkılı numuneler üzerinde gerçekleştirdikleri CBR deney sonuçlarında da görülmektedir.

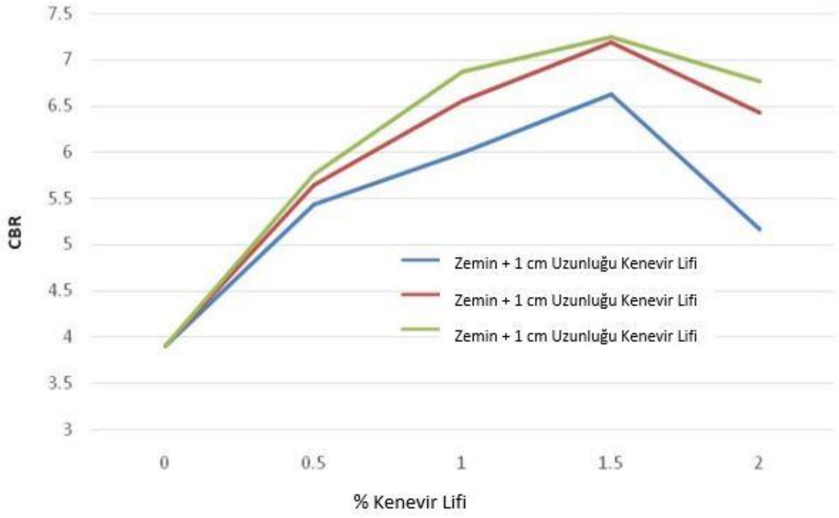
1.4.



***Şekil 2.** a) 20 kPa, b) 100 kPa, c) 200 kPa çevre basıncı altında üç eksenli basınç deneyi uygulanan kenevir lifi katkılı numunelerin deney cihazından çıkan görüntüleri (Ahmad vd. (2019))*

(a) (b)

***Şekil 3.** a) CH zemin numunesinin serbest basınç deneyi altında kırılma davranışı b) Kenevir lifi katkılı CH zemin numunessinin serbest basınç deneyi altında kırılma davranışı (Özdemir, (2023))*



Şekil 4. *Hazra vd. (2017)'nin kenevir lifi katkılı zeminlerde gerçekleştirdiği CBR deney sonuçları*

SONUÇLAR

Bu çalışmada zemin takviyesi olarak sentetik ve doğal liflerin kullanımı incelenmiştir. Doğal liflerle yapılan zemin iyileştirme yöntemlerinin çevre dostu çözümler sunması, erişilebilir olması, maliyet açısından uygunluğu ve tarımsal ekonomiye katkı sağlaması ile pek çok avantajının bulunduğu belirlenmiştir.

Literatürde yapılan deneysel çalışmalardan elde edilen veriler değerlendirildiğinde değişen zemin türleri dikkate alınarak doğal liflerin zeminlerin basınç dayanımlarında 3 kata varan artışlar sağladığı belirlenmiştir. Aynı zamanda, doğal lif katkısı zeminlerin CBR değerlerini, kohezyon ve içsel sürtünme açısı değerlerini 2 kata kadar arttırmaktadır.

Kenevir lifleri ile yapılan çalışmalar incelendiğinde kenevir lifi katkılı zeminlerin sentetik lif katkılı zeminlerle benzer iyileştirmeler yaptığı gözlemlenmiştir. Bu iyileştirme değerleri değişen zemin türü, lif oranı, lif uzunlukları vb. değerler göz önünde bulundurulduğunda farklı oranlarda gerçekleşmektedir. Kenevir lifleri yüksek çekme mukavemeti gösteren ve yüzey yapısı nedeniyle zeminle aderansı güçlü olan liflerdir. Bu yapıları sayesinde zeminde gevrek kırılma davranışını önleyerek zeminin şekil değiştirme özelliklerini iyileştirmektedir. Araştırmacılar kenevir lifleri ile gerçekleştirdikleri serbest basınç ve üç eksenli basınç deneylerinde 3 kata varan, CBR deneylerinde 2 kata varan iyileştirmeler olduğunu gözlemlemiştir.

KAYNAKLAR

Ahmad, M. E., Sadek, S., Najjar, S., (2019). Drained Triaxial Response of Clay Reinforced with Natural Hemp Fibers. (s. 305-314). Geo-Congress.

Ammar, A., Najjar, S., Sadek, S. (2018). Interface Resistance between Clays and Natural Hemp Fibers. *The International Foundations Congress & Equipment Expo*.

Anggraini, V. (2016). *Potential of Coir Fibres as Soil Reinforcement.* Pertanika Journal of Scholarly Research Reviews.

Butt, W.A., Mir, B.A., Jha, J.N., (2016). Strength Behavior of Clayey Soil Reinforced with Human Hair as a Natural Fibre. *Geotechnical and Geological Engineering*.

Cai, Y., Shi, B., Ng, C. W., & Tang, C.-s. (2006). Effect of polypropylene fibre and lime admixture on engineering properties of clayey soil. Engineering geology, 87(3), 230-240.

Choobbasti, A.J., Samakoosh, M.A., Kutanaei, S. S. (2019). Mechanical Properties Soil Stabilized with Nano Calcium Carbonate and Reinforced with Carpet Waste Fibers. *Construction and Building Materials*

Diab, A.A., Sadek, S., Najjar, S., Daya, M.H.A. (2016). Undrained Shear Strength Characteristics of Compacted Clay Reinforced with Natural Hemp Fibers. *International Journal of Geotechnical Engineering*.

Dutta, R., Khatri, V. N., & Venkataraman, G. (2012). Effect of addition of treated coir fibres on the compression behaviour of clay. Journal of Civil Engineering (IEB), 40(2), 203-214.

Gümüşer, C., Şenol, A. (2013). Effect of Fly Ash and Different Lengths of Polypropylene Fibers Content on The Soft Soils. *International Journal of Civil Engineering*.

Hazra, D., Maity, H., Chattopadhyay, B.C.. (2017). Application of Hemp Fibre for Subgrade Improvement. *International Journal of Engineering and Advanced Research Technology*.

Jiang, P., Chen, Y., Li, N., Zhou, L., Wang, W. (2022). Strength Properties and Microscopic Mechanism of Lime and Fly Ash Modified Expandable Poly Styrene Lightweight Soil Reinforced by Polypropylene Fiber. *Case Studies in Construction Materials*.

Maity, J., Chattopadhyay, B.C., Mukherjee, S.P. (2018). Improvement of Characteristics of Clayey Soil Mixed with Randomly Distributed Natural Fibers. *Journal of The Institution of Engineers (India)*.

Mandal, J., & Murthi, M. (1989). Potential use of natural fibres in geotechnical engineering. Paper presented at the Proceedings of the International Workshops on Geo-Textiles, Bangalore, November.

Mishra, M., Maheshwari, U. K., and Saxena, N. K., (2016). "Improving Strength of Soil using Fiber and Fly ash -A Review", International Research Journal of Engineering and Technology.

Mishra, M., Maheshwari, U. K., Saxena, N. K. (2016). Improving Strength of Soil using Fiber and Fly ash -A Review. *International Research Journal of Engineering and Technology*.

Najjar, S.S., Sadek, S., Taha, H. (2014). The Use of Hemp Fibers in Sustainable Compacted Clay Systems. *Geo-Congress*.

Nezhad, M. G., Tabarsa, A., Latifi, N. (2021). Effect of Natural and Synthetic Fibers Reinforcement on California Bearing Ratio and Tensile Strength of Clay. *Journal of Rock Mechanics and Geotechnical Engineering*.

Özdemir, B. (2019), Doğal/Sentetik Lif ve Uçucu Kül Katkılı Killerin Bazı Geoteknik Özelliklerinin Araştırılması (Yüksek Lisans Tezi), 33-38 Atatürk Üniversitesi, Erzurum.

Özdemir, A. M. (2023), Kenevir Liflerinin, Mermer Tozu Ve Uçucu Kül İle İyileştirilmiş Killi Zeminlerin Dayanımına Etkisinin Araştırılması (Yüksek Lisans Tezi), Yozgat Bozok Üniversitesi, Yozgat.

Praveen, G.V., Kurre, P. (2021). Influence of Coir Fiber Reinforcement on Shear Strength Parameters of Cement Modified Marginal Soil Mixed with Fly Ash. *Materials Today: Proceedings*, 504-507.

Rabab'ah, S., Hattamleh, O. A., Aldeeky, H., Alfoul, B. A. (2021). Effect of Glass Fiber on the Properties of Expansive Soil and Its Utilization as Subgrade Reinforcement in Pavement Applications. *Case Studies in Construction Materials*.

Sarsılmaz, (2017), Zemin İyileştirme Yöntemlerinin Sınıflandırılması, İncelenmesi, Değerlendirilmesi ve Anılan Yöntemlerin Seçilme Kriterleri Üzerine Kapsamlı Bir Araştırma (Yüksek Lisans Tezi), 1-10, Ege Üniversitesi, İzmir.

Sharma, V., Vinayak, H.K., Marwaha, B.M. (2015). Enhancing Compressive Strength of Soil Using Natural Fibers. *Construction and Building Materials*.

Sravani, K., Kommu, S., Asadi, S.S. (2019). Effect of Synthetic Fibres and Silica Fume on Behavior of Expansive Soil. *International Journal of Recent Technology and Engineering*.

Tajdini, M., Bonab, B. H., Golmohamadi, S. (2018). An Experimental Investigation on Effect of Adding Natural and Synthetic Fibres on Mechanical and Behavioural Parameters of Soil–Cement Materials. *International Journal of Civil Engineering*

Tang, Q., Shi, P., Zhang, Y., Liu, W., and Chen, L., (2019). "Strength and Deformation Properties of Fiber and Cement Reinforced Heavy Metal-Contaminated Synthetic Soils", Advances in Materials Science and Engineering.

Tran, K. Q., Satomi, T., Takahashi, H. (2018). Improvement of Mechanical Behavior Reinforced with Both Lime and Four kinds of Fiber. *Construction and Building* Materials.

Wei, L., Chai, S. X., Zhang, H. Y., and Shi, Q., (2018). "Mechanical Properties of Soil Reinforced with Both Lime and Four kinds of Fiber", Construction and Building Materials.

Zhang, J., Deng, A., Jaksa, M. (2021). Enhancing Mechanical Behavior of Micaceous Soil with Jute Fibers and Lime Additives. *Journal of Rock Mechanics and Geotechnical Engineering*.

INDUSTRIAL HEMP AGRONOMY AND FIBRE VALUE CHAIN IN PAKISTAN: CURRENT PROGRESS, CHALLENGES, AND PROSPECTS

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Abstract

Pakistan is one of the most vulnerable countries to climate change. Being a country, where 23% of the country's GDP relies on agriculture, this is a serious cause of concern. Introducing industrial hemp in Pakistan can help build climate resilience in the agricultural sector of the country, as hemp has recently emerged as a sustainable, eco-friendly, resource-efficient, and climate-resilient crop globally. Hemp has the potential to absorb huge amounts of CO_2, nourish the soil, and be used to create various biodegradable and eco-friendly products. Hemp is twice as effective as trees at absorbing and locking up carbon, with 1 hectare (2.5 acres) of hemp reckoned to absorb 8 to 22 tonnes of CO_2 a year, more than any woodland. Along with its high carbon-sequestration ability, it produces higher biomass and can be successfully grown as a cover crop. Hemp can grow in almost all soil conditions and does not require pesticides. It has fast-growing qualities and needs only 120 days to be ready for harvest. Compared with cotton, hemp requires 50% less water to grow and can produce three times higher fiber yield with a lower ecological footprint. Recently, the Government of Pakistan has allowed the cultivation of industrial hemp for industrial and medicinal purposes, making it possible for hemp to be reinserted into the country's economy. Pakistan's agro-climatic and edaphic conditions are well-suitable to produce industrial hemp and its cultivation can bring economic benefits to the country. Pakistan can enter global markets as a new exporter of hemp products. The production of hemp in Pakistan can be most exciting to the workforce, especially for farmers participating in hemp markets. The minimum production cost of hemp makes it affordable to small holding farmers especially those who need their cropping system to be as highly sustainable as possible.

Dr. Saddam Hussain is leading the first pilot project of Industrial Hemp in Pakistan. In the past three years, he has been able to recruit high-impact research grants on industrial hemp as Principal Investigator. He has already screened the non-toxic hemp genotypes, tested the adaptability of exotic material in various agroecological conditions, formulated the production agronomy, and successfully developed the complete value chain. He has developed prototypes (fabric, denim, knitwear) using hemp fibre in collaboration with industrial partners, and has optimized the indigenous fibre processing techniques. In this lecture, Dr. Hussain will talk on hemp agronomy and its complete fibre value chain. He will discuss the current progress, and will highlight the major challenges and future research direction on hemp research.

INVESTIGATING THE THERAPEUTIC EFFECTS OF CANNABIDIOL ON SPORTS PERFORMANCE AND RECOVERY

SPOR PERFORMANSI VE İYİLEŞMEDE CBD UYGULAMALARININ ETKİNLİĞİNİN ARAŞTIRILMASI

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Abstract

This research aims to systematically examine the effects of CBD on sports performance and recovery. There are many methods available to optimize athletes' performance, but important challenges include post-injury recovery, muscle damage, pain management, anxiety, sleep disorders, as well as concentration and focus issues. In particular, CBD's anti-inflammatory, analgesic, and antioxidant effects offer promising potential to enhance athletes' performance and support recovery processes. Specifically, it provides significant benefits for conditions such as neuropathic pain, inflammation, and muscle damage. Therefore, many athletes prefer CBD as an alternative to traditional painkillers and anti-inflammatory drugs. However, the limited research in this field and the small-scale or methodological flaws in existing studies make it difficult to clarify the effects of CBD on sports performance and recovery. Furthermore, the potential effects of CBD on anxiety and sleep regulation are also being investigated. Stress and anxiety management in athletes are crucial for performance. CBD reduces anxiety, exhibits a calming eff ect on the mind and body, interacts with the endocannabinoid system to balance the body's sleep-wake cycle, thus providing a better sleep pattern for athletes. These effects make CBD an attractive option for athletes. Another area where CBD could have a significant impact is on athletes' concentration and focus. By regulating the activity of the endocannabinoid system, CBD is thought to enhance concentration and focus in athletes.

As a result, this research could be a significant step towards better understanding the effects of CBD on sports performance and recovery, as well as supporting the health and performance of athletes. Studies in this field indicate the need to focus not only on traditional methods but also on alternative treatment options to optimize athletes' performance. However, the lack of comprehensive research and methodological flaws in existing small-scale studies make it challenging to determine the effectiveness of CBD on sports performance and recovery. Ultimately, the effects of CBD on sports performance and recovery should be further investigated and carefully evaluated by health professionals.

Özet

Bu araştırma, CBD'nin spor performansı ve iyileşme üzerindeki etkilerini sistemli bir şekilde incelemeyi amaçlamaktadır. Sporcuların performansını optimize etmek için birçok yöntem mevcuttur ancak sporcuların karşılaştığı önemli zorluklar arasında sakatlık sonrası iyileşme, kas hasarı, ağrı yönetimi, anksiyete ve uyku bozuklukları ile kosantrasyon ve odaklanma

sorunları bulunmaktadır. Özellikle, CBD'nin anti-inflamatuar, analjezik ve antioksidan etkileri ile birlikte, sporcuların performansını artırmak, iyileşme süreçlerini desteklemek için umut vaat etmektedir. Spesifik olarak, nöropatik ağrı, enflamasyon ve kas hasarı gibi durumlar da önemli faydalar sağlamaktadır. Bu nedenle birçok sporcu, geleneksel ağrı kesici ilaçlar ve anti-enflamatuar ilaçlara alternatif olarak CBD'yi tercih etmektedir. Ancak, bu alandaki araştırmaların sınırlı olması ve mevcut çalışmaların küçük ölçekli veya metodolojik kusurlara sahip olması, CBD'nin spor performansı ve iyileşme üzerindeki etkilerini netleştirmeyi zorlaştırmaktadır. Öte yandan, CBD'nin anksiyete ve uyku düzenlemesi üzerindeki potansiyel etkileri de incelenmektedir. Sporcularda stres ve anksiyete yönetimi, performansın önemli bir parçasıdır. CBD anxieteyi azaltarak, zihin ve vücut üzerindeki sakinleştirici etki göstermekte, endokannabinoid sistemiyle etkileşime girerek vücudun uyku-uyanıklık döngüsünü dengelemekte, böylece, sporcular için daha iyi bir uyku düzeni sağlamaktadır. Bu etkiler, CBD'yi sporcular için çekici bir seçenek haline getirmektedir. CBD'nin önemli bir etkisi olabileceği alanlardan bir diğeri, sporcularda konsantrasyon ve odaklanma üzerindedir. Endokannabinoid sisteminin aktivitesini düzenleyerek, CBD'nin sporcularda konsantrasyonu ve odaklanmayı artırabileceği düşünülmektedir.

Sonuç olarak, bu araştırma, CBD'nin spor performansı ve iyileşme üzerindeki etkilerini daha iyi anlamak ve sporcuların sağlık ve performansını desteklemek için önemli bir adım olabilir. Bu alanda yapılan çalışmalar, sporcuların performansını optimize etmek için geleneksel yöntemlerin yanı sıra alternatif tedavi seçeneklerine de odaklanılması gerektiğini göstermektedir. Ancak, kapsamlı araştırma eksikliği ve mevcut küçük ölçekli çalışmalardaki metodolojik kusurlar, CBD'nin spor performansı ve iyileşme üzerindeki etkinliğini belirlemeyi zorlaştırmaktadır. Netice de, CBD'nin spor performansı ve iyileşme üzerindeki etkileri daha fazla araştırılmalı ve sağlık profesyonelleri tarafından dikkatle değerlendirilmelidir.

GİRİŞ

Araştırmalar, sporcuların limitlerini zorlamadıklarını ve performanslarını en üst seviyeye çıkarmak için bilinen tüm metodları uyguladıklarını göstermektedir. Ancak, sakatlık sonrası iyileşme, kas hasarı, ağrı yönetimi, ansiyete ve uyku bozuklukları gibi durumlar sporcuların performansını tehdit eden önemli faktörler arasında sayılabilir. Özellikle nöropatik ağrı ve enflamasyon nedeniyle oluşan ağrılar, kas hasarına karşı oluşan iltihaplanmaların yanısıra sporcuların performanslarına yönelik ansiyete ve stres durumları gibi zihinsel bileşenler sporcularda performans optimasyonu için araştırmacı ve uygulamacıları farklı arayışlara yönlendirmiştir.

Geleneksel antrenman ve tedavi metotları, beslenme düzeni ve dinlenme süreçleri genellikle sporcuların performansını artırmak için başvurduğu ilk yöntemlerdir. Ancak, son yıllarda çeşitli araştırmalar ve çalışmalar, performans artırıcı etkileri olan daha az bilinen veya uygulanan yöntemlerin varlığını ortaya koymaktadır. Bunlardan biri de CBD (kannabidiol) gibi alternatif tedavi yöntemleridir.

ARAŞTIRMA VE BULGULAR

CBD'nin spor performansı ve iyileşmedeki etkileri

Cannabis bitkisinden elde edilen psikoaktif olmayan bir bileşik olan Cannabidiol (CBD), performansı artırma ve iyileşmeye yardımcı olma potansiyeli nedeniyle spor ve sağlık topluluklarında önemli bir yer edinmiştir. Psikoaktif karşıtının aksine, CBD, Yasaklı Maddeler Listesi'nde yer almadığından sporcular için cazip bir seçenektir (Aguiar, 2023; McCartney et al., 2020).

CBD veya kannabidiol, son yıllarda spor performansı ve iyileşme konusunda potansiyel faydaları nedeniyle popülerlik kazanmıştır (Burr et al., 2021). Birçok sporcu geleneksel ağrı kesici ilaçlar ve anti-enflamatuar ilaçlara doğal bir alternatif olarak CBD'ye yönelmiştir. Ancak, CBD uygulamalarının sporda etkinliği konusu araştırmacılar ve sağlık profesyonelleri arasında tartışma konusu olmaya devam etmektedir (Lunn et al., 2023) . CBD, kenevir bitkisinde bulunan 100'den fazla kannabinoidden biridir ve anti-enflamatuar, analjezik, antioksidan özellikleriyle bilinir. Bu özellikler, kronik ağrı, anksiyete ve epilepsi gibi çeşitli durumları tedavi etmek için kullanımına yol açmıştır.

Spor performansı ve iyileşme bağlamında, birçok sporcu CBD'nin onlara ağrıyı yönetmede, enflamasyonu azaltmada ve uyku kalitesini artırmada yardımcı olduğunu iddia etmektedir. Bu faydalar özellikle yüksek yoğunluklu antrenman ve müsabakalara katılan sporcular için faydalı olabilir, çünkü onlar daha fazla sakatlık ve kas ağrısı riski altındadır. Bazı çalışmalar, CBD'nin iyileşme sürecini hızlandırabileceğini ve genel performansı artırabileceğini öne sürmüştür (Malige et al., 2024). Ancak, spor performansındaki CBD'nin etkinliği üzerine anekdotal kanıtlar ve sporculardan gelen olumlu referanslara rağmen, henüz sınırlı sayıda bilimsel araştırma yapılmıştır (Aguiar, 2023). Mevcut çalışmaların birçoğu küçük ölçekli ya da metodolojik kusurlara sahiptir, sporcuların sağlık ve performansı üzerindeki uzun vadeli etkilerini tam olarak anlamak için daha fazla araştırmaya ihtiyaç vardır.

Spor alanında CBD'nin etkilerini incelemek için potansiyel bir zorluk, ürün kalitesi ve dozajındaki değişkenliklerdir. Ürünlerdeki CBD konsantrasyonu büyük ölçüde değişebilir ve şu anda sporcular için standart bir dozaj kılavuzu bulunmamaktadır. Bu, farklı çalışmaların sonuçlarını karşılaştırmayı ve CBD'nin spor alanındaki gerçek etkinliğini değerlendirmeyi zorlaştırmaktadır. Spor performansı ve iyileşmesinde CBD'nin potansiyel faydalarına artan ilgi olsa da, CBD'nin spor alanındaki etkinliği muhtemelen dozaj, ürün kalitesi ve sporculara özgü gereksinimler gibi bireysel faktörlere bağlı olacaktır. Sporcular ve antrenörler, CBD kullanımına dikkatle yaklaşmalı ve antrenman programlarına dâhil etmeden önce sağlık profesyonellerinden tavsiye almalıdır (Kouvelioti & Vagenas, 2015).

Ancak, CBD'nin kullanımı ile ilgili olarak sporcuların dikkat etmesi gereken bazı hususlar vardır. Örneğin, Dünya Dopingle Mücadele Ajansı (WADA), 2018 yılında CBD'yi yasaklı maddeler listesinden çıkarmıştır; ancak, CBD ürünlerinin THC içerme potansiyeli bulunmaktadır ve THC hala yasaklı bir madde olarak kalmaktadır. Bu nedenle, sporcuların sadece yüksek kaliteli, üçüncü taraf laboratuvarlar tarafından test edilmiş ve THC içermeyen CBD ürünlerini kullanması önemlidir. İşte CBD'nin sporcular üzerindeki potansiyel etkileri:

CBD, Kas Hasarı ve Ağrı Yönetimi

Sporcular, sıkı antrenmanlar ve yarışmalar sonucunda kas ağrısı ve inflamasyon (iltihap) yaşayabilirler (Isenmann et al., 2020). İltihap, egzersizden kaynaklanan kas hasarına karşı doğal bir tepkidir; ancak aşırı iltihap, iyileşmeyi ve performansı engelleyebilir. CBD, sıkı fiziksel aktivite ile ilişkilendirilen iltihabı azaltarak iyileşme sürelerini teorik olarak hızlandırabileceği anti-enflamatuar özellikleriyle tanınmaktadır. (Kennedy, 2022). CBD'nin en çok övülen faydalarından biri, sporcular için önemli bir iyileşme olan ağrıyı yönetme potansiyelidir. Birçok çalışma, CBD'nin bağımlılık yapmayan ve geleneksel ağrı ilaçlarıyla ilişkilendirilen yan etkilere sahip olmayan çeşitli ağrı türlerini, özellikle nöropatik ağrı ve enflamasyon nedeniyle oluşan ağrıyı hafifletebileceğini öne sürmektedir (Kasper et al., 2020; Stauch et al., 2021). İnflamasyon, egzersize doğal bir yanıt olmasına rağmen, aşırı veya kronik inflamasyon ağrıya neden olabilir ve performansı engelleyebilir (Lunn et al., 2023) CBD'nin sporcularda inflamasyon ve ağrıyla nasıl yardımcı olabileceğinin temel yollarından biri, endokannabinoid sistemi (ECS) ile etkileşimidir. ECS, ağrı, inflamasyon ve bağışıklık tepkisi de dâhil olmak üzere vücuttaki çeşitli fonksiyonları düzenleyen reseptörler ve moleküllerin karmaşık bir ağıdır.

CBD, ECS ile belirli reseptörleri etkinleştirerek veya inhibe ederek etkileşime girer, bu da inflamasyon ve ağrının azalmasına neden olur (Baswan et al., 2020). Bu özellikle yoğun antrenman veya rekabete katılan sporcular için faydalı olabilir, çünkü onlar daha fazla inflamasyona ve ağrıya eğilimlidirler. (Kasper et al., 2020)

Anti-inflamatuar özelliklerinin yanı sıra, CBD'nin antioksidan etkilere sahip olduğu da gösterilmiştir. Antioksidanlar ile serbest radikaller arasında dengesizlik olduğunda ortaya çıkan oksidatif stres, vücutta kas hasarına ve sporcularda bozulmuş iyileşmeye katkıda bulunabilir. Oksidatif stresi azaltarak, CBD kasları hasardan korumaya ve daha hızlı iyileşmeyi teşvik etmeye yardımcı olabilir (McCartney et al., 2020) .(da Silva Conter et al., 2023; Gamelin et al., 2020)

Ayrıca, CBD'nin nörokoruyucu özelliklere sahip olduğu bulunmuştur, bu da yüksek etkili sporlar veya aktivitelere katılan sporcular için faydalı olabilir. Travmatik beyin yaralanmaları veya tekrarlayan darbeler sonucunda nörolojik hasar meydana gelebilir ve uzun vadeli bilişsel ve motor bozukluklara yol açabilir. CBD'nin hayvan çalışmalarında nöronal hasara karşı koruma sağladığı ve bilişsel fonksiyonu artırdığı gösterilmiştir, bu da onun nörolojik yaralanma riski altındaki sporcular için potansiyel uygulamalara sahip olabileceğini düşündürmektedir (Aychman et al., 2023; Gamelin et al., 2020; McCartney et al., 2020 Rojas-Valverde, 2021; Rojas-Valverde & Fallas-Campos, 2023). Ancak, CBD'nin her şeyi tedavi edici bir çözüm olmadığı ve inflamasyon ve ağrıyı yönetme için diğer tedaviler ve yöntemlerle birlikte kullanılması gerektiği unutulmamalıdır. Ön çalışmalar umut verici olsa da, bu alandaki etkinliğini kesin olarak belirlemek için daha fazla kapsamlı araştırmaya ihtiyaç vardır. Her zamanki gibi, sporcular CBD'yi rejimlerine dahil etmeden önce bir sağlık profesyoneli ile danışmalıdır.

Anksiyete ve Uyku

Spor performansının sıklıkla göz ardı edilen bir yönü, stres ve anksiyete yönetimini de içeren zihinsel bileşendir. CBD'nin, anksiyete gibi uyku bozukluklarının temel nedenlerine odaklanarak uyku kalitesini artırabileceğini göstermektedir.

Anksiyete

CBD'nin spor alanında kullanımı, sporcuların anksiyete ve stresle başa çıkmalarına yardımcı olma potansiyeli nedeniyle son yıllarda artan bir popülerlik kazanmıştır. CBD veya kannabidiol, cannabis bitkisinde bulunan doğal bir bileşik olup, anksiyete ve stresi azaltma etkileri de dahil olmak üzere çeşitli terapötik özelliklere sahip olduğu gösterilmiştir (Lunn vd., 2023; McCartney vd., 2020a).

Anksiyete ve stres, yüksek seviyede performans gösterme baskısı altındaki sporcular arasında yaygın problemlerdir. Rekabetin getirdiği stres ya da sakatlıklar ve başarısızlıklarla başa çıkma anksiyetesi ile baş etmeleri gereken sporcular, genellikle performanslarını etkileyebilecek zihinsel sağlık zorluklarıyla karşılaşmaktadır. CBD'nin anksiyolitik etkilere sahip olduğu ve anksiyete hissini azaltarak sakinlik ve rahatlama hissini teşvik edebileceği gösterilmiştir (Rojas-Valverde, 2021; Rojas-Valverde & Fallas-Campos, 2023).

Araştırmalar, CBD'nin stres yanıtını düzenlemeye yardımcı olabileceğini göstermiştir. Bu, endokannabinoid sistemi ile etkileşime girerek, ruh hali, uyku ve stresin düzenlenmesinde önemli bir rol oynayan sistemi düzenler. Stres yanıtında rol alan nörotransmitterlerin aktivitesini modüle ederek, CBD, sporcuların antrenman ve rekabetin getirdiği zorluklarla daha iyi başa çıkmalarına yardımcı olabilir (da Silva Conter vd., 2023b). Ayrıca, CBD psikoaktif değildir, yani genellikle esrar kullanımıyla ilişkilendirilen "uyuşma"yı üretmez. Bu, geleneksel ilaçların olumsuz yan etkileri olmadan kaygı ve stresi yönetmek isteyen sporcular için güvenli ve yasal bir seçenek haline getirir (Moltke & Hindocha, 2021; Spinella et al., 2021).

Uyku kalitesi

Uykusuzluk ve düşük uyku kalitesi, sporcularda performansı önemli ölçüde etkileyen faktörlerden biridir (Eichler et al., 2023). CBD uygulamalarının sporcularda uyku kalitesi üzerine etkileri konusundaki araştırmalar, son zamanlarda büyük bir ilgi odağı haline gelmiştir. Uyku, kas onarımı ve büyümesi için gereklidir ve yeterli uyku alamayan sporcuların performanslarında düşüş yaşanabilir. Bu nedenle, CBD'nin sporcuların uyku kalitesini arttırması, performanslarını olumlu şekilde etkileyebilir (Rojas-Valverde, 2021; Rojas-Valverde & Fallas-Campos, 2023). Bazı araştırmalar, CBD'nin endokannabinoid sistemini etkileyerek uyku düzenini düzenleyebileceğini göstermektedir. Endokannabinoid sistem, vücudun homeostazını düzenleyen bir sistemdir ve uyku düzenlemesinde de önemli bir rol oynamaktadır. Birçok sporcu, uykuya dalma ve uykuda kalma yeteneklerini etkileyebilecek düzeyde yoğun antrenman programları ve performans beklentileri nedeniyle yüksek stres ve anksiyete seviyeleri yaşarlar.

CBD'nin zihin ve vücut üzerinde sakinleştirici etkisi sayesinde sporcuların gevşemesine ve daha iyi bir gece uykusu almalarına yardımcı olabilir (Ichikawa et al., 2023; Moltke & Hindocha, 2021).

Sakinleştirici etkilerinin yanı sıra, CBD'nin vücudun iç saatini düzenleyerek uyku üzerinde olumlu bir etkisi olabilir. Çalışmalar, CBD'nin endokannabinoid sistemiyle etkileşime girerek vücudun uyku-uyanıklık döngüsünü etkileyebileceğini göstermiştir. Daha dengeli ve düzenli bir uyku-uyanıklık döngüsünü teşvik ederek, CBD sporcuların sağlıklı bir uyku düzeni oluşturmalarına ve genel uyku kalitelerini iyileştirmelerine yardımcı olabilir (Gamelin et al., 2020; Tamanaha, 2023).

Genel olarak, CBD'nin sporculardaki uyku kalitesi üzerindeki potansiyel faydaları umut vericidir. Ancak, bu etkilerin altında yatan mekanizmaları tam olarak anlamak ve uyku kalitesini iyileştirmek için CBD kullanımının optimal dozu ve zamanlamasını belirlemek için daha fazla araştırma yapılması gerektiğini belirtmek önemlidir. CBD'yi uyku rutinine dahil etmeyi düşünen sporcuların, güvenli ve etkili kullanımı sağlamak için bir sağlık uzmanına veya spor tıbbı profesyoneline danışmaları önemlidir.

Konsantrasyon ve odaklanma

CBD'nin sporcularda kullanımına bir diğer ilgi konusu ise konsantrasyon ve odaklanmaya olan etkisidir. CBD, THC gibi i psikoaktif özelliklere sahip olmamakla birlikte, CBD'nin, ruh halini, stresi ve enerji seviyelerini düzenlemekte rol oynayan vücudun endokannabinoid sisteminin aktivitesini düzenleyerek, CBD'nin sporcularda konsantrasyonu ve odaklanmayı artırabileceği düşünülmektedir (Rojas-Valverde, 2021).

Sporcularda konsantrasyon ve odaklanmanın önemi, performanslarını artırmak ve hedeflerine ulaşmak için oldukça önemlidir. Stres ve dikkat dağınıklığı gibi faktörler, sporcuların başarısını olumsuz yönde etkileyebilir. Bu nedenle, sporcuların konsantrasyon ve odaklanma becerilerini geliştirmek için farklı yöntemler arayışı içinde olmaları son derece doğaldır (Maurer et al., 2020). CBD içeren ürünlerin düzenli kullanımının zihinsel netliği artırdığı ve stresi azalttığı gözlemlenmektedir (Wedman-St Louis, 2019). Sporcular, antrenman ve maç öncesi CBD uygulamaları sayesinde daha fazla konsantre olabildiklerini ve performanslarını daha iyi bir şekilde sergileyebildiklerini belirtmektedirler. Farklı spor dallarında ve farklı seviyelerde sporcular üzerinde yapılan çalışmalarla elde edilen bulguların genelleştirilmesi ve doğrulanması gerekmektedir (Burr et al., 2021; Kennedy, 2022).

Sporcuların performanslarını artırmak ve hedeflerine odaklanmak için CBD içeren ürünleri kullanmaları, uygun dozajlar ve profesyonel danışmanlık eşliğinde gerçekleşmelidir. Ayrıca, sporcuların CBD kullanımı öncesinde doktorlarına danışmaları da son derece önemlidir. Bu sayede, sporcuların konsantrasyon ve odaklanma becerilerini geliştirmelerine yardımcı olabilir ve daha başarılı performanslar sergilemelerine katkıda bulunabilir.

Kullanım ve Gelecek Yönelimler

CBD'nin spor performansı ve iyileşme alanındaki terapötik potansiyeli ilgi çekici olsa da, birkaç önemli düşünce bulunmaktadır. CBD ürünleri için düzenleyici standartlar geniş bir şekilde değişebilir, bu da kalite ve dozaj konusunda tutarsızlıklara neden olabilir. CBD'yi rutinlerine dahil etmeyi düşünen sporcular, saflık ve konsantrasyon açısından üçüncü taraflarca test edilen ürünler aramalıdır. Ayrıca, CBD'nin yasal durumu bölgeye göre değişebilir, bu nedenle sporcuların kendi bölgelerinde veya yarışma alanlarında geçerli olan düzenlemeler hakkında bilgili olmaları çok önemlidir.

CBD'nin spor performansı ve iyileşme alanındaki rolüne olan ilgi arttıkça, kapsamlı araştırmalara olan ihtiyaç da artmaktadır. Gelecek çalışmalar, optimal dozajları, uygulama yöntemlerini ve uzun süreli kullanımın etkilerini anlamayı amaçlamalıdır. Ayrıca, araştırmalar aynı zamanda CBD ile sporcuların kullandığı diğer yaygın takviyeler veya ilaçlar arasındaki etkileşimleri de keşfetmelidir.

SONUÇ

Sonuç olarak, CBD'nin spor performansı ve iyileşme üzerindeki etkileri hakkındaki araştırmalar, bu bileşiğin sporcular için potansiyel faydalarını vurgulamaktadır. Anti-inflamatuar, analjezik ve anksiyolitik özellikleri sayesinde CBD, sporcuların ağrıyı yönetmelerine, inflamasyonu azaltmalarına ve stresle başa çıkmalarına yardımcı olabilir. Ayrıca, uyku kalitesini artırma ve konsantrasyonu artırma gibi potansiyel etkileriyle, sporcuların performanslarını ve iyileşmelerini destekleyebilir. Performans ve iyileşme için CBD'yi düşünen sporcular, güvenilir kaynaklardan ürünleri önceliklendirmeli ve spor alanlarında CBD'nin etkinliği ve güvenliği hakkında devam eden yasal ve bilimsel anlayış hakkında bilgili olmalıdır. Sporcular ve antrenörler, CBD kullanımı konusunda dikkatli olmalı ve sağlık uzmanlarından tavsiye almalıdır. Sonuç olarak, CBD'nin spor performansı ve iyileşme üzerindeki etkileri, bireysel faktörlere bağlı olarak değişebilir ve bu nedenle her sporcu için farklı sonuçlar verebilir. Bu nedenle, CBD'nin sporcular için tam olarak nasıl kullanılacağına dair net yönergeler oluşturmak için daha fazla araştırmaya ihtiyaç vardır.

KAYNAKLAR

Aguiar, A. S. (2023). Cannabis Is Not Doping. *Cannabis and Cannabinoid Research*, *8*(6), 949–954.

Aychman, M. M., Goldman, D. L., & Kaplan, J. S. (2023). Cannabidiol's neuroprotective properties and potential treatment of traumatic brain injuries. *Frontiers in Neurology*, *14*, 1087011.

Baswan, S. M., Klosner, A. E., Glynn, K., Rajgopal, A., Malik, K., Yim, S., & Stern, N. (2020). Therapeutic Potential of Cannabidiol (CBD) for Skin Health and Disorders. *Clinical, Cosmetic and Investigational Dermatology*, *Volume 13*, 927–942.

Burr, J. F., Cheung, C. P., Kasper, A. M., Gillham, S. H., & Close, G. L. (2021). Cannabis and Athletic Performance. *Sports Medicine*, *51*(S1), 75–87.

da Silva Conter, F., Ishikawa, V. N., Gontijo, G. M., Ichikawa, A. I. T., & Bubna, P. (2023). Effects of cannabidiol on metabolic modulation and improving sports performance: A systematic review. *International Journal of Nutrology*, *16*(4).

Eichler, F., Poźniak, B., Machnik, M., Schenk, I., Wingender, A., Baudisch, N., Thevis, M., Bäumer, W., Lischer, C., & Ehrle, A. (2023). Pharmacokinetic modelling of orally administered cannabidiol and implications for medication control in horses. *Frontiers in Veterinary Science*, *10*.

Gamelin, F.-X., Cuvelier, G., Mendes, A., Aucouturier, J., Berthoin, S., Di Marzo, V., & Heyman, E. (2020). Cannabidiol in sport: Ergogenic or else? *Pharmacological Research*, *156*, 104764.

Ichikawa, A. I. T., da Silva Conter, F., Bubna, P., Ishikawa, V. N., & Gontijo, G. M. (2023). Major aspects of cannabidiol in the interaction with microRNAs and exosomes in the modulation of inflammatory and immunological processes in athletes: A systematic review. *International Journal of Nutrology*, *16*(2).

Isenmann, E., Veit, S., & Diel, P. (2020). Effects Of Cannabidiol Supplementation On The Skeletal Muscle Regeneration After Intensive Resistance Training. *Medicine & Science in Sports & Exercise*, *52*(7S), 766–766.

Kasper, A. M., Sparks, S. A., Hooks, M., Skeer, M., Webb, B., Nia, H., Morton, J. P., & Close, G. L. (2020). High Prevalence of Cannabidiol Use Within Male Professional Rugby Union and League Players: A Quest for Pain Relief and Enhanced Recovery. *International Journal of Sport Nutrition and Exercise Metabolism*, *30*(5), 315–322.

Kennedy, M. (2022). Cannabis, cannabidiol and tetrahydrocannabinol in sport: An overview. *Internal Medicine Journal*, *52*(9), 1471–1477.

Kouvelioti, R., & Vagenas, G. (2015). Methodological and Statistical Quality in Research Evaluating Nutritional Attitudes in Sports. *International Journal of Sport Nutrition and Exercise Metabolism*, *25*(6), 624–635.

Lunn, W. R., Axtell, R. S., Venard, A., Bodurtha, P., Brunello, G., & Bukowski, Z. (2023). Cannabidiol Supplementation Alleviates Anxiety, Mitigates Pain, Extends Endurance, and Facilitates Greater Exercise Exertion. *Medicine & Science in Sports & Exercise*, *55*(9S), 92–92.

Malige, A., Boyd, A., & Limpisvasti, O. (2024). Perceptions of Orthopaedic Sports Medicine Surgeons About Medical Cannabidiol Use: A Survey Study. *Cureus*.

Maurer, G. E., Mathews, N. M., Schleich, K. T., Slayman, T. G., & Marcussen, B. L. (2020). Understanding Cannabis-Based Therapeutics in Sports Medicine. *Sports Health: A Multidisciplinary Approach*, *12*(6), 540–546. https://doi.org/10.1177/1941738120956604

McCartney, D., Benson, M. J., Desbrow, B., Irwin, C., Suraev, A., & McGregor, I. S. (2020). Cannabidiol and Sports Performance: A Narrative Review of Relevant Evidence and Recommendations for Future Research. *Sports Medicine - Open*, *6*(1), 27.

Moltke, J., & Hindocha, C. (2021). Reasons for cannabidiol use: A cross-sectional study of CBD users, focusing on self-perceived stress, anxiety, and sleep problems. *Journal of Cannabis Research*, *3*(1), 5.

Rojas-Valverde, D. (2021). Potential Role of Cannabidiol on Sports Recovery: A Narrative Review. *Frontiers in Physiology*, *12*.

Rojas-Valverde, D., & Fallas-Campos, A. (2023). Cannabidiol in sports: Insights on how CBD could improve performance and recovery. *Frontiers in Pharmacology*, *14*.

Spinella, T. C., Stewart, S. H., Naugler, J., Yakovenko, I., & Barrett, S. P. (2021). Evaluating cannabidiol (CBD) expectancy effects on acute stress and anxiety in healthy adults: A randomized crossover study. *Psychopharmacology*, *238*(7), 1965–1977.

Stauch, C. M., Ammerman, B., Sepulveda, D., Aynardi, M. C., Garner, M. R., Lewis, G., Morgan, D., & Dhawan, A. (2021). Biomechanical Effects of Δ9-Tetrahydrocannabinol (THC) and Cannabidiol (CBD), the Major Constituents of Cannabis, in a Sprague Dawley Rat Achilles Tendon Surgical Repair Model: A Pilot Study. *The American Journal of Sports Medicine*, *49*(9), 2522–2527.

Tamanaha, T. (2023). *A Cross Sectional Comparison of the Mental Health, Sleep, and Anaerobic Power of Cannabis Users, Cannabidiol Users, and Non Users*.

The Endocannabinoid System and its Modulation by Cannabidiol (CBD)—PubMed. (n.d.). Retrieved 19 April 2024, from https://pubmed.ncbi.nlm.nih.gov/31202198/

IN SILICO INVESTIGATION ON THE BENEFICIAL EFFECTS OF THE PLANT PLUMBAGO ZEYLANICA AGAINST PROSTATE CANCER: MOLECULAR DOCKING, MOLECULAR DYNAMICS SIMULATION, AND ADMET STUDIES

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Abstract
Throughout history, plant-based medicines have been crucial to human civilization. Natural sources have provided some of the most significant pharmaceuticals in modern medicine, including vincristine, aspirin, quinine, and more. In this context, Plumbago zeylanica is a plant that is commonly used in African traditional medicine to treat prostate cancer. We have employed computational methods that simulate several scientific approaches, such as molecular docking, ADME-Tox, molecular dynamics, and Density Functional Theory (DFT), to investigate the advantages of this plant. We have employed various in-silico techniques to identify the most efficient compounds for treating prostate cancer in the root extract of Plumbago zeylanica. We have identified multiple bioactive constituents, such as hispidulin and diosmetin that effectively combat prostate cancer by inhibiting three crucial receptors, namely AR, CYP17A1, and PI3K. This study aims to enhance future in-vitro research by providing a more comprehensive and meticulous analysis. The ultimate objective is to develop more effective prostate cancer medications using natural plant sources, specifically Plumbago zeylanica.
Keywords: Plumbago zeylanica, Prostate cancer, Molecular docking, Molecular dynamics, DFT

POTENTIAL EFFECT OF *Cannabis sativa* L. FOR THE TREATMENT OF DENTAL AND ORAL DISEASE

DİŞ VE AĞIZ HASTALIKLARININ TEDAVİSİNDE Cannabis sativa L.'NİN OLASI ETKİSİ

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Abstract

Oral and dental diseases, which are among the most common non-communicable diseases worldwide, can affect quality of life and general health. These diseases include dental caries, oral cancers, gingivitis, periodontitis, gum disease, Noma, oro-dental trauma, HIV oral symptoms, sensitive teeth, cracked teeth, broken teeth and cleft lip and palate. Traditional Chinese, African, Indian and Western medicine have used herbs for centuries to treat oral and dental health problems such as dental caries, gingivitis, toothache, toothache, dental pulp inflammation, halitosis, mucositis, sore throat, mouth sore infections and periodontal abscesses. Herbs are often used for their antimicrobial, analgesic, anti-inflammatory and antiseptic properties. *Cannabis sativa* L., the most common of these plants used, is prominent in Asian medicine to relieve toothache, prevent dental caries and reduce gingivitis. The presence of CB receptors in the mouth has raised the issue of targeting the endocannabinoid system to treat oral and dental problems. Recently, Cannabidiol (CBD), a secondary metabolite derived from *Cannabis sativa* L., has anti-inflammatory, analgesic, anxiolytic, antimicrobial and anti-cancer properties, so it may benefit conditions such as burn mouth syndrome, dental anxiety, gingivitis and oral cancer. Furthermore, terpenes and flavonoids, other important secondary metabolites found in *Cannabis sativa* L., have anti-inflammatory, analgesic, anxiolytic and antimicrobial effects, suggesting that they can be used in oral and dental care. This review aims to investigate the potential of *Cannabis sativa* L. to treat dental and oral diseases.

Keywords: *Cannabis sativa* L., Endocannabinoid system, Cannabidiol (CBD), Terpenes and flavonoids, Oral and dental diseases

Özet

Dünya çapında en sık görülen bulaşıcı olmayan hastalıklar arasında yer alan ağız ve diş hastalıkları yaşam kalitesini ve genel sağlığı etkileyebilmektedir. Bu hastalıklar arasında diş çürükleri, ağız kanserleri, diş eti iltihabı, periodontit, diş eti hastalığı, Noma, oro-dental travması, HIV ağız semptomları, hassas dişler, çatlak dişler, kırık dişler ve yarık dudak ve damak yer alır. Geleneksel Çin, Afrika, Hint ve Batı tıbbı, diş çürüğü, diş eti iltihabı, diş ağrısı, diş pulpası iltihabı, ağız kokusu, mukozit, boğaz ağrısı, ağrılı ağız enfeksiyonları ve periodontal apseler gibi ağız ve diş sağlığı sorunlarını tedavi etmek için yüzyıllardır şifalı bitkileri kullanmıştır. Tıbbi bitkiler, sıklıkla antimikrobiyal, analjezik, antiinflamatuar ve antiseptik özelliklerinden dolayı kullanılır. Halk ilacı olarak kullanılan bitkilerden *Cannabis sativa* L., Asya tıbbında diş ağrısını dindirmek, diş çürüklerini önlemek ve diş eti iltihabını azaltmak için öne çıkmaktadır. Ağızda CB reseptörlerinin varlığı, ağız ve diş problemlerini tedavi etmek için endokannabinoid sistemin hedeflenmesi sorununu gündeme getirmiştir. Son zamanlarda, *Cannabis sativa* L.'den türetilen ikincil bir metabolit olan Cannabidiol (CBD), anti-inflamatuar, analjezik, anksiyolitik, antimikrobiyal ve anti-kanser özelliklerine sahiptir, bu nedenle yanık ağız sendromu, diş kaygısı, diş eti iltihabı ve ağız içi rahatsızlıklar ve oral kanser gibi durumlara fayda sağlayabilir. Ayrıca *Cannabis sativa* L.'de bulunan diğer önemli sekonder metabolitler olan terpenler ve flavonoidlerin antiinflamatuar, analjezik, anksiyolitik ve antimikrobiyal etkilere sahip olması, bunların ağız ve diş bakımında kullanılabileceğini düşündürmektedir. Bu derleme, *Cannabis sativa* L.'nin diş ve ağız hastalıklarını tedavi etme potansiyelini araştırmayı amaçlamaktadır.

Anahtar Kelimeler: *Cannabis sativa* L., Endokannabinoid sistem, Cannabidiol (CBD), Terpenler ve flavonoidler, Ağız ve diş hastalıkları

GİRİŞ

Bilimsel olarak *Cannabis sativa* L. olarak bilinen kenevir, uzun bir tıbbi kullanım geçmişine sahiptir (Bonini et al., 2018). Son yıllarda, çeşitli tıbbi durumların tedavisinde kenevirin potansiyeli üzerine araştırmalar artmıştır (Rupasinghe et al., 2020). Bu durumlar arasında ağız ve diş enfeksiyonları da bulunmaktadır (Lowe et al., 2021). Ağız ve diş enfeksiyonları, ağız içinde veya dişlerde meydana gelen bakteri, virüs veya mantar kaynaklı enfeksiyonlardır (Laheij et al., 2012). Bu tür enfeksiyonlar, ağız sağlığını olumsuz etkileyebilir ve tedavi edilmezse ciddi komplikasyonlara yol açabilir (Haque et al., 2019). Ağız ve diş enfeksiyonları toplumda oldukça yaygın ve genellikle ağrılı olup, etkili tedavi gerektirir (Peres et al., 2019). Diş çürükleri, dişlerin yüzeyinde bulunan bakterilerin şekerleri asitlere dönüştürmesi sonucu oluşur. Bu asitler, diş minesini aşındırarak çürükler oluşturur. Çürükler tedavi edilmezse dişin daha derin katmanlarına yayılabilir ve ağrıya, enfeksiyona ve diş kaybına yol açabilir. Diş apsesi, diş kökünde veya dişin etrafındaki dokularda oluşan bir enfeksiyon sonucu oluşan irin dolu keseciktir. Diş apseleri şiddetli ağrıya, şişmeye ve ateşe neden olabilir (Robertson & Smith, 2009). Tedavi edilmezse enfeksiyon çevre dokulara ve hatta vücuda yayılabilir (Hardie, 1992; Watt et al., 2020). Dişeti hastalıkları, diş etlerini ve dişleri destekleyen kemik yapısını etkileyen enfeksiyonlardır. Gingivitis (erken evre) ve periodontitis (ileri evre) olarak iki ana kategoriye ayrılır. Gingivitis, diş etlerinin iltihaplanması ve kanaması ile karakterizedir. Genellikle iyi bir ağız hijyeni ile geri döndürülebilir. Periodontitis, diş etlerinin ve çevre dokuların ciddi hasar görmesi ile karakterizedir. Tedavi edilmezse diş kaybına yol açabilir (Tanzer et al., 2001). Pamukçuk, ağız içinde *Candida albicans* adlı mantarın aşırı çoğalması sonucu oluşan bir enfeksiyondur. Genellikle beyaz, kremsi lezyonlar şeklinde ortaya çıkar ve ağızda rahatsızlık veya yanma hissine neden olabilir (He & Shi, 2009). Bağışıklık sistemi zayıflamış kişilerde daha yaygın görülür (Tavares et al., 2014). *Herpes simpleks* virüsü (HSV), ağız çevresinde ve içinde ağrılı yaralara neden olabilir. HSV-1 genellikle ağız çevresinde uçuklara neden olurken, HSV-2 daha çok genital bölgede enfeksiyona yol açar. Ancak her iki tür de ağızda enfeksiyona neden olabilir (Lewis, 2004). Perikoronit, genellikle kısmen çıkmış veya gömülü olan üçüncü azı dişlerinin (20 yaş dişleri) etrafındaki diş etlerinin enfeksiyonudur. Diş etlerinde şişme, ağrı ve bazen irin oluşumu ile karakterizedir (Moloney & Stassen, 2009). Diş pulpasının (sinir ve damar dokusu) enfekte olması sonucu oluşan enfeksiyonlardır (Kwon & Serra, 2022). Genellikle diş çürüğü veya travma sonucu dişin pulpası zarar gördüğünde ortaya çıkar ve tedavi edilmezse apseye neden olabilir. Ağız ve diş enfeksiyonları ayrıca çene kemiğine de yayılabilir, bu da osteomiyelit gibi ciddi komplikasyonlara yol açabilir (Kwon & Serra, 2022). Geleneksel tedavi yöntemleri, bu enfeksiyonların kontrol altına alınması ve semptomların hafifletilmesi amacıyla uygulanır. Bu yöntemler antibiyotikler, ağrı kesiciler ve cerrahi müdahaleler şeklinde sıralanabilir.

Antibiyotikler

Antibiyotikler, bakteriyel enfeksiyonları tedavi etmek için yaygın olarak kullanılır. Ancak, antibiyotiklerin uzun süreli ve sık kullanımı antibiyotik direncine yol açabilir. Bu durum, bakterilerin antibiyotiklere karşı direnç geliştirmesi ve tedavilerin etkisiz hale gelmesi anlamına gelir. Ayrıca, antibiyotikler mide bulantısı, ishal ve alerjik reaksiyonlar gibi yan etkilere de neden olabilir (Levi & Eusterman, 2011; Qiu et al., 2020).

Ağrı Kesiciler

Ağrı kesiciler, ağız ve diş enfeksiyonlarının neden olduğu ağrıyı hafifletmek için kullanılır. İbuprofen ve parasetamol gibi reçetesiz satılan ağrı kesiciler, ağrıyı ve iltihabı azaltmada etkili olabilir. Ancak, bu ilaçlar sadece semptomları hafifletir ve enfeksiyonu tedavi etmez. Ayrıca, uzun süreli kullanımda mide ülserleri, böbrek hasarı ve karaciğer sorunları gibi yan etkiler ortaya çıkabilir (Mehlisch et al., 2010).

Cerrahi Müdahaleler

Ciddi enfeksiyonlar durumunda, cerrahi müdahaleler gerekebilir. Bu müdahaleler arasında enfekte dişin çekilmesi, apse drenajı ve kök kanal tedavisi yer alır. Cerrahi müdahaleler genellikle etkili olsa da, invaziv olmaları ve iyileşme sürecinin uzun olması gibi dezavantajları vardır (Goodson, 2019).

Antibiyotik Direnci ve Yan Etkiler

Antibiyotiklerin aşırı ve yanlış kullanımı, antibiyotik direncinin artmasına neden olmuştur. Bu durum, tedavi seçeneklerinin azalmasına ve enfeksiyonların kontrol altına alınmasının zorlaşmasına yol açar (Frieri et al., 2017). Ayrıca, antibiyotiklerin bağırsak florasını bozarak sindirim problemlerine neden olabileceği bilinmektedir. Ağrı kesicilerin ise mide-bağırsak sorunları, böbrek ve karaciğer fonksiyonlarında bozulma gibi yan etkileri bulunmaktadır. Uygulamada önemli bir yer edinen bu yöntemlerin yan etkileri ve antibiyotik direnci gibi sorunlar nedeni ile alternatif tedavi yöntemleri araştırılmaktadır (Urban-Chmiel et al., 2022). Kenevir, bu bağlamda potansiyel bir tedavi seçeneği olarak öne çıkmaktadır. Antibiyotik direnci, çeşitli bulaşıcı hastalıkların, özellikle de biyotik ve abiyotik materyaller üzerinde biyofilm oluşumuyla ilişkili hastalıkların tedavisinde giderek artan bir zorluk haline gelmiştir. Biyofilme gömülü bakterileri de hedef alabilecek yeni tedavi protokollerine acil ihtiyaç vardır. Bitkilerin birçok sekonder metaboliti anti-bakteriyel aktiviteye sahiptir ve özellikle *Cannabis sativa* L. çeşitlerinin fitokanabinoidleri umut vaad etmekte ve normal memeli hücrelerinde sitotoksik eşiğin altındaki konsantrasyonlarda anti-mikrobiyal ve anti-biyofilm aktiviteleri nedeniyle büyük ilgi görmektedir (Sionov & Steinberg, 2022).

ARAŞTIRMA VE BULGULAR

Kenevirin Potansiyel Tedavi Olarak Değerlendirilmesi

Kenevirin Terapötik Özellikleri

Kenevir (*Cannabis sativa*), terapötik özellikleri nedeniyle tıbbi kullanımlarıyla dikkat çeken bir bitkidir. Kenevirin terapötik potansiyeli, bitkinin içeriğinde bulunan çeşitli kimyasal bileşiklere, özellikle kanabinoidlere ve terpenlere bağlıdır. En yaygın bilinen kanabinoidler arasında tetrahidrokanabinol (THC) ve kanabidiol (CBD) bulunur (Schrot & Hubbard, 2016).

1. Ağrı Yönetimi

Kenevir, kronik ağrı yönetiminde etkili olabilir. Özellikle THC ve CBD, ağrı kesici özelliklere sahiptir. Sinir sistemi üzerinde etki ederek ağrı algısını azaltabilirler (Amar, 2006).

2. Anksiyete ve Depresyon

CBD'nin anksiyolitik ve antidepresan özellikleri üzerine yapılan araştırmalar, anksiyete ve depresyon belirtilerini azaltmada yardımcı olabileceğini göstermektedir. CBD'nin beyindeki serotonin reseptörleri ile etkileşime girerek bu etkileri gösterdiği düşünülmektedir (Botsford et al., 2020).

3. Epilepsi ve Nöbetler

CBD, bazı epilepsi türlerinde nöbet sıklığını ve şiddetini azaltmada etkili bulunmuştur. FDA tarafından onaylanmış bir CBD ilacı olan Epidiolex, özellikle Lennox-Gastaut sendromu ve Dravet sendromu gibi zor tedavi edilen epilepsi formlarında kullanılır (Britch et al., 2021).

4. Uyku Bozuklukları

Kenevir, uyku bozukluklarının tedavisinde de kullanılabilir. Hem THC hem de CBD, uyku kalitesini iyileştirebilir ve insomnia gibi durumlarda yardımcı olabilir (Ranum et al., 2023).

5. Anti-inflamatuar Etkiler

CBD, anti-inflamatuar özelliklere sahiptir ve bu nedenle çeşitli inflamatuar durumların tedavisinde yardımcı olabilir. Özellikle artrit gibi kronik inflamatuar hastalıklarda ağrıyı ve şişmeyi azaltabilir (Bunman et al., 2023).

6. Kanser Tedavisi ve Yan Etkilerinin Yönetimi

Kenevir, kemoterapiye bağlı bulantı ve kusma gibi yan etkileri hafifletebilir. Ayrıca bazı çalışmalar, kanser hücrelerinin büyümesini yavaşlatabileceğini veya durdurabileceğini öne sürmektedir (Valenti et al., 2022).

7. Nöroprotektif Özellikler

Kenevirdeki bazı bileşikler, nöroprotektif özelliklere sahip olabilir, yani sinir hücrelerini koruyabilir ve nörodejeneratif hastalıkların ilerlemesini yavaşlatabilir. Bu, Alzheimer hastalığı ve Parkinson hastalığı gibi durumlarda potansiyel terapötik kullanımlara işaret eder (Cooray et al., 2020).

8. Cilt Sağlığı

Kenevir yağı ve CBD, cilt sağlığı için de kullanılabilir. Akne, egzama ve sedef hastalığı gibi cilt problemlerini hafifletebilir ve cildi yatıştırıcı ve nemlendirici etkileri olabilir (Baswan et al., 2020).

Kenevirin Ağız ve Diş Enfeksiyonlarında Kullanımı

Geleneksel tedavideki başarısızlıklar nedeniyle, alternatif tedavi yöntemleri araştırılmaktadır. Kenevir, bu bağlamda potansiyel bir tedavi seçeneği olarak öne çıkmaktadır. Kenevirin ağız ve diş enfeksiyonlarında kullanılabilme potansiyeli, özellikle içerdiği aktif bileşenler olan tetrahidrokannabinol (THC) ve kannabidiol (CBD) sayesinde dikkat çekmektedir. Bu bileşikler, diş enfeksiyonlarının tedavisinde faydalı olabilecek antienflamatuvar, analjezik ve antimikrobiyal özelliklere sahiptir.

Kenevirin Antienflamatuvar ve Antimikrobiyal Özellikler

CBD, güçlü antienflamatuvar özelliklere sahiptir. Enflamasyon, vücudun enfeksiyona karşı verdiği bir tepkidir ve bunu azaltmak ağrıyı hafifletebilir ve iyileşmeyi hızlandırabilir (Garzón et al., 2024). Enflamasyon, diş enfeksiyonlarının ana bileşenlerinden biridir ve bu süreçte ağrı ve şişlik oluşur. CBD, enflamatuvar yanıtı düzenleyerek bu semptomları hafifletebilir. Ayrıca, THC ve CBD'nin çeşitli bakterilere karşı antimikrobiyal etkiler gösterdiği bilinmektedir. Bu durum, kenevirin enfeksiyonu doğrudan hedef alarak etkili bir tedavi yöntemi olabileceğini gösterir (Bellocchio et al., 2023). İlk çalışmalar, kannabinoidlerin *Streptococcus mutans* gibi ağız ve diş enfeksiyonlarına neden olan bakterilere karşı antimikrobiyal özelliklere sahip olduğunu önermektedir (Barak et al., 2022; Garzón et al., 2024). Bazı kanabinoidlerin gram pozitif bakterilere karşı güçlü antimikrobiyal aktiviteye sahip olduğu bulunmuştur. Bunlardan biri psikoaktif olmayan, minör fitokanabinoid Cannabigerol'dür (CBG). CBG'nin *S. mutans*'a karşı anti-bakteriyel aktiviteler sergilediğini gösteren çalışmalar vardır. Çalışmalarda CBG, başlangıçtaki hücre yoğunluğundan etkilenen planktonik olarak büyüyen *S. mutans*'ın çoğalmasını durdurmuştur (Aqawi et al., 2021a). *S. mutans* ile birlikte ağız enfeksiyonlarına sıklıkla karışan *Candida albicans* mantarının biyofilm oluşumunu önlemede, triklosan ve kannabidiol (CBD) içeren sürekli salınımlı bir verniğin, her bir bileşiğin tek başına kullanılmasından daha etkili olduğu gözlemlenmiştir (Avraham et al., 2023). Cannabidiol (CBD) ve kannabigerolün (CBG) oral bakteriler ve periodontal ligaman fibroblastları (PLF) üzerindeki in vitro antimikrobiyal ve antibiyofilm özelliklerini ve immün modülatör aktivitesinin değerlendirildiği bir çalışmada *S. mutans* ve *C. albicans* için CBD ve CBG'nin minimum inhibitör konsantrasyonu (MIC) ile CBD ve CBG tedavileri altında subgingival biyofilm üzerindeki etkinliğine bakılmıştır. Sonuçta hem CBG hem de CBD, *S. mutans*'ı inhibe etmiş; ayrıca oluşan biyofilmlerin azaldığı görülmüştür; ancak CBD'nin halihazırda gelişmiş olan biyofilmler üzerindede etkisinin varlığı saptanmıştır (Aqawi et al., 2021b; Garzón et al., 2024). Bu çalışmalar kenevirin semptomları hafifletmenin yanı sıra enfeksiyonla doğrudan mücadele edebileceği anlamına geldiğini göstermektedir.

Ağrı Giderici Özellikler

THC, ağrı yönetiminde önemli bir rol oynar. Endokannabinoid sistem üzerinden etki ederek ağrı algısını azaltır. Diş enfeksiyonlarının neden olduğu ağrı genellikle şiddetlidir ve THC'nin analjezik özellikleri bu ağrıyı hafifletebilir (Chrepa et al., 2024). Kenevirin bu özellikleri, özellikle kronik ağrı yönetiminde etkili olabileceğini göstermektedir.

Kenevirin Ağız ve Diş Enfeksiyonlarında Uygulama Yöntemleri

Kenevirin Ağız ve Diş Enfeksiyonlarında kullanımı çeşitli formlarda olabilir:

Topikal Uygulama: CBD yağı, doğrudan diş etine veya enfekte bölgeye uygulanabilir. Bu yöntem, hızlı ve hedefe yönelik bir rahatlama sağlar. Topikal uygulama, lokal etkiler sağlayarak enflamasyonu ve ağrıyı doğrudan enfekte bölgede azaltabilir.

Oral Yollarla Alım: Kapsül veya tabletler, sistemik bir etki sağlamak için kullanılabilir. Kannabinoidler, vücutta dağılarak geniş çaplı enflamasyon ve ağrı yönetimine yardımcı olabilir. Bu yöntem, kronik ağrı ve enflamasyonun olduğu durumlarda daha uygun olabilir.

Ağız Çalkalama Solüsyonları: Kenevir bazlı ağız çalkalama solüsyonları, ağız içindeki bakteri yükünü azaltabilir. Bu, hem enfeksiyonu kontrol altında tutmaya yardımcı olabilir hem de ağız sağlığını genel olarak iyileştirebilir.

SONUÇ

Kenevir, antienflamatuvar, antimikrobiyal ve ağrı kesici özellikleri sayesinde ağız ve diş enfeksiyonlarının tedavisinde umut verici bir alternatif olarak öne çıkmaktadır. Ancak, klinik uygulamalara geçiş yapmadan önce daha fazla bilimsel araştırma ve klinik çalışma gereklidir. Kenevirin bu alandaki potansiyelini tam anlamıyla anlayabilmek için multidisipliner yaklaşımlar ve kapsamlı araştırmalar şarttır. Bu sayede, kenevir diş sağlığı alanında değerli bir tedavi aracı haline gelebilir. Kenevirin terapötik kullanımları, geniş bir yelpazeye yayılmıştır ve birçok farklı sağlık durumu için potansiyel faydalar sunar. Ancak, kenevirin tıbbi kullanımı hakkında daha fazla araştırmaya ihtiyaç vardır ve bu bitkinin kullanımı her zaman bir sağlık profesyoneli gözetiminde yapılmalıdır. Ayrıca, yasal düzenlemeler ülkeden ülkeye değişiklik gösterdiği için kenevir ürünlerinin kullanımında yerel yasalara uyulması önemlidir. Kenevirin diş enfeksiyonlarının tedavisinde kullanılabilme potansiyeli, umut verici olmakla birlikte, daha fazla bilimsel araştırma ve klinik çalışma gerekmektedir. Gelecekteki araştırmalar, kenevirin etkinliğini ve güvenliğini değerlendirmek için kapsamlı klinik deneyler içermelidir. Bu çalışmalar, kenevirin diğer ağız ve diş tedavileri ile etkileşimlerini ve/veya uzun vadeli kullanımının olası yan etkilerini de incelemelidir. Gelecekteki çalışmalar şunlara odaklanmalıdır:

- Etkili dozların belirlenmesi
- Diğer diş tedavileri ile etkileşimlerin anlaşılması
- Uzun vadeli yan etkilerin değerlendirilmesi

KAYNAKLAR

Amar, M. B. (2006). Cannabinoids in medicine: A review of their therapeutic potential. *Journal of ethnopharmacology*, *105*(1-2), 1-25.

Aqawi, M., Sionov, R. V., Gallily, R., Friedman, M., & Steinberg, D. (2021a). Anti-bacterial properties of cannabigerol toward Streptococcus mutans. *Frontiers in Microbiology*, *12*, 656471.

Aqawi, M., Sionov, R. V., Gallily, R., Friedman, M., & Steinberg, D. (2021b). Anti-biofilm activity of cannabigerol against Streptococcus mutans. *Microorganisms*, *9*(10), 2031.

Avraham, M., Steinberg, D., Barak, T., Shalish, M., Feldman, M., & Sionov, R. V. (2023). Improved anti-biofilm effect against the oral cariogenic Streptococcus mutans by combined Triclosan/CBD treatment. *Biomedicines*, *11*(2), 521.

Barak, T., Sharon, E., Steinberg, D., Feldman, M., Sionov, R. V., & Shalish, M. (2022). Anti-bacterial effect of cannabidiol against the cariogenic Streptococcus mutans bacterium: An In Vitro Study. *International Journal of Molecular Sciences*, *23*(24), 15878.

Baswan, S. M., Klosner, A. E., Glynn, K., Rajgopal, A., Malik, K., Yim, S., & Stern, N. (2020). Therapeutic potential of cannabidiol (CBD) for skin health and disorders. *Clinical, cosmetic and investigational dermatology*, 927-942.

Bellocchio, L., Patano, A., Inchingolo, A. D., Inchingolo, F., Dipalma, G., Isacco, C. G., De Ruvo, E., Rapone, B., Mancini, A., & Lorusso, F. (2023). Cannabidiol for oral health: A new promising therapeutical tool in dentistry. *International Journal of Molecular Sciences*, *24*(11), 9693.

Bonini, S. A., Premoli, M., Tambaro, S., Kumar, A., Maccarinelli, G., Memo, M., & Mastinu, A. (2018). Cannabis sativa: A comprehensive ethnopharmacological review of a medicinal plant with a long history. *Journal of ethnopharmacology*, *227*, 300-315.

Botsford, S. L., Yang, S., & George, T. P. (2020). Cannabis and cannabinoids in mood and anxiety disorders: impact on illness onset and course, and assessment of therapeutic potential. *The American journal on addictions*, *29*(1), 9-26.

Britch, S. C., Babalonis, S., & Walsh, S. L. (2021). Cannabidiol: pharmacology and therapeutic targets. *Psychopharmacology*, *238*, 9-28.

Bunman, S., Muengtaweepongsa, S., Piyayotai, D., Charlermroj, R., Kanjana, K., Kaew-amdee, S., Makornwattana, M., & Kim, S. (2023). Anti-inflammatory effects of oral cannabidiol in rat models. *F1000Research*, *12*, 680.

Chrepa, V., Villasenor, S., Mauney, A., Kotsakis, G., & Macpherson, L. (2024). Cannabidiol as an alternative analgesic for acute dental pain. *Journal of Dental Research*, *103*(3), 235-242.

Cooray, R., Gupta, V., & Suphioglu, C. (2020). Current aspects of the endocannabinoid system and targeted THC and CBD phytocannabinoids as potential therapeutics for Parkinson's and Alzheimer's diseases: a review. *Molecular neurobiology*, *57*(11), 4878-4890.

Frieri, M., Kumar, K., & Boutin, A. (2017). Antibiotic resistance. *Journal of infection and public health*, *10*(4), 369-378.

Garzón, H. S., Loaiza-Oliva, M., Martínez-Pabón, M. C., Puerta-Suárez, J., Téllez Corral, M. A., Bueno-Silva, B., Suárez, D. R., Díaz-Báez, D., & Suárez, L. J. (2024). Antibiofilm and Immune-Modulatory Activity of Cannabidiol and Cannabigerol in Oral Environments—In Vitro Study. *Antibiotics*, *13*(4), 342.

Goodson, J. M. (2019). Dental applications. In *Medical applications of controlled release* (pp. 115-138). CRC Press.

Haque, M., Sartelli, M., & Haque, S. Z. (2019). Dental infection and resistance—global health consequences. *Dentistry journal*, *7*(1), 22.

Hardie, J. (1992). Oral microbiology: current concepts in the microbiology of dental caries and periodontal disease. *British Dental Journal*, *172*(7), 271-278.

He, X. s., & Shi, W. y. (2009). Oral microbiology: past, present and future. *International journal of oral science*, *1*(2), 47-58.

Kwon, G., & Serra, M. (2022). Pericoronitis. In *StatPearls [Internet]*. StatPearls Publishing.

Laheij, A., Kistler, J., Belibasakis, G., Välimaa, H., De Soet, J., & Workshop, E. O. M. (2012). Healthcare-associated viral and bacterial infections in dentistry. *Journal of oral microbiology*, *4*(1), 17659.

Levi, M. E., & Eusterman, V. D. (2011). Oral infections and antibiotic therapy. *Otolaryngologic Clinics of North America*, *44*(1), 57-78.

Lewis, M. (2004). Herpes simplex virus: an occupational hazard in dentistry. *International dental journal*, *54*(2), 103-111.

Lowe, H., Toyang, N., Steele, B., Bryant, J., Ngwa, W., & Nedamat, K. (2021). The current and potential application of medicinal cannabis products in dentistry. *Dentistry journal*, *9*(9), 106.

Mehlisch, D. R., Aspley, S., Daniels, S. E., & Bandy, D. P. (2010). Comparison of the analgesic efficacy of concurrent ibuprofen and paracetamol with ibuprofen or paracetamol alone in the management of moderate to severe acute postoperative dental pain in adolescents and adults: a randomized, double-blind, placebo-controlled, parallel-group, single-dose, two-center, modified factorial study. *Clinical therapeutics*, *32*(5), 882-895.

Moloney, J., & Stassen, L. (2009). Pericoronitis: treatment and a clinical dilemma. *J Ir Dent Assoc*, *55*(4), 190-192.

Peres, M. A., Macpherson, L. M., Weyant, R. J., Daly, B., Venturelli, R., Mathur, M. R., Listl, S., Celeste, R. K., Guarnizo-Herreño, C. C., & Kearns, C. (2019). Oral diseases: a global public health challenge. *The Lancet*, *394*(10194), 249-260.

Qiu, W., Zhou, Y., Li, Z., Huang, T., Xiao, Y., Cheng, L., Peng, X., Zhang, L., & Ren, B. (2020). Application of antibiotics/antimicrobial agents on dental caries. *BioMed Research International*, *2020*.

Ranum, R. M., Whipple, M. O., Croghan, I., Bauer, B., Toussaint, L. L., & Vincent, A. (2023). Use of Cannabidiol in the Management of Insomnia: a systematic review. *Cannabis and cannabinoid research*, *8*(2), 213-229.

Robertson, D., & Smith, A. (2009). The microbiology of the acute dental abscess. *Journal of medical microbiology*, *58*(2), 155-162.

Rupasinghe, H. V., Davis, A., Kumar, S. K., Murray, B., & Zheljazkov, V. D. (2020). Industrial hemp (Cannabis sativa subsp. sativa) as an emerging source for value-added functional food ingredients and nutraceuticals. *Molecules*, *25*(18), 4078.

Schrot, R. J., & Hubbard, J. R. (2016). Cannabinoids: medical implications. *Annals of medicine*, *48*(3), 128-141.

Sionov, R. V., & Steinberg, D. (2022). Anti-microbial activity of phytocannabinoids and endocannabinoids in the light of their physiological and pathophysiological roles. *Biomedicines*, *10*(3), 631.

Tanzer, J. M., Livingston, J., & Thompson, A. M. (2001). The microbiology of primary dental caries in humans. *Journal of dental education*, *65*(10), 1028-1037.

Tavares, M., Calabi, K. A. L., & San Martin, L. (2014). Systemic diseases and oral health. *Dental Clinics*, *58*(4), 797-814.

Urban-Chmiel, R., Marek, A., Stępień-Pyśniak, D., Wieczorek, K., Dec, M., Nowaczek, A., & Osek, J. (2022). Antibiotic resistance in bacteria—A review. *Antibiotics*, *11*(8), 1079.

Valenti, C., Billi, M., Pancrazi, G. L., Calabria, E., Armogida, N. G., Tortora, G., Pagano, S., Barnaba, P., & Marinucci, L. (2022). Biological effects of cannabidiol on human cancer cells: Systematic review of the literature. *Pharmacological Research*, *181*, 106267.

Watt, R. G., Daly, B., Allison, P., Macpherson, L. M., Venturelli, R., Listl, S., Weyant, R. J., Mathur, M. R., Guarnizo-Herreño, C. C., & Celeste, R. K. (2020). The Lancet oral health series: Implications for oral and dental research. *Journal of Dental Research*, *99*(1), 8-10.

KENEVİR (Cannabis sativa L.) YAĞININ İÇERİĞİ VE SAĞLIK ÜZERİNDE POTANSİYEL ETKİLERİ

THE OIL CONTENT AND POTENTIAL HEALTH EFFECT OF HEMP OIL

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Özet

Cannabis sativa L. Cannabaceae familyasına ait bir türdür. Keneverin insan hayatında bulunması M.Ö 8000 yıllarına dayanmaktadır. Kenevir ilk olarak liflerinden faydalanılmak için kullanılırken zaman içerisinde tohumlarından elde edilen yağ ve çiçekleri de kullanılmaya başlanmıştır. Dişi çiçeklerin trikomlarında biriken tetrahidro kannabinoid türevleri psikoaktif etkilerinden dolayı eğlence ve dini ayinlerin bir parçası olarak insan yaşamında yerini almıştır. Etnobotanik kullanımı incelendiğinde tohumlarından elde edilen yağ, gıda maddesi olarak kullanıldığı gibi topikal uygulanarak cilt yanıkları ve kas ağrıları için kullanılmıştır. *C. sativa* tohumlarından elde edilen yağın bileşimi çoğunlukla çoklu doymamış yağ asitlerinden (PUFA) meydana gelmektedir. *C. sativa* yağı; linoleik asit, α-linolenik asit, oleik asit, palmitik asit, γ-linolenik asit gibi yağ asitleri majör yağ asitleridir. Bu yağ içeriğinin zenginliği göz önüne alındığında topikal olarak psoriyazis, akne, dermatit gibi cilt hastalıklarında iyileşmeye pozitif bir etkisi olduğu görülmüştür. Ayrıca kenevir tohumu yağı THC içermemesine karşın kenevir yağı (Hemp oil) kannabidiol türevi bileşikleri taşımaktadır. Bununla birlikte; kenevir tohum yağı THC içermediği için gıda maddesi olarak da umut vaat etmektedir. Kardiyovasküler hastalıklar için de gerek kan lipit düzeyleri gerek vasküler fonksiyonların iyileştirilmesinde pozitif etki göstermektedir. Ayrıca kenevir yağı Geleneksel Çin Tıbbı'nda romatoid artrit tedavisinde de kullanılmaktadır. Tüm bu çalışmalar göz önüne alındığında kenevir yağının hem tıbbi olarak oldukça önemli bir kaynak olabileceği hem de gıda potansiyeli taşıyabileceği düşünülmektedir.

Anahtar Kelimeler: *Cannabis sativa*, Kenevir Yağı, Yağ Asitleri, Kenevir, Hemp oil, Kenevir tohum yağı

Abstract

Cannabis sativa L. is a species belonging to the Cannabaceae family. The presence of hemp in human life dates back to 8000 BCE. Initially, hemp was used for its fibers, but over time, the oil obtained from its seeds and flowers also began to be utilized. The tetrahydrocannabinol derivatives accumulated in the trichomes of the female flowers have taken their place in human life due to their psychoactive effects, both as a part of recreational activities and religious rituals. When examining its ethnobotanical uses, the oil obtained from its seeds has been used as a food item and applied topically for skin burns and muscle pains. The composition of the oil extracted from **Cannabis** seeds is mostly made up of polyunsaturated fatty acids (PUFAs). Major fatty acids in **Cannabis** oil include linoleic acid, α-linolenic acid, oleic acid, palmitic acid, and γ-linolenic acid. Considering the richness of this oil content, it has been observed to positively affect the healing of skin diseases such as psoriasis, acne, and dermatitis when applied topically. Additionally, although hemp seed oil does not contain THC, hemp oil (hemp oil) contains cannabidiol derivatives. Furthermore, because hemp seed oil does not contain THC, it also shows promise as a food item. It positively affects cardiovascular diseases by improving blood lipid levels and vascular functions. Moreover, hemp oil is also used in Traditional Chinese Medicine for the treatment of rheumatoid arthritis. Considering all these studies, it is thought that hemp oil could be a significant medical resource and has potential as a food source.

Keywords: *Cannabis sativa*, Hemp Oil, Fatty Acids, Hemp, Hemp Oil, Cannabis seed oil

GİRİŞ

Cannabis sativa L. Cannabaceae familyasında yer almaktadır. Çoğunlukla dioik, 1-6m yüksekliğe kadar büyüyen, tek yıllık bitkilerdir. Gövdeleri yeşil, içi boş, silindirik, yaprak dizilimi alt dallarda dekussatken terminal dallara doğru alternat diziliş göstermektedir. Yapraklar 3-9 lobludur. Yapraklarda trikomlar bulunur ve lamina kenarı serrattır (Raman vd., 2017).

Bu türe ait kullanım MÖ 8000 yıllarına dayanmaktadır (Sun vd., 2021). Kenevir, ilk olarak liflerinden faydalanılmak için kullanılırken zaman içerisinde tohumlarından elde edilen yağ ve çiçekleri kullanılmaya başlanılmıştır. Dişi çiçeklerin trikomlarında biriken kannabinoidler psikoaktif etkilerinden dolayı eğlence ve dini ayinlerin bir parçası olarak insan yaşamında yerini almıştır (Bonini vd., 2018). Tarih boyunca bitkilerin kullanımı konusunda önemli bir el kitabı niteliği taşıyan Materia Medica'nın 3.cildinde kenevirin iltihap ve ödem giderici olarak anlatıldığı görülmektedir (Russo, 2007). Çin'in ilk hekimi olan Hua Tuo'nun ameliyat uygulamaları yaptığı ve anestezi kullandığı bilinmektedir. Anestezik olarak kullandığı karışımın içerisinde kenevir olduğu da kayıtlara geçmiştir (Tubbs vd., 2011).

Etnobotanik kullanımı incelendiğinde sıkılmış yaprak suyu kulak ağrısı için uygulanırken yapraklarından hazırlanan macun hemoroit tedavisi için kullanılmıştır. Ayrıca tohumlarından elde edilen yağ gıda maddesi olarak kullanıldığı gibi topikal uygulanarak cilt yanıkları ve kas ağrıları için uygulanmıştır (Nautiyal vd., 2000). Geleneksel kullanıma dayanarak yapılan *in vitro*, *in vivo* ve klinik çalışmalar kenevir tohum yağının terapötik olarak değerli bir ürün olabileceğini göstermektedir.

Sentetik bir kannabidiol türevi olan Dronabinol isimli bileşik oral kapsül formuyla 1985 yılında FDA (ABD Gıda ve İlaç İdaresi) tarafından AIDS/HIV için onaylanmıştır.2016 yılında ise aynı bileşiğe ait oral solüsyon FDA onayıyla kullanılmaya başlanmıştır. Dronabinol, CB1'i aktive ederek iştah uyarımının üretilmesinden öncelikli olarak sorumludur. Dronabinol doğrudan beyindeki kusma ve iştah kontrol merkezlerine etki ederek iştahı artırır ve kusmayı önler. İştah açıcı özelliklerinin yanı sıra merkezi sinir sisteminde duygusal, duyusal, somatik ve bilişsel etkiler de üretir ve merkezi sempatomimetik aktiviteye sahiptir. HIV/AIDS'e bağlı anorekside iştah artışı hayati bir klinik hedeftir çünkü artan iştah, önemli ölçüde artan yaşam kalitesiyle ilişkilendirilmiştir. Bazı çalışmalar AIDS hastalarında kilo kaybının nispeten kötü sonuçlarla ilişkili olduğunu bildirmiştir. Bu sebeple dronabinol HIV/AIDS için endike kabul edilmiştir (Badowski & Yanful, 2018).

Kenevir bitkisi, tohumları, çiçekleri, gövdesi ve sabit yağıyla tıbbi ve ekonomik değere sahip olan bir bitkidir. Kenevir çiçekleri ve tohumlarının tıbbi değerinin yanı sıra gövdesi de lif üretimi noktasında tekstil ve kağıt sanayisinde önemlidir. Ayrıca doymamış yağ asitlerince zengin oluşu da terapötik değerine dair pozitif bir bakış açısı sunmaktadır (Żuk-Gołaszewska vd., 2018). Kenevir tohum yağının kimyasal bileşimini aydınlatmak için yapılan çalışmalar sonucunda; palmitik asit, sterarik asit, oleik asit (C 18:1 w-9), linoleik asit (C 18:2 ω-6), γ-linolenik asit (C18:3 ω-6), α- linolenik asit (C 18:3 ω-3) eikosenoik asit (C 20:1 ω-9) behenik asit, ß- karoten, sitosterol, lutein, tokoferol (E vitamini) ve kalsiferol (D vitamini) gibi zengin bir kimyasal bileşime sahip olduğu görülmüştür (Da Porto vd., 2012). Kenevir tohum yağına ait yağ asitleri ve bulunma yüzdeleri Tablo 1'de gösterilmektedir.

Tablo 1: Kenevir tohumu yağı bileşimi *(Aladić vd., 2015; Da Porto vd., 2012)*

Yağ Asitleri	Bulunma Miktarı (%)
α- linolenik asit (C18:3 ω-3)	% 16.18- 17.96
Linoleik asit (C18:2 ω-6)	% 58.09- 59.16
γ-linolenik asit (C18:3 ω-6)	%3.05- 3.48
Eikosenoik asit (C20:1 ω-9)	%0.40- 0.80
Oleik asit (C18:1 ω-9)	% 11.51-12.98
Behenik asit (C22:0)	%0.18-1.9
Palmitik asit (C16:0)	% 5.37-7.12
Stearik asit(C18:0)	%1.56-3.4
γ-tokoferol	90-110 mg/L

Yapılan analizler sonucu elde edilen bulgular; kenevir tohum yağının %80 civarında doymamış yağ asidi içerdiğini göstermektedir. Doymamış yağ asitleri, yapılarında en az 1 adet çift bağ içeren yağ asitleridir. Doğada birçok yağ asidi vardır ve canlılar bünyelerinde bazı yağ asitlerini üretebilme yetisine sahiptirler ancak üretemedikleri yağ asitleri de vardır. Canlıların kendi yapılarında üretemedikleri ve dışarıdan diyetle alması gereken yağ asitlerine esansiyel yağ asitleri denilmektedir. α- linolenik asit, linoleik asit, γ-linolenik asit esansiyel yağ asitlerinden bazılarıdır (Lunn & Theobald, 2006). Linoleik asit, γ-linolenik asit sentezinde prekürsör olarak görev almaktadır. Bu sebeple linoleik asit miktarı doğrudan γ-linolenik asit sentezini arttırmaktadır (Shrestha vd., 2020). Doymamış yağ asitleri; antioksidan, antienflamatuvar, kalp damar sistemini destekleyici etkilere sahiptir. Ayrıca esansiyel yağ alımının anksiyete gibi sorunların çözümünde de destekleyici olduğu görülmüştür (Calder, 2015).

Kenevir yağı (Hemp oil) olarak bilinen ve bitkinin çiçek, gövde gibi diğer kısımlarından çeşitli ekstraksiyon yöntemleriyle elde edilen yağ, kenevir tohumu yağından farklıdır. Kenevir tohum yağı, kenevir bitkisinin tohumlarından preslenerek elde edilen ve THC içermeyen bir sabit yağdır. Tıbbi kullanım açısından bakıldığında kenevir tohum yağı kannabidiol türevi bileşikleri içermemesi sebebiyle dikkat çekicidir. Ayrıca THC/CBD miktarı arttırılarak kannabidiolce zengin yağlar (CBD oil) da terapötik amaçlarla kullanılmaktadır (VanDolah vd., 2019).

Kenevir tohumu yağı kannabinoid türevi bileşikler içermemesine karşın bitkinin diğer kısımlarından (örneğin; çiçekler) kontamine olabilirler (Jang vd., 2020). Bu sebeple kullanılacak yağın analizlerinin yapılmış olması önem arz etmektedir.

ARAŞTIRMA VE BULGULAR

Kenevir tohum yağının kimyasal bileşiminin aydınlatılmasının ardından bu bileşiklerin etki düzeyinin tespit edilebilmesi için *in vitro*, *in vivo* ve klinik çalışmalar yapılmıştır.

Kenevir yağının antioksidan potansiyeli yapılan *in vitro* deneylerde ABTS ve ORAC testleriyle araştırılmıştır. Elde edilen bulgulara göre orta seviyede bir antioksidan aktivite gözlenmiştir. Deney sonucunda; ORAC 28,2 µmol TE/g, ABTS 11,4 µmol TE/g verileri elde edilmiştir (Yu vd., 2005). Kenevir yağının kolesterol seviyeleri üzerindeki etkisini in vivo olarak araştıran bir çalışmanın sonuçlarına göre; 20 günlük uygulama sonrasında LDL- kolesterol değerinin 117,7'den 82,9 değerine düştüğü görülmüştür (Karimi & Hayatghaibi, 2006).

20 alopesi hastası üzerinde yapılan bir klinik çalışmada saç derisine 2 ay boyunca kenevir tohumu yağı uygulanmıştır. Elde edilen bulgular sonucunda belirgin iyileşme oranının %25, orta seviyede iyileşme oranının %40 olduğu sonucuna ulaşılmıştır. Ayrıca hastaların %25'inin tedaviden yanıt alamadığı görülmüştür (Farhood vd., 2023). Alopesi saç dökülmesiyle karakterize otoimmün bir hastalıktır (Pratt vd., 2017). Bu durum kenevir tohum yağının immünomodülatör etkinliği olabileceğini göstermektedir.

32 atopik dermatitli birey ile yapılan klinik bir çalışmada kenevir yağının topikal uygulamasının atopik dermatit üzerindeki etkisi araştırılmıştır. Cilt kuruluğu ve kaşıntı gibi atopik dermatit belirtilerinin anlamlı düzeyde iyileştiği ve ilaç kullanma oranının belirgin seviyede azaldığı görülmüştür (Callaway vd., 2005). Atopik dermatitin her 10 kişiden 1'inin yaşamı boyunca en az bir kez yaşadığı bir cilt hastalığı olduğu göz önüne alındığında tedavisinin oldukça önemli olduğu düşünülmektedir (Frazier & Bhardwaj, 2020).

Çin'de kolonoskopi uygulaması hazırlığı yapılacak 690 hasta üzerinde yapılan çift kör randomize bir çalışmada kenevir tohum yağının bağırsaklar üzerindeki etkisi araştırılmıştır. Kolonoskopi hazırlığında kullanılan PEG (Polietilen glikol) gerek tadının kötü olması gerek yetersiz kalori alımı gibi sebeplerle hasta uyumunu olumsuz etkilemektedir. Bunun önüne geçebilmek ve kullanılan PEG miktarını azaltmak için kenevir yağı uygulanmıştır. Elde edilen bulgulara göre kenevir yağının kolonoskopi sürecini olumlu etkileyeceği düşünülmektedir (Zhu vd., 2023).

100 MS hastasında yapılan çift kör randomize çalışmada kenevir yağının diyete eklenmesinin immünolojik bulgularda pozitif bir değişim oluşturduğu gözlenmiştir. Bu sonuçtan kenevir tohum yağında bulunan ω-3 yağ asitlerinin IFN-γ üretimini baskılamasının ve γ-linolenik asitin (C18:3 ω-6) prostoglandin E2'yi indüklemesinin sorumlu olduğu düşünülmektedir (Rezapour-Firouzi vd., 2013).

SONUÇ

Kenevir bitkisi tarihi çok eskiye dayanan ve birçok farklı milletçe kullanılmış bir bitkidir. Tıbbi olarak da halk arasında yaygın kullanımı dikkat çekmektedir. Ancak bitkinin psikoaktif maddeler içermesi tıbbi kullanım noktasında dahi önyargıları ve kanuni kısıtlamaları beraberinde getirmektedir.

Kenevir tohum yağının kannabidiol türevi bileşikleri içermemesi, ω-3 ve ω-6 yağ asitlerince zengin olması terapötik anlamda oldukça önem arz etmektedir. Bu doğrultuda yapılan *in vivo* ve klinik araştırmaların detaylandırılması, geliştirilmesi gerekmektedir. Ayrıca doymamış yağ asitlerince zengin bir yapısının olması gıda hammaddesi olarak da kenevir yağının önemli olabileceğini göstermektedir. Yapılan klinik çalışmaların sayısının ve kapsamının arttırılması ile kenevir yağının tıbbi değerinin daha çok ön plana çıkacağı düşünülmektedir.

KAYNAKLAR

Aladić, K., Jarni, K., Barbir, T., Vidović, S., Vladić, J., Bilić, M., & Jokić, S. (2015). Supercritical CO2 extraction of hemp (Cannabis sativa L.) seed oil. *Industrial Crops and Products*, *76*, 472-478.

Badowski, M. E., & Yanful, P. K. (2018). Dronabinol oral solution in the management of anorexia and weight loss in AIDS and cancer. *Therapeutics and Clinical Risk Management*, *14*, 643-651.

Bonini, S. A., Premoli, M., Tambaro, S., Kumar, A., Maccarinelli, G., Memo, M., & Mastinu, A. (2018). Cannabis sativa: A comprehensive ethnopharmacological review of a medicinal plant with a long history. *Journal of Ethnopharmacology*, *227*, 300-315.

Calder, P. C. (2015). Functional Roles of Fatty Acids and Their Effects on Human Health. *Journal of Parenteral and Enteral Nutrition*, *39*(1). 18-32.

Callaway, J., Schwab, U., Harvima, I., Halonen, P., Mykkänen, O., Hyvönen, P., & Järvinen, T. (2005). Efficacy of dietary hempseed oil in patients with atopic dermatitis. *Journal of Dermatological Treatment*, *16*(2), 87-94.

Da Porto, C., Decorti, D., & Tubaro, F. (2012). Fatty acid composition and oxidation stability of hemp (*Cannabis sativa* L.) seed oil extracted by supercritical carbon dioxide. *Industrial Crops and Products*, *36*(1), 401-404.

Farhood, I. G., Mamoori, A., & Sahib, Z. H. (2023). Clinical and Pathological Evaluation of Hemp Seeds Oil Effectiveness in the Treatment of Alopecia Areata. *Medical Journal of Babylon, 20*(1), 108-111.

Frazier, W., & Bhardwaj, N. (2020). Atopic Dermatitis: Diagnosis and Treatment. *American Family Physician*, *101*(10), 590-598.

Iftikhar, A., Zafar, U., Ahmed, W., Shabbir, M. A., Sameen, A., Sahar, A., Bhat, Z. F., Kowalczewski, P. Ł., Jarzębski, M., & Aadil, R. M. (2021). Applications of Cannabis Sativa L. in Food and Its Therapeutic Potential: From a Prohibited Drug to a Nutritional Supplement. *Molecules (Basel, Switzerland)*, *26*(24), 7699. 1-21

Jang, E., Kim, H., Jang, S., Lee, J., Baeck, S., In, S., Kim, E., Kim, Y., & Han, E. (2020). THC, CBD, and CBN concentrations in commercial hemp seeds and hempseed oil sold in Korea. *Forensic Science International*, *306*, 110064.

Karimi, I., & Hayatghaibi, H. (2006). Effect of Cannabis sativa L. Seed (Hempseed) on Serum Lipid and Protein Profiles of Rat. *Pakistan Journal of Nutrition*, *5*(6), 585-588.

Lunn, J., & Theobald, H. E. (2006). The health effects of dietary unsaturated fatty acids. *Nutrition Bulletin*, *31*(3), 178-224.

Majewski, M., & Jurgoński, A. (2021). The Effect of Hemp (Cannabis sativa L.) Seeds and Hemp Seed Oil on Vascular Dysfunction in Obese Male Zucker Rats. *Nutrients*, *13*(8), Mnekin, L., & Ripoll, L. (2021). Topical Use of Cannabis sativa L. Biochemicals. *Cosmetics*, *8*(3), Article 3.

Nautiyal, S., Rao, K. S., Maikhuri, R. K., Semwal, R. L., & Saxena, K. G. (2000). Traditional knowledge related to medicinal and aromatic plants in tri'al societies in a part of Himalaya. *Journal of Medicinal and Aromatic Plant Sciences*, *22*, 528-541.

Pratt, C. H., King, L. E., Messenger, A. G., Christiano, A. M., & Sundberg, J. P. (2017). Alopecia areata. *Nature Reviews Disease Primers*, *3*(1), 1-17.

Raman, V., Lata, H., Chandra, S., Khan, I. A., & ElSohly, M. A. (2017). Morpho-Anatomy of Marijuana (Cannabis sativa L.). Içinde S. Chandra, H. Lata, & M. A. ElSohly (Ed.), *Cannabis sativa L. - Botany and Biotechnology* 1, 123-136.

Rezapour-Firouzi, S., Arefhosseini, S. R., Mehdi, F., Mehrangiz, E.-M., Baradaran, B., Sadeghihokmabad, E., Mostafaei, S., Fazljou, S. M. B., Torbati, M., Sanaie, S., & Zamani, F. (2013). Immunomodulatory and therapeutic effects of Hot-nature diet and co-supplemented hemp seed, evening primrose oils intervention in multiple sclerosis patients. *Complementary Therapies in Medicine*, *21*(5), 473-480.

Rupasinghe, H. P. V., Davis, A., Kumar, S. K., Murray, B., & Zheljazkov, V. D. (2020). Industrial Hemp (Cannabis sativa subsp. Sativa) as an Emerging Source for Value-Added Functional Food Ingredients and Nutraceuticals. *Molecules*, *25*(18), Article 18.

Russo, E. B. (2007). History of Cannabis and Its Preparations in Saga, Science, and Sobriquet. *Chemistry & Biodiversity*, *4*(8), 1614-1648. https://doi.org/10.1002/cbdv.200790144

Shrestha, N., Holland, O. J., Kent, N. L., Perkins, A. V., McAinch, A. J., Cuffe, J. S. M., & Hryciw, D. H. (2020). Maternal High Linoleic Acid Alters Placental Fatty Acid Composition. *Nutrients*, *12*(8), 1-14. https://doi.org/10.3390/nu12082183

Sun, X., Sun, Y., Li, Y., Wu, Q., & Wang, L. (2021). Identification and Characterization of the Seed Storage Proteins and Related Genes of Cannabis sativa L. *Frontiers in Nutrition*, *8*. https://doi.org/10.3389/fnut.2021.678421

Tubbs, R. S., Riech, S., Verma, K., Chern, J., Mortazavi, M., & Cohen-Gadol, A. A. (2011). China's first surgeon: Hua Tuo (c. 108–208 AD). *Child's Nervous System*, *27*(9), 1357-1360.

VanDolah, H. J., Bauer, B. A., & Mauck, K. F. (2019). Clinicians' Guide to Cannabidiol and Hemp Oils. *Mayo Clınıc Proceedıngs*, *94*(9), 1840-1851.

Yu, L. L., Zhou, K. K., & Parry, J. (2005). Antioxidant properties of cold-pressed black caraway, carrot, cranberry, and hemp seed oils. *Food Chemistry*, *91*(4), 723-729. https://doi.org/10.1016/j.foodchem.2004.06.044

Zhu, X. W., Yan, J., Miao, L., He, Y. L., Wang, H. P., & Li, X. (2023). Safety and efficacy comparison of polyethylene glycol, hemp seed oil, and 5% sugar brine for bowel preparation in older patients: Study protocol for a randomized controlled trial. *Trials*, *24*(1), 168. https://doi.org/10.1186/s13063-022-07059-1

Żuk-Gołaszewska, K., Żuk-Gołaszewska, K., & Gołaszewski, J. (2018). Cannabis sativa L. – cultivation and quality of raw material. *Journal of Elementology*, *23*(3), 971-984. https://doi.org/10.5601/jelem.2017.22.3.1500

THE IMPORTANCE OF HEMP AND CORK IN INNOVATIVE MATERIALS IN THE FIELD OF CIVIL ENGINEERING: ADDRESSING THE ISSUE OF DEPLETION AND PROPOSING SOLUTIONS THROUGH REPLACEMENT WITH PNEUMATIC WASTE OR RUBBER WASTE

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Abstract

Biological resources such as hemp and cork are two very important biosourced materials in civil engineering due to their significant thermal performance. Hemp and cork are harvested from green spaces, and therefore, the consumption of these two substitutes in civil engineering and construction helps minimize the depletion of these materials. Through legislation governing these biosourced materials, we can manage their usage to ensure sustainability. As technicians in the field of civil engineering, it is imperative that we prioritize replenishing the environmental aspect.

In this study, we will elucidate the importance of cork and hemp in innovative concrete, particularly their role in improving thermal comfort in buildings. This will be supported by calculations and comparisons between the two materials based on both experiential knowledge and literature precedent studies, whether analytical or experimental. Furthermore, we will provide statistical estimates to illustrate the potential consequences of mismanaging these natural materials and propose technical solutions, such as utilizing pneumatic or rubber waste as substitutes for these biosourced materials. This will involve further calculations and comparisons.

Finally, our findings demonstrate that biosourced materials can be effectively replaced by tire and rubber waste, providing a compelling reason to preserve natural materials like cork and hemp.

Keywords: Biological resources, Hemp, Cork, Civil engineering, Thermal performance, Sustainability, Innovative materials.

ANALYSIS OF METALS ADSORPTION ON CHITOSAN DIMER BY USING DENSITY FUNCTIONAL THEORY

YOĞUNLUK FONKSİYONEL TEORİSİ KULLANILARAK KİTOSAN DİMER ÜZERİNDE METAL ADSORPSİYON ANALİZİ

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Abstract

Modeling the membrane structure of chitosan containing heavy metal ions like Ni^{+2}, Cu^{+2}, and Co^{+2} can provide valuable insights into their interactions and potential applications, especially in fields like environmental remediation or materials science.

In this study, Density Functional Theory (DFT) is a powerful computational method using Gauss View 6 software in quantum chemistry to study the electronic structure of molecules and materials. DFT was employed to investigate the adsorption process between chitosan dimer (CS) and metals at the B3LYP level, which is a commonly used exchange-correlation functional. Additionally, two different basis sets, 6-31G(d,p) and LANL2DZ, were used to accurately capture the electronic structure and energy of the adsorption process.The polarizable continuum model (PCM) was employed with water as the solvent, to account for solvent effects.

The interaction between chitosan and metal species was observed to be predominantly covalent in nature in almost all cases. This insight suggests strong chemical bonding between chitosan and the metal ions, highlighting the effectiveness of chitosan as an adsorbent for heavy metal removal in aqueous environments.

Chitosan dimer consists of two structures, type a and b, and it was observed that both a and b structures of the chitosan dimer retained metal ions. This observation is aimed at understanding the binding behavior of chitosan with different metal ions (Ni^{+2}, Cu^{+2}, and Co^{+2}) and how this may vary depending on the structure of the chitosan molecule. Results indicate that transition metal coordination to the chitosan biopolymer has occurred.

Keywords: DFT, Gaussian09, Chitosan, Nickel, Copper, Cobalt

Özet

Ni^{+2}, Cu^{+2} ve Co^{+2} gibi ağır metal iyonları içeren kitosanın membran yapısının modellenmesi, özellikle çevresel iyileştirme veya malzeme bilimi gibi alanlarda bunların etkileşimleri ve potansiyel uygulamaları hakkında değerli bilgiler sağlamaktadır

Yoğunluk Fonksiyonel Teorisi (DFT), moleküllerin ve malzemelerin elektronik yapısını incelemek için kuantum kimyasında Gauss View 6 yazılımını kullanan güçlü bir hesaplama yöntemidir. Bu çalışmada, yaygın olarak kullanılan bir değişim-korelasyon fonksiyoneli olan B3LYP seviyesinde kitosan dimer (CS) ve metaller arasındaki adsorpsiyon sürecini araştırmak için DFT kullanıldı. Ek olarak, adsorpsiyon işleminin elektronik yapısını ve enerjisini doğru bir şekilde yakalamak için 6-31G(d,p) ve LANL2DZ olmak üzere iki farklı temel set kullanılıp, çözücü etkileri için Polarize edilebilir süreklilik modeli (PCM), solvent olarak su ile kullanılarak hesaplamalar yapıldı.

Kitosan ve metal türleri arasındaki etkileşimin hemen hemen tüm durumlarda ağırlıklı olarak kovalent nitelikte olduğu gözlemlendi. Bu görüş, kitosan ile metal iyonları arasında güçlü bir kimyasal bağ olduğunu öne sürerek, kitosan'ın sulu ortamlarda ağır metallerin uzaklaştırılmasında bir adsorban olarak etkinliğini vurgulamaktadır.

Kitosan dimerinin A ve B tipi olmak üzere iki yapıdan oluştuğu ve kitosan dimerinin hem A hem de B yapılarının metal iyonlarını tuttuğu gözlendi. Bu gözlem, Kitosan'ın farklı metal iyonları (Ni^{+2}, Cu^{+2} ve Co^{+2}) ile bağlanma davranışını ve bunun kitosan molekülünün yapısına bağlı olarak nasıl değişebileceğini anlamayı amaçlamaktadır. Sonuçlar kitosan biyopolimerine geçiş metali koordinasyonunun meydana geldiğini göstermektedir.

Anahtar Kelimeler: DFT, Gaussian09, Kitosan, Nikel, Bakır, Kobalt

GİRİŞ

Kitin ve kitosan biyolojik olarak önemli olan doğal polisakkaritlerdir. Kitin, kabuklu deniz hayvanlarının (yengeçler, istakozlar ve karidesler gibi) kabuklarında ve eklemli böceklerin dış iskeletlerinde bulunan bir polisakkarittir. Selülozdan sonra doğada en fazla bulunan yenilenebilir bir polisakkarit olan kitin kimyasal olarak ise N-asetilglukozamin adı verilen monomerlerden oluşur. Kitosan ise, kitinin deasetilasyonu (N-asetil gruplarının çıkarılması) ile elde edilen kitinden türetilmiş ve ağırlıklı olarak D-glukozamin ve N-asetil-D-glukozamin monomerlerinden oluşan bir polisakkarittir[1].

Deasetilasyon işlemi, kitinin üzerindeki asetilamino ($-NH-CO-CH_3$) gruplarının amino ($-NH_2$) gruplarına dönüştürülmesi sürecidir. Bu süreçte, N-asetil-D-glukozamin grupları D-glukozamin gruplarınka dönüşür, ancak tamamen dönüştürülemeyebilirler. Bu yüzden, deasetilasyon sonucunda kitosanda N-asetil-D-glukozamin grupları azalırken, D-glukozamin gruplarının sayısı artar. [2]

Kitosan, benzersiz özelliklere sahip çok yönlü bir biyopolimer olması sebebiyle, çeşitli uygulama alanlarında kullanılmaktadır. Kitosan'ın uygulandığı bazı önemli alanlar şunlardır:

Biyomedikal ve İlaç Endüstrileri: Kitosan, biyoaktif ve biyoçözünür bir polimer olduğundan dolayı tıbbi ve biyomedikal alanlarda kullanılmaktadır.

Yiyecek ve İçecek Endüstrisi: Doğal bir koruyucu ve antimikrobiyal olan kitosan, gıda ambalaj malzemelerinde raf ömrünü uzatmak ve gıda kalitesini korumak amacıyla kullanılmaktadır.

Su Arıtma ve Çevresel Uygulamalar: Kitosan bazlı adsorbanlar, adsorbsiyon kapasitelerinden dolayı ağır metaller, organik kirleticiler ve boyalar gibi maddeleri su çözeltilerinden adsorbe edebilir ve su arıtma sistemlerinde, endüstriyel atık arıtımında kullanılabilirler.

Tarım ve Bitki: Biyopestisit olarak kullanıldığında, zararlı organizmaları kontrol altına alır, bitki büyümesini destekler, bitkilerin bağışıklık sistemini güçlendirebilir, toprak verimliliğini artırabilir. Ayrıca bitkilerin su ve besin alımına destek sağlayabilir, toprak kalitesini arttırarak toprak iyileştirmede kullanılabilmektedir. Bu nedenle, kitosan tarımsal uygulamalarda iyi bir seçenek olarak kabul edilmekte ve günümüzde daha fazla kullanılmaktadır.

Kitin, kabuklu deniz hayvanlarına bulunan 1811 yılında Fransa'daki botanik bahçesinin müdürü Profesör Henri Braconnot'un mantar hücre duvarlarından fungin adı verdiği kısmı izole etmesi ile keşfedilmiştir. 1823 yılında Odier, aynı yapıyı böceklerin kabuklarında bulmuş ve bu yapıya Yunanca kökenli olan kitin ismini vermiştir. [3]

Kitosan, kitinin kimyasal olarak değiştirilmiş bir türevidir. Kitosanın keşfi, 1859 yılında Fransız bilim insanı Profesör C. Rouget tarafından gerçekleştirilmiştir.

Rouget, kitinin kimyasal özelliklerini inceleyerek, asitlerle işlenerek yeni bir bileşik elde etti. Bu bileşiğe "kitosan" adını verdi. [4]

Kitosan, sulu ortamlarda ağır metal iyonları gibi çeşitli kirleticilerin giderilmesinde etkili bir adsorban olarak kullanılmaktadır. Kitosanın sahip olduğu polimerik yapı, ağır metal iyonlarını adsorbe etmek için uygun bir ortam sağlamaktadır.

Kitosanın amfoterik yapısı ise, metal iyonlarının çeşitli yollarla adsorbe edilmesine olanak sağlamaktadır. Bunlar arasında iyon değişimi, elektrostatik etkileşimler ve kovalent bağlanma gibi mekanizmalar bulunabilir. Kitosan, metal iyonlarıyla kovalent bağlar oluşturabilen amino (-NH2) ve hidroksil (-OH) grupları gibi fonksiyonel gruplar içermektedir. Bu sebepten ötürü kitosanın ağır metallerin etkileşmsinde genellikle kovalent bağlanma mekanizmaları kullanılmaktadır.

HESAPLAMA YÖNTEMLERİ

Bu çalışmada Kitosanın dimer yapısı kullanılarak metal iyonlarıyla arasındaki etkileşme süreci incelenmiştir. İncelemede, yaygın olarak kullanılan bir değişim-korelasyon fonksiyoneli olan B3LYP seviyesinde, Yoğunluk Fonksiyonel Teorisi (DFT) ve Gauss View 6 yazılımı kullanılmıştır.

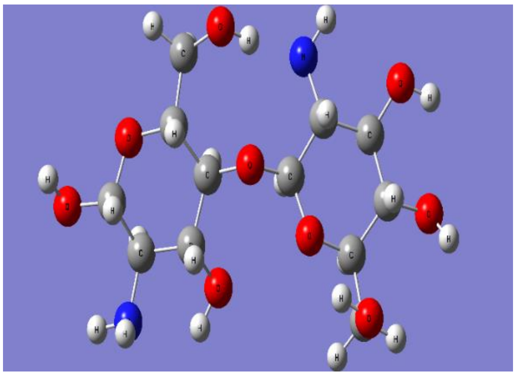
Gaussian programı, kuantum mekaniğinin prensiplerine dayanarak moleküler sistemlerin özelliklerini tahmin etmek için kullanılan bir hesaplama yazılımıdır ve moleküler yapıların, enerji seviyelerinin, titreşim frekanslarının ve reaksiyon kinetiklerinin hesaplanmasına yardımcı olmaktadır.

Bu program, moleküllerin atomik düzenlemelerini temel alarak elektronların davranışını hesaplamaktadır. Elektronların olasılık dağılımını temsil eden bir dalga fonksiyonunu kullanarak moleküler özelliklerin hesaplanmasını sağlayan Gaussian programı, moleküler yapıların optimize edilmesi, moleküler özelliklerin hesaplanması, reaksiyon yollarının analizi ve spektroskopik özelliklerin tahmini gibi çeşitli uygulamalarda kullanılabilir. Bu sayede, organik, inorganik ve biyokimyasal sistemlerin incelenmesi ve anlaşılması için önemli bir araç haline gelmektedir.

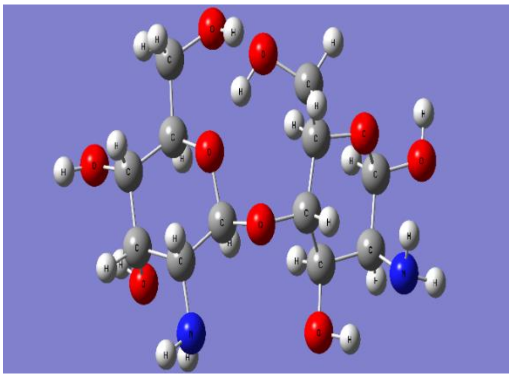
HESAPLAMALAR

Ağır metal iyonlarını (Ni^{+2}, Cu^{+2}, Co^{+2}) içeren kitosan membran yapısı iki farklı şekilde modellenmiş ve moleküler yapılar karşılaştırılmıştır. Tablo 1'de verilen veriler, kitosanın B tipi modellemesine ait olup, örnek bir çalışma ile karşılaştırılmıştır

Kitosan dimeri, iki kitosan molekülünün bir araya gelerek oluşturduğu bir bileşiği ifade etmektedir. Kitosan dimer, belirli koşullar altında iki kitosan zincirinin kimyasal olarak birleşmesi sonucunda oluşabilmektedir.



Şekil 1. 3D Yapılı Dimer Kitosan A Tipi



Şekil 2. 3D Yapılı Dimer Kitosan B Tipi

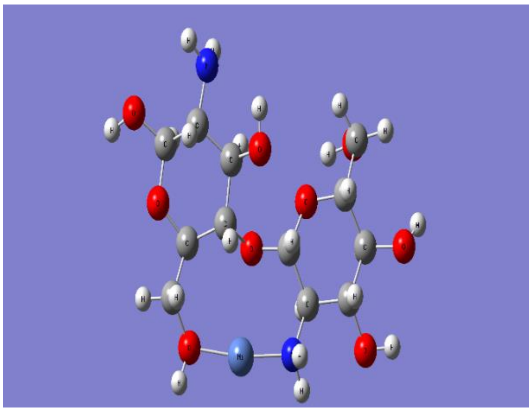
Etkileşme Enerjisi

Etkileşme enerjisi, bir adsorbantın (Örneğin, nikel metalinin) bir yüzey (Kitosan'ın) üzerine geldiğinde kovalent bağa karşılık gelen enerji miktarını ifade eder.

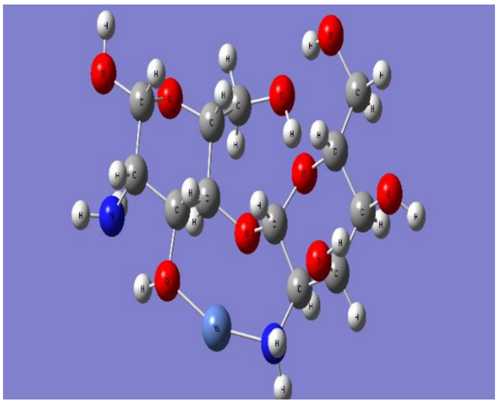
Negatif bir etkileşme enerjisi değeri, karşılık gelen etkileşme durumunun termodinamik olarak daha kararlı olduğunu göstermektedir. Kısacası, negatif bir değer, adsorbatın kitosan yüzeyine termodinamik olarak daha fazla bağlandığını veya adsorbanın etkileşmesi için enerjik olarak daha uygun olduğunu gösterir.

Bu tür bir sistemde, etkileşme enerjisi, kitosan yüzeyi ve nikel metal arasındaki etkileşimlerin doğası ve yoğunluğuna bağlı olarak değişebilir. Genellikle, daha güçlü ve termodinamik olarak daha istikrarlı bir etkileşme durumu, negatif bir etkileşme enerjisi ile ilişkilendirilir. Bu, adsorbatın kitosan yüzeyine sıkıca bağlandığı ve etkileşmenin kolaylıkla gerçekleştiği anlamına gelmektedir.

Bu bilgiler ışığında, negatif bir etkileşme enerjisi değeri, nikel metalin kitosan yüzeyine termodinamik olarak stabil bir şekilde adsorbe olduğunu göstermektedir [5].



Şekil 3. 3D Yapılı Dimer Cs-Ni^{+2} A Tipi



Şekil 4. 3D Yapılı Dimer Cs-Ni^{+2} B Tipi

Tablo 1. CS-Ni^{+2} Metal Kompleksinin Sulu ve Susuz Ortamdaki Etkileşme Enerjileri (eV)

Parametreleri	SULU (ev)		SUSUZ (ev)		
	A Tipi	**B Tipi**	**A Tipi**	**B Tipi [5]**	**B Tipi**
Cs-Ni (**$E_{kompleks}$**)	-38840.570	-38840.789	-38839.461	-38826.900	-38839.560
Cs (**E_{ligand}**)	-34238.675	-34238.572	-34237.990	-34232.772	-34237.829
Ni^{+2}(**$E_{metal\ iyon}$**)	-4594.339	-4594.339	-4575.897	-4575.897	-4575.897
Etkileşme Enerjisi (**E_{int}**)	-7.556	-7.878	-25.574	-18.236	-25.834

Yapılan Cs-Ni^{+2} literatür karşılaştırmasında kullanılan moleküllerin enerji değerleri belirlenip, elde edilen veriler $\mathbf{E_{etkileşme} = E_{kompleks}-(E_{ligand}+E_{metal\ iyon})}$ denklemi ile hesaplanmıştır. Aynı zamanda kitosanın A Tipi içinde elde edilen enerji değerleri aynı yöntem ve metodla hesaplanarak etkileşme enerjileri Tablo.1 de gösterilmiştir.

Tablo 2. Kompleks Yapıların Etkileşme Enerjilerinin Karşılaştırılması

Parametreleri	SUSUZ (eV)		SULU (eV)	
	A Tipi	**B Tipi**	**A Tipi**	**B Tipi**
Cs-Ni^{+2}	-25.574	-25.834	-7.556	-7.878
Cs-Cu^{+2}	-24.231	-24.498	-9.632	-10.176
Cs-Co^{+2}	-19.079	-23.829	-2.693	-6.042

Kitosan Dimerin sulu ve susuz ortamlarda Ni^{+2}, Cu^{+2}, Co^{+2} metal iyonlarıyla yapmış olduğu A tipi ve B tipi molekül yapılarının enerji değerleri hesaplanmış ve karşılaştırmalar yapılmıştır.

Tablo 1. ve Tablo 2. de Cs-Ni^{+2} Dimer yapısının bulunan etkileşme enerji değerleri, sulu ortamda her iki tip içinde susuz ortama göre daha düşük etkileşme enerjisine sahip olması, nikel metalinin kitosan yüzeyine zayıf bağlandığını gösterir.

Susuz ortamda yapılan karşılaştırmalarda; etkileşme enerji değerlerine bakılarak kararlılık durumları hakkında bilgi sahibi olunmuştur.

A Tipi (susuz) kompleks molekül yapısı için: $Ni^{+2}>Cu^{+2}>Co^{+2}$

B Tipi (susuz) kompleks molekül yapısı için: $Ni^{+2}>Cu^{+2}>Co^{+2}$

A Tipi (sulu) kompleks molekül yapısı için: $Cu^{+2}>Ni^{+2}>Co^{+2}$

B Tipi (sulu) kompleks molekül yapısı için: $Cu^{+2}>Ni^{+2}>Co^{+2}$

Bu nedenle etkileşme ortamın özelliklerine, kitosanın özelliklerine ve adsorbatın (metal iyonunun) özelliklerine bağlı olarak değişebilir. Genel olarak, sulu ortam, kitosanın metal iyonlarına bağlanma yeteneği açısından daha elverişli bir ortam olabilmektedir.

3.2 Homo-Lumo Enerji Gap Değerleri (ΔE)

HOMO adı verilen en yüksek dolu yörünge ve LUMO adı verilen en düşük boş yörünge, Enerji gap, LUMO enerji değeri ile HOMO enerji değeri arasındaki farktır. [6]

$$(\Delta E)=E_L-E_H$$

Bilindiği üzere bu enerji değeri bileşiğin kararlı yapısı hakkında bilgi verir. HOMO ve LUMO arasındaki enerji farkı büyükse kararlı bir molekülü, küçükse daha reaktif bir molekülü temsil eder. FMO değerleri molekül içi enerji transferinden biyoaktiviteyi belirlemek için kullanılır.

Tablo 3. Cs-Ni^{+2} Susuz Ortamda HOMO–LUMO Orbital Enerjileri, Enerji Gap Değerleri (Hartree)

Molekül	B Tipi [5] (Hartree)			B Tipi (Hartree)		
	E_{HOMO}	E_{LUMO}	ΔE	E_{HOMO}	E_{LUMO}	ΔE
Cs-Ni^{+2}	-0.48460	-0.38004	0.10456	-0.09038	0.00646	0.09684
Cs	-0.20870	0.02611	0.23481	-0.22907	0.04203	0.27110
Ni^{+2}	-1.10279	-1.00066	0.10213	-1.10279	-1.00066	0.10213

Cs-Ni $^{+2}$yapısındaki enerji Gap değeri kitosanın enerji Gap değerinden daha küçüktür. Gap değeri küçüldükçe etkileşme gücü artar, metal iyonu daha hızlı bağlanır.

Tablo4. Kitosan Dimer Kompleks Yapılarının Susuz ortamda (ΔE) Enerji Gap Değerlerinin Karşılaştırılması (Hartree)

Molekül	A Tipi	B Tipi
Cs-Ni^{+2}	0.09913	0.09684
Cs-Cu^{+2}	0.14695 0.1185	0.14483 0.08862
Cs-Co^{+2}	0.10185	0.06971 0.14269

Tablo5. Kitosan Dimer Kompleks Yapılarının Sulu ortamda (ΔE) Enerji Gap Değerlerinin Karşılaştırılması (Hartree)

Molekül	A Tipi	B Tipi
Cs-Ni^{+2}	0.12111	0.12594
Cs-Cu^{+2}	0.10532	0.11364
	0.15054	0.14554
Cs-Co^{+2}	0.10588	0.15263
		0.09256

Homo-Lumo arasındaki enerji fark büyüklüğü, molekülün kararlılık durumu hakkında bilgi sahibi olmamıza yardımcı olur. Eğer enerji farkı büyükse o molekül daha kararlı bir yapıya sahiptir.

Kitosan Dimer Kompleks yapılarının enerji Gap değerleri karşılaştırıldığında geçiş metallerinin iyonlaşma enerjisine paralel olarak enerji Gap değeri sıralamasının Cu $^{+2}$ > Ni $^{+2}$ > Co $^{+2}$ şeklinde olduğu söylenebilir.

SONUÇ

Sonuç olarak, A ve B Tipi Dimer Kitosan molekülü Cu $^{+2}$,Ni $^{+2}$,Co $^{+2}$ metalleri ile bağlanması sulu ve susuz ortamlarda incelenmiştir. DFT/ B3LYP/6-31 G(d,p) ile LanL2DZ yöntemleri kullanarak hesaplamalar yapıldı. Adsorbsiyon Enerjileri , Homo-Lumo Enerjileri ve Gap Değerleri her iki tip için (A ve B tipi) sulu ve susuz ortamlarda hesaplandı. Hesaplamalar sonucunda Kitosan molekülünün metal atomlarına sulu ortamda daha kuvvetli bağlandığı görülmaktadır. Kitosanın bu özelliğiyle su içinde bulunan ve çevre kirliliğine neden olan, sanayi atığı ağır metallerin su içinden alınmasında etkili madde olarak kullanılabileceği görülmektedir.

Kaynaklar

[1] Choi, C., Nam, J. P., & Nah, J. W. (2016). Application of chitosan and chitosan derivatives as biomaterials. Journal of Industrial and Engineering Chemistry, 33, 1-10.

[2] Aiba, S., Studies on chitosan: 4. Lysozymic hydrolysis of partially nacetylated chitosans, International Journal of Biological Macromolecules, 14, 225-228, 1992.

[3] Winterowd J.G., Sandford P.A., Chitin and Chitosan, Food Polysaccharides and Their Applications, (eds: Stephen, A.M.) Marcel Dekker Inc., New York, 441, 1995.

[4] Gökçe, Yavuz. (2008). Kitosan Nanoparçacıklarının Sentezi. Ankara Üniversitesi Fen Bilimleri Enstitüsü, Kimya Mühendisliği Anabilim Dalı, Yüksek Lisans Tezi

[5] Natsir, M. A., Zam Zam, Z., Muin, F., Umar, S. (2022). Analysis of Ni^{2+} Metal Adsorption on Chitosan Membrane Using Density Functional Theory, *TECHNO: Jurnal Penelitian,* 11(1), 63-70.

[6] Oliveira, M. S., Costa, S. N., Monteiro, N. K., Magalhães, G. A., Diógenes, I. C., Araújo, R. S., &Longhinotti, E. (2019). Experimental and Computational Studies of the Adsorption of Furan, Pyrrole, and Thiophene on Hydroxyapatites in a Single and Ternary Component.Journal of the Brazilian Chemical Society, 30(11), 2367-2375. https://doi.org/10.21577/0103-5053.20190146.

EVALUATING THE SENSORY ATTRIBUTES AND CONSUMER ACCEPTANCE OF COCOA-TIGERNUT-DATE BEVERAGE POWDER BLENDS COMPARED TO A COMMERCIAL COCOA POWDER PRODUCT (MILO)

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Abstract

This study aimed to assess the sensory properties of beverage powder derived from blends of cocoa, tiger nut, and date powder. Three samples, AB1, AB2, and AB3, were produced with varying ratios of the ingredients (50: 30:20, 30:20:50, 20:50:30) respectively, while AB0, a commercially available cocoa beverage powder (Milo), served as the control. Sensory analysis was conducted using standard analytical methods to evaluate the acceptability of the resulting beverage powder samples. The findings revealed that while sample AB0 was the most preferred by panelists, with no significant difference observed ($p > 0.05$), sample AB2 emerged as the most accepted blend of cocoa, tiger nut, and date for beverage powder production. Conversely, sample AB1 was the least preferred but still accepted by the panelists. Furthermore, upon comparison with the control (Milo), sample AB2 demonstrated comparable sensory acceptability, suggesting its potential as a viable alternative. These results underscore the potential of the AB2 blend in beverage powder formulation, offering a healthier alternative to traditional commercial beverage powder products.

Keywords: Beverage powder, cocoa powder, Tigernut powder, Date fruit powder, Sensory Evaluation.

STUDY OF THE CHEMICAL INHIBITION OF SCALING PHENOMENON IN TREATED WASTEWATER PIPES

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Abstract

The development of scale resulting from the deposition of calcium carbonate poses a significant challenge in treated wastewater conduits, causing obstruction problems and decreasing the efficiency of these pipes. Various formulations of anti-scale agents, known as inhibitors, are employed to manage the deposition of $CaCO_3$. Evaluating the performance of inhibitors is a time-consuming challenge. In the present work, a rapid approach for evaluating the inhibitors effectiveness in controlling calcium carbonate scale is proposed, based on continuous pH measurement under pot test conditions. Two green inhibitors were assessed. It was possible to evaluate their effectiveness at the same concentration level (80 ppm), with AULE showing better performance under the studied conditions. The primary mechanism of action of each inhibitor was also identified through this methodology.

Keywords: Calcium carbonate; Green inhibitor; Plant extract.

OPTIMIZING THE CIRCULAR BIOECONOMY: INNOVATIVE UTILIZATION OF FOOD RESIDUES AS HIGH-QUALITY LIVESTOCK FEED

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Abstract

Global and National Contexts The escalating global issue of food waste demands urgent attention, particularly in Morocco, where over 5 million tons of organic waste are generated annually, with food waste comprising more than 40% of municipal solid waste. This significant volume underscores the imperative for sustainable waste management strategies. Main Problems The nonevaluation of food waste poses multifaceted challenges, including environmental and health risks, economic losses, and exacerbation of climate change effects. Inefficient waste disposal contributes to greenhouse gas emissions, soil contamination, and resource depletion, threatening ecosystem integrity and human well-being. For the proposed solutions to address these challenges, innovative solutions such as recycling food waste into animal feed present promising avenues for sustainable waste management. By transforming organic waste into valuable resources, including compost, biofuel, and animal feed, a circular economy can be fostered, mitigating environmental degradation and promoting resource efficiency. Real Experience Drawing from practical experience, the ‘EcoMAN Chark Cooperative’ in Oujda (Eastern Morocco), exemplifies the successful transformation of food waste into broiler feed. Through a controlled process, food waste is converted into high-quality feed, adhering to stringent quality standards and ensuring nutritional adequacy for livestock. This initiative not only diverts waste from landfills but also addresses the nutritional needs of animals, reducing the pressure on fragile ecosystems and mitigating the impacts of climate change on agricultural productivity. The valorization of food waste biomass into animal feed represents a sustainable solution to the pressing challenges of waste management, environmental degradation, and climate change. By harnessing the potential of organic waste as a valuable resource, Morocco and similar countries can transition towards a more sustainable and resilient future, fostering economic prosperity, environmental stewardship, and social well-being. Through collaborative efforts and innovative initiatives, the circular economy model can be advanced, paving the way for a more sustainable and equitable society.

Keywords: Circular Bioeconomy; Food Waste Valorization; Livestock Feed; Sustainable Waste Management; Climate Change Mitigation

ÇƏTƏNƏ – QƏDİM DİNİ RİTUALLARIN AÇAR ÜNSÜRÜ

HEMP – A KEY ELEMENT OF ANCIENT RELIGIOUS RITUALS

Müşərrəf HƏSƏNOVA

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Özet

Çətənə Qara dəniz və Xəzər dənizi ətrafı, əsasən dağlıq ərazilərdə geniş yayılmış yabanı halda bitən bilinən ən qədim bitki növlərindən biridir. Bu coğrafiya xalqlarının sosial-mədəni həyatının mühüm hissəsinə çevrilmiş çətənə haqqında ilkin məlumatlara Avestada, I Daranın kitabələrində, antik müəlliflərdən Herodot, Strabon, Ktesifon, Ktessinin əsərlərində, eləcə də orta əsr şərq mənbələrində atəşpərəstlik rahibləri olan maqların haoma içkisiylə əlaqədar rast gəlinir.

Çətənə Medea tayfalarından olan maqların və Asiya steplərinin köçəri tayfaları skiflərin dini ayinlərinin önəmli tərkib hissəsidir. Xüsusi qablarda əzilərək süd rəngi alan qarışımı odapərəstiş rahibləri içdikdən sonra, tilsimlər oxuyar, sehrbazlıqla məşğul olardılar. Əhəməni, Parfiya və Sasani dövlətlərində dini mərasimləri yalnız maqlar həyata keçirərdilər. Onların müşayiətilə "sirli südü - haomanı" (hauma, soma, şuma) xüsusilə hökmdar olacaq vəliəhd içə bilərdi. Maqların gücünə o qədər inanılırdı ki, hətta vəliəhdlərin təlim-tərbiyəsi onlara tapşırılırdı.

Çətənə yalnız dini dünyagörüşlə bağlı rituallarda deyil, həm də antik dövrdə əhalinin təsərrüfatında önəmli məqamlarda qarşımıza çıxır. Möhkəm, bərk xammal kimi kəndir, səbət, sandal, çətir, yelkən, geyim hazırlanmasında bu bitkidən geniş istifadə olunurdu. Atranı simvolizə edən çətənə rəsmlərinə və ya bənzətmələrinə memarlıq abidələrində, xalça naxışlarında, bəzək əşyalarında da rast gəlinir. (Atra - Avestadakı həqiqət, daxildəki alov, günəşi-işığı tapmağın yolu)

Qədim sivilizasiyalar mərkəzi olan Şərqi Anadolu, İran, Cənubi Qafqaz, Şimali Hindistan xalqları bu gün də çətənə ilə bağlı ənənələrini davam etdirirlər. Odlar yurdu Azərbaycanda Suraxanı atəşpərəstlik məbədi daxilindəki muzeydə haoma hazırlanan qablar və maq geyimləri sərgilənir. Trabzonda, Rizedə çətənə toxuculuğu qanuni həyata keçirilir. Bir çox dünya ölkələri isə dərman sənayesində çətənənin faydasından yararlanır.

Açar sözlər: çətənə, atəşpərəstlik, maq, haoma.

Abstract

Hemp is one of the oldest known plant species, growing wild in the Black Sea and Caspian Sea regions, mainly in mountainous areas. Initial information about hemp, which has become an important part of the social and cultural life of the peoples of this geography, can be found in the Avesta, in the inscriptions of Darius I, in the works of ancient authors Herodotus, Strabo,

Ctesiphon, and Ctesi, as well as in medieval Eastern sources about the haoma drink of the Magians (magus, magi), who were fire worshiping monks.

Hemp is an important part of the Scythian religious rites of the Magians from the Medea tribes and the nomadic tribes of the Asian steppes. After the fire-worshipping monks drank the milk-colored mixture crushed in special containers, they would recite spells and engage in magic. In the Achaemenid, Parthian and Sasanian states, religious ceremonies were performed only by the Magians. Accompanied by them, the "mysterious milk - haoma" (hauma, soma, shuma) could be drunk especially by the crown prince who would be the ruler. The power of mages was believed so much that even crown princes were entrusted with training.

Hemp appears not only in rituals related to the religious worldview, but also in important moments in the economy of the population in ancient times. As a solid raw material, this plant was widely used in making rope, baskets, sandals, umbrellas, sails, and clothes. Hemp paintings or similes symbolizing Atra can also be found in architectural monuments, carpet patterns, and decorative items. (Atra - the truth in the Avesta, the fire within, the way to find the sun-light)

The peoples of Eastern Anatolia, Iran, South Caucasus, and North India, which are the centers of ancient civilizations, continue their traditions related to hemp even today. Home of fire In the museum inside the Surakhani fire worship temple in Azerbaijan, haoma dishes and mag clothes are exhibited. Hemp weaving is carried out legally in Trabzon and Rize. Many countries of the world are taking advantage of the benefits of hemp in the pharmaceutical industry.

Keywords: hemp, fire worship, magus, haoma.

GREEN SYNTHESIS OF SILVER NANOPARTICLES AND PRODUCTION OF NANOFIBERS BY ELECTROSPINNING AS AA FUNCTIONAL MATERIAL

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Abstract

Industrial hemp (Cannabis sativa L.) was used in this study, which is globally very important due to its high seed and fiber yield.

Functional materials have taken great interest due to their superior physical and chemical features which allow them to be succesfully used in a wide range of engineering applications. Nanomaterials, specifically nanofibers are regarded as functional materials due the their high surface area to volume ratio, high pore interconnectivity, small pore dimensions and superior chemical and mechanical features. Nanofibers are produced by mainly electrospinning which is a simple and inexpensive technique. Moreover, many types of polymers or polymer blends can be converted to nanofibers by electrospinning. Combination of two or more materials in a nanofibrous structure can result in functional materials

In this study, the goal was obtaining functional nanofibrous materials by incorporating a silver nanoparticles in novel polymeric nanofiber structures and evaluate the biological features of the samples for medical applications.

In this study, silver nanoparticles (AgNPs) were obtained by biological method in a simple, low-cost and environmentally friendly way. The characterization of the synthesized AgNPs was fulfilled using UV-visible Spectrophotometer, Field Emission Scanning Electron Microscope (FE-SEM), Transmission Electron Microscopy (TEM), Energy-Dispersive X-Ray Spectroscopy, X-Ray Diffraction Diffractrometer (XRD), Fourier Transform Infrared Spectroscopy and Zeta sizer and potential devices.

Nanofibers were produced by electrospinning method using PCL (polycaprolactone) as a biodegradable polymer, gelatin as a natural polymer and silver nanoparticles produced from hemp, and the morphological, mechanical properties, antibacterial activities and biodegradability of the nanofibers were analyzed.

Keywords: Silver Nanoparticle, Green Synthesis, Industrial Hemp, Electrospinning Method, Nanosize, Nanotechnology, Plant extract

EFFECTIVE UTILIZATION OF HEMP SEED MEAL (*CANNABIS SATIVA*) IN POULTRY FEEDS (BROILERS AND LAYING HENS)

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Abstract

According to the predictions of Food and Agriculture Organization (FAO) that human population will increase up to 30% near 2050 with consequent rise in demand for food. The largest component of human food is animal protein and this is totally dependent on livestock production. According to estimation about 70% of the price of livestock production is feed. Other component as well as cost of feed is the crude protein; for which the scientific and commercial communities should be creative and innovative. However, various less conventional and non-conventional ingredients were investigated as an alternative protein sources for livestock in previous few decades.

Hemp (*Cannabis sativa* L.) being an annual herbaceous plant belong to the Cannabinaceae family, conventionally grown-up for seed production and fiber. Composition of whole hemp seed is around 33-35 % oil, 25 % crude protein and 34 % carbohydrate, several minerals and vitamins are also included and so could function as an alternative feed constituent for human food and for livestock. However, hemp and its by-products like hempseed meal have been recognized to be reasonable substitute to conventional protein source for animal feeding. However, important research work has been bringing out on their dietary values to animals and human.

In this report, experimental work will be designed after the collection of hempseed meal. Different parameters will also be studied in order to accomplish the work. Scope of this review report is to make an assessment about utilization of hempseed meal (remaining portion of hemp seed after oil extraction) in poultry feed for growing broilers as well as laying hens. Specific aims of this report are follwoing;

- Reduction on the dependency of poultry feed
- Proper usage of the remaining portion of hempseed after oil extraction
- Exploring the highly nutritious by-products of hempseed

Key words: Industrial hempseed, nutrition, poultry, livestock

INTRODUCTION

In Old World cultures, hemp seed was considered a significant source of nutrition for thousands of years. Non-drug variety of Cannabis generally known as hemp, now studies broadly done for its nutritional potential in latest years, hemp seed used to a great level by the food markets and industrial processes that have developed during the 20th century. Hempseed oil is generally obtained mechanically using a low heat technique, also known as cold-pressing. This process results in a by-product known as hempseed meal (Hempseed meal, Figure 1), which contains different amounts of remaining fat, protein and oil etc. But the hempseed meal still has 25% protein and gives an outstanding nutritional source of fiber for poultry birds, animals and humans (Cheeke & Otero, 2005).


Fig. 1 (a) Hempseed **(b) Hempseed meal**

Main nutrients need for broiler and laying hen growth and maintenance are crude protein, fat, Carbohydrates, minerals, vitamins and water(Cheriane & Quezada, 2016). Dietary carbohydrates part from cereal grains like grain, corn, barley, wheat and sorghum are significant source of energy for poultry. Soybean and Corn meal are most frequently used ingredients in poultry feed. With the rise in price of soybean and corn meal increase the attention for some different ingredients. Hemp because of high protein quality and unsaturated fatty-acid amount plus less amount of anti-nutritional features might be utilized as a substitute feed element in the commercial poultry feed (FAO,2019).

Poultry feeds have an important direct effect on the chicken meat`s lipid profile (House *et al*., 2010). According to a study, DPA (docosapentaenoic acid), DHA (docosahexaenoic acid) and EPA (eicosapentaenoic acid) was enhanced in broiler thigh and breast meat upto 4-9 times when dietary ALA (alpha- linolenic acid) was increased in contrast to control feed (Howe et al.,2002). Flaxseed due to its lofty level of ALA is utilized in laying hens feed for the production of eggs enriched with omega-3 (Hau et al., 1996).

Hempseed meal is well-known in the world for its use in human food products due to its high contents of essential Fatty Acids – the omegas, omega-3, omega-6, omega-9, GLA, and high content of protein having all the amino acids. Polyunsaturated fatty acids (PUFAs), mostly the n-3 (omega-3) series, consisting of alpha-linolenic acid (ALA), and its long-chain (LC) derivatives docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), are necessary nutrients and required for the optimal health of animals and humans (Kartikasari et al., 2012).

Animals cannot be synthesized both LA and ALA, so it be obliged to be supplied in the feed. In animal cells, long chain polyunsaturated fatty acids (LC-PUFA) are prepared via metabolism of LA and ALA. Hemp, sunflower, soybean, and canola are edible oil that includes sensibly good quantity of omega-6 fatty acids. Conversely, not all vegetable oils offer considerable amounts of n-3 fatty acids. Hemp oil offers a ratio (3:1) of omega-6 to n-3 fatty acids, one that is regarded positive in favor of human health (Kalmendal, 2008).

Healthy hens after consuming a complete protein-rich feed mean better eggs and meat etc. Chicken's daily feed having hempseed meal may help them in following parameters

- Ease itchy skin
- Provide a bloom to their feathers
- Resist external parasites
- Improve the mobility
- Increase the immune system
- Improve the health

According to several reports in humans have revealed their health-promoting outcomes, involving decreasing the risk of neurological disorders, cardiovascular disease, diabetes, autoimmune disorders, inflammation, cancer and is showing visual and brain development (Kasula et al., 2021, Plourde et al., 2007).The raising curiosity in n-3 fatty acids for human health has lead the research that has investigated chances to enhance n-3 content in eggs, meat, and milk via feeding to animals with n-3 rich diets. Rich sources of n-3 PUFAs used in animal feeds are oilseeds i.e. hempseed (Russo, 2009). After obtaining oil through hempseed, the resulting hempseed meal has high protein content and a less energy value in contrast to whole hemp seed, because of elimination of the dilution effect of the oil. Crude protein and fiber values for the hempseed meal are about 1.7 times as compared to hemp seed (40 and 10%, correspondingly).[4] Hemp oil has polyunsaturated fatty acids (PUFA) between 75 to 80%, with α-linolenic acid (ALA) 17-19 % and linoleic acid (LA) of about 60% (Parker et al., 2003).

Fatty acids that are not generated by the body and have to be additionally added in the diet are known as essential fatty acids. The omega-6 LA and n-3 ALA, these are two essential dietary fatty acids for animals. In recently, researchers mainly emphasize on these EFAs because of their affirmative task in the prevention of diseases. N-3 fatty acids have an important function in struggling against cardiovascular diseases and in confirming normal brain functions (Wang et al., 2006). Saturated and trans fatty acids together with cholesterol are chief dietary components associated to atherosclerosis in humans. On the contrary, n-3 PUFAs can reduce level of serum cholesterol and are claimed to be valuable in decreasing the frequency and severity of myocardial infarction (Zyriax & Windler, 2000). Hypertriglyceridemia, also is a further reason of cardiovascular diseases which can be reduced by including n-3 fatty acids to the diet. The EFA and their long chain derivatives become integrated into cell membranes and play imperative roles in anti-inflammatory procedures and cell membrane viscosity (Smith et al., 2011). DHA and EPA are also needed for healthy aging and fetal development.

As such, hempseed as well as its derived products proved valuable feed ingredients in poultry feeds to boost the ALA and total n-3 intake, with potential beneficial effects on both the health of birds and the follow-on animal-derived food products intended for human consumption.

RESEARCH AND FINDINGS

Production of hemp seeds and Selection of birds

Hempseed was collected from the local fields of yozgat city, Turkiye. Broiler Birds and laying hens randomly selected from the local poultry farms of yozgat city, Turkiye.

Preparation of hemp seed poultry feed

Poultry feed was collected from local poultry farms of yozgat, Turkiye. The feed was divided into four categories i.e. 5, 10, 15 and 20% of hemp seed and hemp meal/cake diet as also reported in (kasula *et al*., 2021). A control group was also present without hemp seed.

Experimental house

A control shed house was used for performing the trials. Control shed consisted of a big hall containing big exhaust fans and automatic feeders where the chicks were fed and reared. In order to conduct the trials, a separate space was assigned where nine chicken pens with equal size were created. The chicken pens were built up by wire net barred separating each showing an area of around 500 square foot. Whole area was at first cleaned with brushes appropriately and washed with water including bleaching powder was sprinkled on floor for 24 hours. After 24 hours, bleaching powder was washed and spreaded the rice husk on floor in a way to prevent the moisture level in the experimental area.

Collection of chicks and findings of the experimental design

For the experimental trials, 40 one day old broilers were purchased from a private hatchery in Yozgat. The chicks were checked before the experiment to declare they were healthy and had no infections. Then the chicks were followed to vaccination and handed to the poultry workers for carrying out the feeding experiments under standard conditions for duration of five weeks experiment.The trial consisted of 40 broiler chicks that were equally divided into four groups (A, B, C and D) with each group having ten chicks. Group A chicks were fed with 5% hemp seed diet. Group B chicks were supplemented with 10% hemp seed in the feed. Group C was fed with diet containing 15% hempseed. Group D chicks were fed with 20% hempseed in their feed. The whole setup was designed for duration of five weeks. Body weight, feed intake and feed conversion ratio were determined.

Diet is one of the major factors that influence growth performance, nutritive profile and sensory traits of broiler meat . As indicated in our study, HSC can be included in broilers diet up to 10% without any adverse effects. The findings of this work is to examine growth performance factors and the fatty acid profiles of thigh and breast muscles of fast-growing chickens and broilers eating feeds having hempseed meal (*Cannabis sativa* L.). To complete this purpose, two experiments will be performed in growing laying hens and broiler chickens to evaluate performance (weight gain, feed efficiency and feed intake), muscle lipid level and eggs profile in birds eating feeds having hempseed meal. Generally, the usage of hempseed by-products, leads to an alternative growing trend as a highly nutritious process. Moreover, particular high level of α-linolenic acid, an omega-3 fatty acid, in hemp by-products, muscle tissues of broilers becomes better with this fatty acid.

Similar results were also reported by different researchers who found that growth performance and carcass traits were not influenced by the inclusion of graded levels of HSC in broiler diet. Furthermore, reported that the inclusion of hemp seed powder at 20% of broiler diet had positive effects on the weight of breast, leg, thigh as well as liver, gizzard, intestines and abdominal fat (Khan et al., 2010) In another study, researcher found that the dietary inclusion of hempseed expellers up to 15% affected the color of broilers' meat by increasing the red and yellow indices (Šťastník et al., 2019). On the other hand, significant differences were found for the individual and total n-3 FAs. The HSC diet provided the highest concentration of DHA, with significant differences as compared to the other diet as well as to the control group ($p < 0.05$). Moreover, in both HSC groups, a significant increase of total n-3 FAs ($p < 0.05$), and a consequent reduction of the n-6/n-3 ratio ($p < 0.05$) was observed.

Hempseed oil is generally extracted mechanically using a low heat technique, also known as cold-pressing. This process results in a by-product known as hempseed meal. It still contains 25% protein, fatty fraction (32- 36%) and provide an outstanding dietary source i.e. fiber for animals as well as humans. It has a balanced composition, consisted of 70-75% by a mixture of polyunsaturated fatty acids (PUFA) for example linoleic acid and linolenic acid and the gammalinolenic acid. In short it`s a precious source of energy, long chain fatty acids, and protein. Giving hempseed meal in the feed of laying hens also modifies the fatty acid composition of the eggs.

CONCLUSION

Environmental impact on animal production systems is an important matter. In a way to produce a large volume of feed as possible in the farm and be less dependent on importing it, research on different highly nutritious sources is needed. Potential towards alternative crops, like hempseed meal is a good option in nutritional way and economical performance. HSC may be considered a valuable and sustainable alternative feed ingredient in broiler diet. Further research is needed to thoroughly investigate the influence of functional hemp seed compounds in broiler production systems.

REFERENCES

Cheeke, P.R. and Otero, R., 2005. Yucca, quillaja may have role in animal nutrition. Feedstuffs.

Cherian, G. and Quezada, N., 2016. Egg quality, fatty acid composition and immunoglobulin Y content in eggs from laying hens fed full fat camelina or flax seed. Journal of animal science and biotechnology, 7(1), p.15. DOI: https://doi.org/10.1186/s40104-016-0075-y

Food and Agricultural Organization (FAO) (2019). Population growth forecast; FAO, Rome, Italy, P 74 (2015) http://www.fao.org/news/archive/news-by-date/2019/en/ http://www.fao.org/home/en/

House JD, Neufeld J, Leson G (2010). Evaluating the quality of protein from hemp seed (Cannabis sativa L.) products through the use of the protein digestibility-corrected amino acid score method. Journal of Agricultural Food Chemistry 58:11801-11807. DOI: 10.1021/jf102636b Available from: https://pubmed.ncbi.nlm.nih.gov/20977230

Howe, P.R., Downing, J.A., Grenyer, B.F., Grigonis-Deane, E.M. and Bryden, W.L., 2002. Tuna fishmeal as a source of DHA for n− 3 PUFA enrichment of pork, chicken, and eggs. Lipids, 37(11), pp.1067-1076. DOI: 10.1007/s11745-002-1002-3

Hau, M.F., Smelt, A.H., Bindels, A.J., Sijbrands, E.J., Van der Laarse, A., Onkenhout, W., van Duyvenvoorde, W. and Princen, H.M., 1996. Effects of fish oil on oxidation resistance of 87 87 VLDL in hypertriglyceridemic patients. Arteriosclerosis, thrombosis, and vascular biology, 16(9), pp.1197-1202. DOI: 10.1161/01.atv.16.9.1197

Kartikasari, L.R., Hughes, R.J., Geier, M.S., Makrides, M. and Gibson, R.A., 2012. Dietary alphalinolenic acid enhances omega-3 long chain polyunsaturated fatty acid levels in chicken tissues. Prostaglandins, Leukotrienes and Essential Fatty Acids, 87(4), pp.103-109. DOI: 10.1016/j.plefa.2012.07.005

Khan RU, Durrani FR, Chand N, Anwar H.. 2010. Influence of feed supplementation with Cannabis sativa on quality of broilers carcass. *Pakistan Veterinary J.* 30:34–38

Kalmendal, R., 2008. Hemp seed cake fed to broilers (Doctoral dissertation, slu).

Kasula, R., Solis, F., Shaffer, B., Connett, F., Barrett, C., Cocker, R. and Willinghan, E., 2021. Characterization of the nutritional and safety properties of hemp seed cake as animal feed ingredient. International Journal of Livestock Production, *12*(2), pp.53-63.

Plourde, M., and S. C. Cunnane. 2007. Extremely limited synthesis of long chain polyunsaturates in adults: implications for their dietary essentiality and use as supplements. Appl. Physiol. Nutr. Metab. 32:619–634.

Parker, T.D., Adams, D.A., Zhou, K., Harris, M. and Yu, L., 2003. Fatty acid composition and oxidative stability of cold-pressed edible seed oils. Journal of Food Science, 68(4), pp.1240-1243

Russo, G. L. 2009. Dietary n-6 and n-3 polyunsaturated fatty acids: from biochemistry to clinical implications in cardiovascular prevention, Biochem. Pharmacol. 77:937–946

Smith, G.I., Atherton, P., Reeds, D.N., Mohammed, B.S., Rankin, D., Rennie, M.J. and Mittendorfer, B., 2011. Dietary n-3 fatty acid supplementation increases the rate of muscle protein synthesis in older adults: a randomized controlled trial. The American journal of clinical nutrition, 93(2), pp.402-412. DOI: 10.3945/ajcn.110.005611

Šťastník O, Jůzl M, Karásek F, Fernandová D, Mrkvicová E, Pavlata L, Nedomová Š, Vyhnánek T, Trojan V, Doležal P.. 2019. The effect of hempseed expellers on selected quality indicators of broiler chicken's meat. *Acta Vet Brno*. 88(1):121–128. doi: 10.2754/avb201988010121

Turner CE, Cheng PC, Lewis GS, Russel MH, Sharma GK (1979). Constituents of Cannabis sativa XV: Botanical and chemical profile of Indian variants. Planta Medicine 37:217-225.

Wang, C., Harris, W.S., Chung, M., Lichtenstein, A.H., Balk, E.M., Kupelnick, B., Jordan, H.S. and Lau, J., 2006. n− 3 Fatty acids from fish or fish-oil supplements, but not α-linolenic acid, benefit cardiovascular disease outcomes in primary-and secondary-prevention studies: a systematic review. The American journal of clinical nutrition, 84(1), pp.5-17. DOI: 10.1093/ajcn/84.1.5

Zyriax, B.C. and Windler, E., 2000. Dietary fat in the prevention of cardiovascular disease—a review. European Journal of Lipid Science and Technology, 102(5), pp.355-365.DOI:https://doi.org/10.1002/(SICI)1438-9312(200005)102:5<355::AID-EJLT355>3.0.CO;2-3

PRODUCTION PROCESS OF BIOETHANOL AND BIOBUTANOL FROM INDUSTRIAL HEMP

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Abstract

Today, many research programs are focused on developing concepts such as renewable resources, sustainability, and green energy in the fuel sector. Worldwide, the use of fossil fuels continues to increase day by day.

The rapidly increasing population, industrialization, energy security, and environmental concerns have led to a growing demand for biofuels worldwide. Bioethanol/biobutanol stands out with the advantages it offers. Traditional products such as corn, sugarcane, and sugar beet cannot meet the demand for global bioethanol/biobutanol production due to their primary values as food and feed. Therefore, lignocellulosic materials, known as second-generation feedstocks, are attractive raw materials for bioethanol/biobutanol production due to their low cost, renewable nature, and abundant availability. Thus, bioethanol/biobutanol obtained from second-generation feedstocks could be a promising technology, but effective pretreatment methods for processing the selected biomass and complete delignification of lignocellulosics pose various challenges. However, appropriate pretreatment methods are important to ensure the efficiency of the entire process, as they can increase the amount of fermentable sugars after enzymatic hydrolysis.

The ability of industrial hemp (*Cannabis Sativa* L.), which has significant lignocellulosic biomass, to grow in a wide range of climates with a reasonable water footprint and its short harvest period make it a potential alternative bioresource for bioethanol/biobutanol production. Industrial hemp stands out significantly among second-generation biomass due to its high cellulose and low lignin structure. In bioenergy production, during the hydrolysis stage, the high presence of cellulose not only increases the amount of ethanol and biobutanol but also the low amount of lignin shortens the pretreatment process, accelerating the overall process.

When the literature is reviewed, it is observed that bioethanol production from industrial hemp has been conducted using commercial enzymes, while there is no research available on biobutanol production. In studies, the conversion of cellulose to bioethanol has generally been carried out, and the non-utilization of hemicellulose in the conversion process has affected the bioethanol yield. By genetically engineering cellulolytic and hemicellulolytic enzymes and utilizing microorganisms capable of fermenting both enzymes, specificity can be achieved in bioethanol/biobutanol production.

In this paper, while current technologies for the production of bioethanol and biobutanol from agricultural waste are discussed, the current potential of industrial hemp is also reviewed. Additionally, microorganisms that can be utilized for bioethanol/biobutanol production and fermentation through genetic engineering are also addressed.

Key Words: Industrial Hemp, Bioethanol, Biobutanol, Genetic Engineering

INTRODUCTION

The increase in the world population over time also increases the demand for energy production. This excessive use of fossil fuel resources poses the danger of environmental pollution, climate change and the greenhouse effect. The fact that fossil fuels are limited resources and the concern that they will one day run out increases the demand for biofuels obtained from renewable energy sources. Biofuel sources can be a sustainable alternative to fossil fuels used today. It is possible to obtain various biofuels (bioethanol, biobutanol, biodiesel, biogas) by using biomass raw materials that are environmentally friendly, sustainable and do not harm the food supply (Kreuger et al., 2011). Bioethanol and biobutanol are considered promising biofuel sources because they are similar to the currently used fuel systems and can replace fossil fuels (Talebnia et al., 2010; No, 2016). Worldwide production of fuel bioethanol was over 29.5 billion gallons in 2023. The USA produces 53% of this figure and Brazil produces 28% (RFA, 2024). There is an increase of approximately 1.4 billion gallons in bioethanol production in 2023 compared to the previous year. It is known that biobutanol production in the world is 3,000 million gallons in 2020. A growth of over 8.5% is expected by 2026 (Market, 2022). In addition to being a source of energy, bioethanol and biobutanol are valuable products because they can be used in chemistry, medicine, food and other industrial fields.

Generally, First generation raw material sources (wheat, barley, corn, potatoes, sugar, sugar beet) are generally used in biofuel production. Bioethanol, one of the most widely consumed types of biofuel, is mostly obtained from crops such as corn. However, since these raw materials are used for food and fiber production, they limit economic growth in biofuel production due to high production and processing costs (Fargione et al., 2008; Ocde and Steenblik, 2007). It is a competing challenge with food crops as long as 1st generation biofuels from food crops dominate total biofuel production. In order to prevent this problem, 2nd Generation raw material resources have come to the fore. Such raw materials include lignocellulosic biomass (cereal straw, sugarcane bagasse, forest residues), wastes (organic components of municipal solid waste). Lignocellulosic biomass can be defined as cellulose and hemicellulose that can be converted to sugar using appropriate thermochemical and biological processes and subsequently fermented into bioethanol (Hamelinck et al., 2005). Lignocellulosic biomass includes agricultural residues, forest residues and herbaceous energy plants. Compared with other raw materials, lignocellulosic raw material increases the efficiency of arable land use, is CO_2 neutral, abundant and does not compete with food products, making it superior (Galbe et al., 2011). Therefore, lignocellulosic biomass represents an alternative to traditional raw materials used in biofuel production. In addition to all these advantages, lignocellulosic biomass has a resistant structure, must be disrupted in order to release fermentable sugars during the bioethanol production stage (Hendriks and Zeeman, 2009). The pretreatment step can address these limitations.

The use of industrial hemp plant, one of the second generation raw materials, in biofuel production has become popular recently. Hemp is one of the first crops grown by mankind. Nowadays, hemp cultivation has become widespread in many countries. The entire biomass of industrial hemp is currently being investigated It is used in textile (Van der Werf and Turunen, 2008), composite (Shahzad, 2012), paper (Cirini et al., 2020), and bioenergy production (Prade et al., 2020). The cultivation and use of hemp has become increasingly important in recent years due to its many advantages such as its short harvest time, high carbohydrate content and relatively low lignin content, being durable and adapting to all climatic conditions. With this increased interest in hemp, it is very valuable to use the waste left from hemp cultivation and processing for bioenergy production (Das et al., 2017). Industrial hemp, a lignocellulosic raw material, consists of cellulose (70-74%), hemicellulose (15-20%) and lignin (3-7%). Production of bioethanol and biobutanol from lignocellulosic biomass still faces significant technical difficulties. Success depends on the main focus of a production, the physical and chemical properties of the biomass, the effectiveness of pre-treatment methods, the use of effective enzymes and the microorganisms used in the fermentation stage.

This chapter focuses on pretreatment methods of hemp biomass, enzymes used in enzymatic hydrolysis, and microorganisms used in bioethanol and biobutanol fermentation.

Bioethanol Production Stages

Bioethanol is a potential alternatives to gasoline. Besides sustainable energy production, bioethanol can help reduce greenhouse gases (MacLean et al., 2000). Literature studies have reported that bioethanol production from lignocellulosic biomass provides a higher net energy rate and will produce less greenhouse gas emissions compared to bioethanol produced from first-generation raw material sources such as corn or sugar cane (Wang et al., 2012). Industrial hemp, one of the lignocellulosic biomass sources, is a new, sustainable, cheap raw material source to produce bioethanol due to its high cellulose and low lignin content (Sipos et al., 2010; Neutelings, 2011). The high cellulose and low lignin content of industrial hemp increases bioethanol yield.

Bioethanol production from biomass consists of pre-treatment, hydrolysis, fermentation and separation stages, respectively. The aim of the pre-treatment stage is to eliminate the lignin structure by loosening th ebiomass structure.. Physical, chemical and biological methods are used in the pre-treatment process. Chemical pretreatment is usually done using alkaline and acid reagents. Alkaline pretreatment with NaOH increases the accessibility of cellulose and hemicellulose structures to enzymatic hydrolysis by affecting ester bonds (Xu et al., 2010). Pretreatment with sulfuric acid dissolves hemicelluloses and disrupts the structure of physical and chemical bonds (Papirio et al., 2020). Pre-treatment cost varies depending on the process conditions to be selected. Pretreatment with high temperature ranges may not be very economical. Many researchers are trying to develop new reaction processes to provide economic conditions (Langan et al., 2011).

The next stage is enzymatic hydrolysis, which determines the amount of simple sugars metabolized by the yeast during the fermentation process. Cellulase enzymes are preferred to obtain glucose in fermentable monomer structure from long cellulose chains. The main effect of enzymatic hydrolysis involves enzymes attacking the cellulose structure by binding to cellulose fibers, thereby breaking long cellulose chains and subsequently breaking them down into building blocks until glucose monomers are obtained (Lee et al., 2017). Hemicellulose hydrolysis can also be performed along with cellulose hydrolysis to increase bioethanol production. Cellulase contains three main hydrolytic enzymes: endoglucanases, exoglucanases and cellobiohydrolases (Basotra et al., 2022). Hemicellulases enable hydrolysis of the hemicellulose structure to reach monomers (Brar et al., 2024). Due to the heterogeneous structure of hemicelluloses, depolymerization of hemicellulose requires various enzymes such as xylanases, α-glucuronidase, α-arabinofuranosidase, endoxylanase, β-xylosidase, acetyl xylan esterase and feruloyl xylan esterase, laccases (Basotra et al., 2023). Enzymatic activity is largely related to the process of the pretreatment process. However, factors such as the amount of enzyme, the activity of enzymes, the interaction and ratio of different enzyme structures with each other are very important in determining an effective hydrolysis method (Knott et al., 2014). Commercial enzymes are generally used in enzymatic hydrolysis studies. Enzymes can be obtained from bacterial DNA by various methods using recombinant DNA technology methods. In a study, cellobiohydrolase enzyme was produced from *Clostridium clariflavum* bacterial DNA and showed 77% activity (Zafar et al., 2021). In a different study, β-xylanase was produced from Thermotoga naphthophila and its enzymatic hydrolysis was performed against various substrates (Hamid et al., 2019 & Dinçer et al., 2021). Considering the studies conducted, it is possible to perform enzymatic hydrolysis of industrial hemp using bacterial DNA containing cellulase and hemicellulase enzyme genes.

Microorganisms are used to produce bioethanol by fermentation of sugars obtained as a result of enzymatic hydrolysis of lignocellulosic biomass. Bioethanol is produced by yeasts and bacteria such as *Candida glabrata*, *Pachysolen tannophilus*, *Scheffersomyces stipitis*, *Zymomonas mobilis*, *Saccharomyces cerevisiae*, *Scheffersomyces stipitis*, *Candida shehatae*, *Escherichia coli*, *Candida tropicalis*, *Pichia stipitis* and *Kluyveromyces fagilis* (Azhar et al., 2017). These microorganisms ferment the resulting sugars anaerobically and aerobically. *Saccharomyces cerevisiae* is frequently used in bioethanol production due to its high ethanol yield and greater tolerance to inhibitory compounds (Brar et al., 2024). *Saccharomyces cerevisiae* can ferment C6 carbohydrates but not C5 sugars. Although industrial hemp has C5 and C6 sugar content, not using C5 sugars for ethanol fermentation is wasteful. Co-fermentation of pentoses and hexoses is still in its early stages. For example, *Kluyveromyces marxianus* is a heat-tolerant yeast variety that can ferment both C5 and C6 sugars together (Yanase et al., 2010). Since the industrial hemp plant has a high cellulose and hemicellulose ratio, the amount of bioethanol production can be increased by using microorganisms that ferment both sugar groups. After selecting the appropriate microorganism for the fermentation process, the fermentation method is determined. These methods; separate hydrolysis and fermentation (SHF), simultaneous hydrolysis and fermentation (SSF) and simultaneous hydrolysis and co-fermentation (SSCF). In SHF, lignocellulosic materials are first hydrolyzed , followed by fermentation . In SSF and SSCF, the enzymatic hydrolysis and fermentation process occurs simultaneously and the process is short. After the fermentation stage, separation and purification of bioethanol can be achieved by distillation. The highest ethanol production from dry hemp stalk harvested in different periods was reported to be 4503 L ha -1 (Rheay et al., 2021). In a different study conducted in 2013, it was reported that 413 kg of bioethanol per hectare could be produced from hemp biomass (Rehman et al., 2013).

Biobutanol Production Stages

Biobutanol is superior to existing fuels due to its properties similar to gasoline, mixing with gasoline in certain proportions, low octane value, low volatility, less hygroscopic, lower vapor pressure, less corrosive, and high energy content (Malik, 2014; No, 2016). Hemp, a lignocellulosic biomass, may be an effective source in thi sregard, as it has not been investigated in detail for biobutanol production,. Biobutanol production from lignocellulosic biomass is mostly similar to bioethanol production. Initial pretreatment of the lignocellulosic raw material changes the properties of the biomass, increasing the amount of glucan and xylan during enzymatic hydrolysis, resulting in higher sugar yield. The pretreatment method to be used greatly affects the enzymatic hydrolysis and subsequent fermentation.

Enzymatic hydrolysis of lignocellulosic materials is essential to convert them into monosaccharide structures before being used as substrates in the fermentation stage. Enzymatic hydrolysis is an environmentally friendly option for converting raw material resources into biobutanol. When large-scale biobutanol production is performed, different expensive commercial enzymes are needed during enzymatic hydrolysis, and this increases the cost of hydrolysis process. New and more cost-effective processes can be developed to break down cellulose and hemicellulose into their building blocks. Microorganism DNA containing cellulase and hemicellulase enzyme genes can be converted into enzymes by genetic engineering methods. To convert the hydrolyzed feedstock into biobutanol, *Clostridium* sp. such as *Clostridium acetobutylicum*, *Clostridium beijerinkii*, *Clostridium thermocellum*, *Clostridium cellulolyticum*, *Clostridium saccharobutylicum*, *Clostridium thermocellum* or *Clostridium saccharoperbutylacetonicum* are often used. It is synthesized through acetone-butanol-ethanol (ABE) fermentation using (Ng et al., 2015). Although the *Clostridium acetobutylicum* strain was the first bacteria used in ABE fermentation, it is known that ABE fermentation has a history dating back 100 years (Ranjan and Moholkar, 2012). ABE fermentation includes two stages: acidogenesis and solventogenesis. In the first stage, asodogenesis, a growth phase is observed with the conversion of glucose to acetic and butyric acid and the formation of ATP. This step forms the basis of fermentation. If this step did not exist, there would be a decrease in the number of living cells and difficulty in solvent production (Brar et al., 2024). In the second stage, solventogenesis, butanol is obtained through the conversion of substrate and acids (Green, 2011). Purification of biobutanol produced by fermentation can be achieved using distillation columns, pervaporation methods, and gas stripping methods. Butanol, ethanol and volatile acids produced during fermentation are analyzed by gas chromatograph.

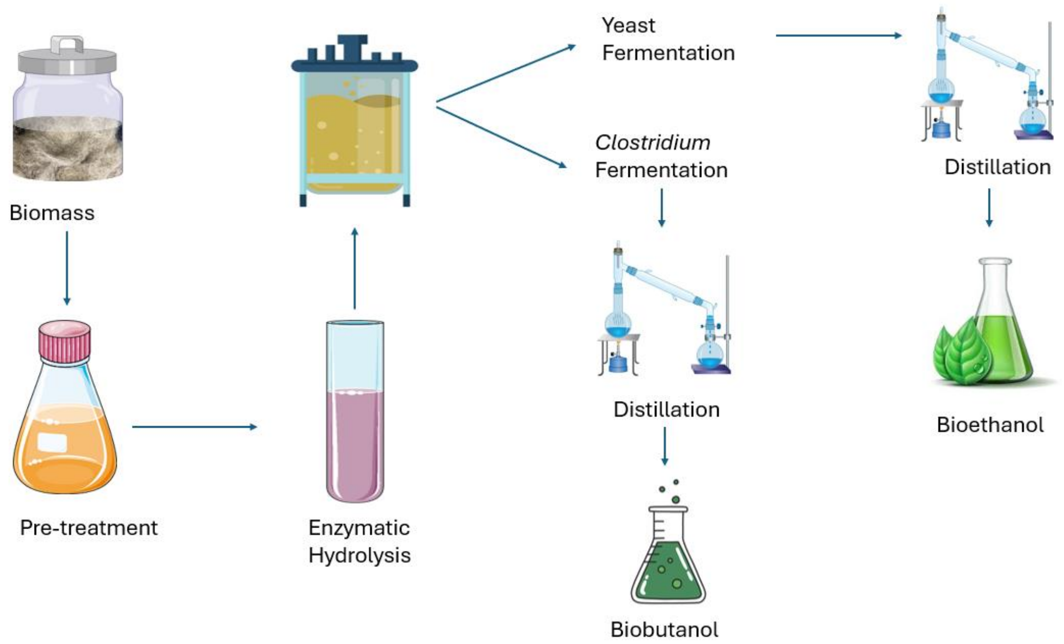

Figure 1. Bioethanol and biobutanol production stages.

Comparison of Bioethanol and Biobutanol

Compared to bioethanol, biobutanol is superior as a fuel or fuel additive because of its similar properties to gasoline and is well compatible with gasoline. At the same time, biobutanol produced through microbial fermentation is used in the food industry as an artificial sweetener in food and beverage areas. Additionally, biobutanol is used as an extractant for various chemicals and pharmaceuticals. Butanol is largely used as an intermediate, especially for the production of butyl acetate and other industrial chemicals. Compared to bioethanol, butanol has high energy content, low volatility and is less corrosive (Jin et al., 2011). The Reid vapor pressure of butanol is 7.5 times lower than that of ethanol, making it less evaporative/explosive (Bohlmann and Bray, 2007). The major advantages of biobutanol compared to bioethanol are its well misciblity with liquid fuels, has a higher octane number, less corrosive, high energy content, and can be used directly or mixed with gasoline in automobile engines (Yang et al. 2014). Using butanol as fuel in internal combustion engines has many advantages to bioethanol, and the most important of these advantages is that biobutanol has a low vapor pressure. Thus, it cannot be absorbed in water and can be mixed with biofuel and gasoline without phase separation with water (Dürre, 2008).

CONCLUSION

The depletion of fossil fuels over time, the increasing demand for energy consumption and the damage caused by fossil resources to the environment are the most commonly problems of everyone living in the world. Bioethanol seems possible to be used as an alternative to traditional gasoline due to its impressive features such as reducing greenhouse gas emissions, containing a higher octane number, and being a clean fuel source. Biobutanol, a promising new biofuel source, continues to be the focus of researchers' attention due to its superior properties compared to gasoline. In general, bioethanol and biobutanol production are almost the same, the only difference is the fermentation and recovery step.

It has been seen that the use of lignocellulosic raw materials in bioethanol and biobutanol production is much more promising. It is thought that choosing the pretreatment process according to the lignocellulosic biomass to be used will contribute to the bioethanol and biobutanol yield. Industrial hemp biomass is an alternative lignocellulosic source to bioethanol and biobutanol production due to its superior properties such as being able to be harvested in a fast time and containing high amounts of cellulose. More research on the production of bioethanol and biobutanol from hemp biomass is needed. In this paper, bioethanol and biobutanol production process, specifically for the industrial hemp plant, are mentioned.

REFERENCES

Azhar, S. H. M., Abdulla, R., Jambo, S. A., Marbawi, H., Gansau, J. A., Faik, A. A. M., & Rodrigues, K. F. (2017). Yeasts in sustainable bioethanol production: A review. *Biochemistry and biophysics reports*, *10*, 52-61.

Basotra, N., Kaur, B., Raheja, Y., Agrawal, D., Sharma, G., & Chadha, B. S. (2023). Developing and evaluating lignocellulolytic hyper producing deregulated strains of Mycothermus thermophilus for hydrolysis of lignocellulosics. *Biomass Conversion and Biorefinery*, *13*(6), 5059-5071.

Basotra, N., Raheja, Y., Kaur, B., & Chadha, B. S. (2022). Thermophilic fungal lignocellulolytic enzymes in biorefineries. In *Progress in Mycology: Biology and Biotechnological Applications* (pp. 15-43). Singapore: Springer Nature Singapore.

Bohlmann, G., & Bray, R. (2007). Biobutanol. *SRI Consulting, California*.

Brar, K. K., Raheja, Y., Chadha, B. S., Magdouli, S., Brar, S. K., Yang, Y. H., ... & Koubaa, A. (2024). A paradigm shift towards production of sustainable bioenergy and advanced products from Cannabis/hemp biomass in Canada. *Biomass Conversion and Biorefinery*, *14*(3), 3161-3182.

Brar, K. K., Raheja, Y., Chadha, B. S., Magdouli, S., Brar, S. K., Yang, Y. H., ... & Koubaa, A. (2024). A paradigm shift towards production of sustainable bioenergy and advanced products from Cannabis/hemp biomass in Canada. *Biomass Conversion and Biorefinery*, *14*(3), 3161-3182.

Crini, G., Lichtfouse, E., Chanet, G. ve Morin-Crini, N. (2020). Kenevirin tekstil, kağıt endüstrisi, yalıtım ve yapı malzemeleri, bahçecilik, hayvan beslenmesi, yiyecek ve içecek, nutrasötikler, kozmetik ve hijyen, tıp, tarım kimyası, enerji üretimi ve çevredeki uygulamaları: Bir inceleme. *Çevre Kimyası Mektupları* , *18* (5), 1451-1476.

Das, L., Liu, E., Saeed, A., Williams, D. W., Hu, H., Li, C., ... & Shi, J. (2017). Industrial hemp as a potential bioenergy crop in comparison with kenaf, switchgrass and biomass sorghum. *Bioresource technology*, *244*, 641-649.

Dinçer, Ö., Celebioglu, H. U., Hamıd, A., Aftab, M. N., & Karadağ, A. (2021). Saccharification of Hazelnut and Rhododendron Biomasses Using β-xylanase from Thermotoga naphthophila. *Journal of the Institute of Science and Technology*, *11*(2), 1321-1328.

Dürre, P. (2008). Fermentative butanol production: bulk chemical and biofuel. *Annals of the New York Academy of Sciences*, *1125*(1), 353-362.

Fargione, J., Hill, J., Tilman, D., Polasky, S., & Hawthorne, P. (2008). Land clearing and the biofuel carbon debt. *Science*, *319*(5867), 1235-1238.

Galbe, M., Gorwa-Grauslund, M. F., & Zacchi, G. (2011). Bio-ethanol–the fuel of tomorrow from the residues of today.

Green, E. M. (2011). Fermentative production of butanol—the industrial perspective. *Current opinion in biotechnology*, *22*(3), 337-343.

Hamelinck, C. N., Van Hooijdonk, G., & Faaij, A. P. (2005). Ethanol from lignocellulosic biomass: techno-economic performance in short-, middle-and long-term. *Biomass and bioenergy*, *28*(4), 384-410.

Hendriks, A. T. W. M., & Zeeman, G. (2009). Pretreatments to enhance the digestibility of lignocellulosic biomass. *Bioresource technology*, *100*(1), 10-18.

Jin, C., Yao, M., Liu, H., Chia-fon, F. L., & Ji, J. (2011). Progress in the production and application of n-butanol as a biofuel. *Renewable and sustainable energy reviews*, *15*(8), 4080-4106.

Knott, B. C., Crowley, M. F., Himmel, M. E., Ståhlberg, J., & Beckham, G. T. (2014). Carbohydrate–protein interactions that drive processive polysaccharide translocation in enzymes revealed from a computational study of cellobiohydrolase processivity. *Journal of the American Chemical Society*, *136*(24), 8810-8819.

Kreuger, E., Prade, T., Escobar, F., Svensson, S. E., Englund, J. E., & Björnsson, L. (2011). Anaerobic digestion of industrial hemp–Effect of harvest time on methane energy yield per hectare. *biomass and bioenergy*, *35*(2), 893-900.

Langan, P., Gnanakaran, S., Rector, K. D., Pawley, N., Fox, D. T., Cho, D. W., & Hammel, K. E. (2011). Exploring new strategies for cellulosic biofuels production. *Energy & Environmental Science*, *4*(10), 3820-3833.

Lee, C. R., Sung, B. H., Lim, K. M., Kim, M. J., Sohn, M. J., Bae, J. H., & Sohn, J. H. (2017). Co-fermentation using recombinant Saccharomyces cerevisiae yeast strains hyper-secreting different cellulases for the production of cellulosic bioethanol. *Scientific Reports*, *7*(1), 4428.

MacLean, H. L., Lave, L. B., Lankey, R., & Joshi, S. (2000). A life-cycle comparison of alternative automobile fuels. *Journal of the air & waste management association*, *50*(10), 1769-1779.

Malik, V. S. (2014). Editorial biofuel: the butanol perspective and algal biofuel. *Journal of Plant Biochemistry and Biotechnology*, *23*, 337-338.

Manaia, J. P., Manaia, A. T., & Rodriges, L. (2019). Industrial hemp fibers: An overview. *Fibers*, *7*(12), 106.

Market, R. R. (2022). 27| Industry Share, Size, Growth-Mordor Intelligence. *Information on: https://www. mordorintelligence. com/industryreports/fumaric-acid-market# faqs*.

Neutelings, G. (2011). Lignin variability in plant cell walls: contribution of new models. *Plant Science*, *181*(4), 379-386.

Ng, C. H., He, J., & Yang, K. L. (2015). Purification and characterization of a GH11 xylanase from biobutanol-producing Clostridium beijerinckii G117. *Applied biochemistry and biotechnology*, *175*, 2832-2844.

No, S. Y. (2016). Application of biobutanol in advanced CI engines–A review. *Fuel*, *183*, 641-658.

OCDE, D. R., & STEENBLIK, R. (2007). Round Table on Sustainable Development Biofuels: is the cure worse than the disease.

Papirio, S., Matassa, S., Pirozzi, F., & Esposito, G. (2020). Anaerobic co-digestion of cheese whey and industrial hemp residues opens new perspectives for the valorization of agri-food waste. *Energies*, *13*(11), 2820.

Prade, T., Svensson, S. E., & Mattsson, J. E. (2012). Energy balances for biogas and solid biofuel production from industrial hemp. *Biomass and Bioenergy*, *40*, 36-52.

Ranjan, A., & Moholkar, V. S. (2012). Biobutanol: science, engineering, and economics. *International Journal of Energy Research*, *36*(3), 277-323.

Rehman, M. S. U., Rashid, N., Saif, A., Mahmood, T., & Han, J. I. (2013). Potential of bioenergy production from industrial hemp (Cannabis sativa): Pakistan perspective. *Renewable and sustainable energy reviews, 18,* 154-164.

Renewable Fuels Association. (2024). Annual ethanol production. https://ethanolrfa.org/markets-and-statistics/annual-ethanol-production

Rheay, H. T., Omondi, E. C., & Brewer, C. E. (2021). Potential of hemp (Cannabis sativa L.) for paired phytoremediation and bioenergy production. *GCB Bioenergy*, *13*(4), 525-536.

Shahzad, A. (2012). Hemp fiber and its composites–a review. *Journal of composite materials*, *46*(8), 973-986.

Sipos, B., Kreuger, E., Svensson, S. E., Reczey, K., Björnsson, L., & Zacchi, G. (2010). Steam pretreatment of dry and ensiled industrial hemp for ethanol production. *biomass and bioenergy*, *34*(12), 1721-1731.

Talebnia, F., Karakashev, D., & Angelidaki, I. (2010). Production of bioethanol from wheat straw: an overview on pretreatment, hydrolysis and fermentation. *Bioresource technology*, *101*(13), 4744-4753.

Van der Werf, H. M., & Turunen, L. (2008). The environmental impacts of the production of hemp and flax textile yarn. *industrial crops and products*, *27*(1), 1-10.

Wang, M., Han, J., Dunn, J. B., Cai, H., & Elgowainy, A. (2012). Well-to-wheels energy use and greenhouse gas emissions of ethanol from corn, sugarcane and cellulosic biomass for US use. *Environmental research letters*, *7*(4), 045905.

Xu, J., Cheng, J. J., Sharma-Shivappa, R. R., & Burns, J. C. (2010). Sodium hydroxide pretreatment of switchgrass for ethanol production. *Energy & Fuels*, *24*(3), 2113-2119.

Yanase, S., Hasunuma, T., Yamada, R., Tanaka, T., Ogino, C., Fukuda, H., & Kondo, A. (2010). Direct ethanol production from cellulosic materials at high temperature using the thermotolerant yeast Kluyveromyces marxianus displaying cellulolytic enzymes. *Applied Microbiology and Biotechnology*, *88*, 381-388.

Yang, M., Kuittinen, S., Keinänen M., Vepsäläinen, J., Romar, H., Tynjälä, P., Lassi, U. and Pappinen, A. 2014. The use of (green field) biomass pretreatment liquor for fermentative butanol production and the catalytic oxidation of biobutanol. Chemical Engineering Research and Design. 92:1531-1538.

Zafar, A., Aftab, M. N., Asif, A., Karadag, A., Peng, L., Celebioglu, H. U., ... & Iqbal, I. (2021). Efficient biomass saccharification using a novel cellobiohydrolase from Clostridium clariflavum for utilization in biofuel industry. *RSC advances*, *11*(16), 9246-9261.

EXPLORING STRUCTURAL, ELECTRONIC, AND OPTICAL PROPERTIES OF LEAD-FREE PEROVSKITE CH3NH3SNBR3 UNDER COMPRESSIVE STRAIN

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Abstract

Due to their outstanding efficiency and optoelectronic properties, organic–inorganic lead halide perovskites have attracted considerable interest as light absorbers in photovoltaic cells. However, the presence of toxic lead in the plurality of hybrid perovskites has negative environmental repercussions. This study focused on the structural, electronic, and optical properties of a lead-free organic–inorganic perovskite $CH_3NH_3SnBr_3$ under different compressive strains. An analysis of results obtained using density-functional theory (DFT) and DFT+U indicated high agreement between the results achieved using the DFT+U with the spin-orbit coupling (SOC) approach and the experimental results. The electronic properties obtained using DFT+U with SOC demonstrated that an increase in compressive strain led to variations in the bandgap in an oscillatory manner, passing through decreasing, increasing, and decreasing phases. Moreover, the optical property results revealed an increase in the static dielectric constant as a function of increasing compressive strain. Furthermore, all structures of the $CH_3NH_3SnBr_3$ perovskite exhibited high absorption coefficients (approximately 10^5 cm^{-1}) in the ultraviolet and visible regions, with a shift towards lower energies of the spectrum when the compressive strain increased. Our results could encourage experimenters to develop lead-free materials by considering external factors (e.g., compressive strain) for applications in optoelectronics.

Keywords: Hybrid halide perovskites, Lead-free perovskite, Density functional theory (DFT), Compressive strain, DFT+U

SNAIL SHELL CARBON ADSORPTIVITY IN HEAVY METAL DIMINUTION FROM INDUSTRIAL PAINT WASTEWATER

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Abstract

Industrial discharge of heavy metal into the environment posed a great threat to both flora and fauna, and heavy metal bioaccumulation is carcinogenic and mutagenic in nature. Adsorption has been an effective method in treating heavy metals of wastewater. This study investigates snail shell as an alternative adsorbent, and effects of adsorbent dosage were studied in batch experiments. Heavy metal concentrations were analyzed in triplicate using standard methods for water and wastewater. The percentage removal with increasing adsorbent dosage (5g/l – 20g/l) increased from 35.9 – 46 %, 87.4 – 97.3 %, 56.2 – 87.6 % for manganese, iron and zinc respectively. The result shows that more than 80% and 90% removal of Zn and Fe occurred at optimum dosage of 20g respectively. Based on the results, the application of the snail shell is a potential and economic treatment for excessive Mn, Zn and Fe content in wastewater treatment plant.

Keywords: Adsorption, heavy metals, paint wastewater, snail shell

INTRODUCTION

Increase in urbanization and industrialization have a great impact on the quality of both surface and groundwater (Carvalho *et al.,* 2011). The rapid increase in activities of industries has increased the usage and demand of water which has made the management and treatment of wastewater of utmost importance (Badrealam et al.,2020). The discharge of untreated wastewater into water bodies, land and environment, especially those that contain heavy metals and other organic contaminants, is raising serious concern to the stakeholders in the environmental sector. Heavy metals, which are transferred to the environment, are highly toxic and can bio accumulate in the human body, aquatic life, and natural water bodies and area also possibly trapped in the soil and pose great threat to human health and environment. The bioaccumulation of heavy metal such as zinc, iron and manganese can cause toxic hazardous such as carcinogenesis, mutagenesis and teratogenesis (Bhardwaj et al., 2014).

Various methods have been identified by researchers for removal of heavy metals from wastewater and other aqueous solutions among which are ion exchange, precipitation, electro-dialysis, membrane filtration, reverse osmosis, adsorption and flotation. According to (Reham et al. (2020), the total contact time, the pH, the ionic intensity and temperature are factors that could influence the removal of pollutants in aqueous solutions. However, most of these methods have been discredited due to their high costs and high volume cum low heavy metal concentration of effluents to be treated (Raikwar et al., 2008). Recently, adsorption has gained the attention of scientists due to its low cost because it employs biological materials that are abundantly available and its effectiveness in removing contaminants from wastewater (Ajayi-Banji et al., 2015). In quest to discover readily available and cheap adsorbent, this study seeks to explore the usability of snail shell char potential based on adsorbate dosage in some heavy metals sequestration from mildly polluted paint wastewater.

MATERIALS AND METHOD

Adsorbent collection and preparation

The snail shell that was used for the study were purchased at Dugbe market, Ibadan South West Local Government, Oyo State. The snail shell was chopped into smaller pieces and stored. It was washed with tap water to remove dirts and other contaminants and dried under intense sunlight for one five days to reduce the moisture content. Dried snail shells were weighed and pyrolyzed at 500ºC for 120 mins in a bioreactor at Forestry Research Institute of Nigeria (FRIN). The adsorbent was crushed with mortar and pestle for size reduction and sieved with 250 µm mesh size and thereafter stored for subsequent use.

Collection of wastewaters

The paint wastewater used for this study was obtained from a local paint industry at Aleshinloye Market, Ibadan South West Local Government Area of Oyo State, Nigeria. Grab sampling method was the mode for collecting the wastewater. The wastewater was collected in 5 liters plastic can, which was properly washed with distilled water and allowed to dry. The container was rinsed three times with wastewater before filling to the brim and firmly capped. The wastewater was temporary stored under standard conditions.

Adsorption Experiments

Adsorption experiments were carried out by contacting varying adsorbent dosages (5g to 20g) in increment of 5g with 200ml of paint wastewater sample at natural wastewater pH of 8.4. The content (adsorbent and wastewater) were shaken intermittently for 1 hour at room temperature and then the residues were separated through filtration. The solutions were collected for analysis. The presence of heavy metal (Mn, Zn and Fe) concentration in the solution was determined using standard methods for the examination of water and wastewater (APHA, 1998).

Apparatus used were color comparator cube and plastic vessels. The cap was removed from the plastic vessel and rinsed with water sample. It was then filled to the 10 ml mark. 1 packet of each of the reagent (iron, zinc and manganese) was added. The cap was replaced and the solution mixed until solids dissolved. The cap was removed and the solution transferred into the color comparator cube. The color that matches the solution in the cube was re- corded as mg/l (ppm).

All the adsorption experiments were performed in triplicate for representative and mean value reported.

The percent removal (%) of heavy metal tested was calculated using the following equation:

Percentage adsorbed = $(C_i - C_e)/C_i \times 100$……………..1

RESULTS AND DISCUSSION

Adsorbent dosage effect on removal of heavy metals

Table 3.1: Raw paint wastewater characterization

Parameters	Mean value (mg/l)
Manganese	0.139±0.615
Iron	9.654±0.226
Zinc	0.121±0.212

From the result of characterization of raw paint wastewater before adsorption treatment with prepared snail shell derived adsorbent as shown in table 3.1, the mean value of manganese, iron and zinc were found to be 0.139, 9.654, and 0.121 respectively. The value for iron was higher than the standard requirements of 0.3mg/l as stipulated by WHO for wastewater discharge into water body. Though the value gotten for manganese and zinc were below the permissible limits, the effectiveness of snail shell adsorbent in removal of these parameters from paint wastewater was still carried out.

Studies have revealed that the presences of heavy metal in wastewater even in low concentrations are toxic to living organisms, as well as human beings (Nese et al., 2007). Some of these heavy metals are capable of causing several health problems including hemorrhage, ulceration of skin, nausea, severe irritation of skin and dermatitis and in general, is deleterious to the organisms and can lead to severe and irreversible health consequences etc. (Bolade and Sangodoyin 2018).

Table 3.2: Mean concentration of heavy metals in treated and untreated paint wastewater

PARAMETERS	Untreated(mg/l)	Treated (mg/l)			
		5g	10g	15g	20g
MANGANESE	0.139±0.12	0.089±0.015	0.078±0.616	0.078±0.341	0.075±0.120
IRON	9.654±0.156	1.219±0.223	1.223±0.01	0.401±0.213	0.263±0.
ZINC	0.121±0.15	0.053±0.61	0.039±0.21	0.035±0.052	0.015±0.617

Table 3.2 shows the mean concentration of heavy metals in treated and untreated paint wastewater. The percentage removal with increasing adsorbent dosage (5g/l – 20g/l) increased from 35.9 – 46 %, 87.4 – 97.3 %, 56.2 – 87.6 % for manganese, iron and zinc respectively. The results revealed that adsorption of heavy metals increased with increased adsorbent dosage, though sorbent displayed different sorption tendencies with respect to heavy metals. Such a trend is mostly due to an increase in the sorptive surface area and availability of more active adsorption sites (Bolade, 2016). The percentage removal is very low for manganese when compared with other metals this is an indication of weak interaction between mass snail shell and adsorbate, thus, manganese required higher adsorptive site for proper diminution.

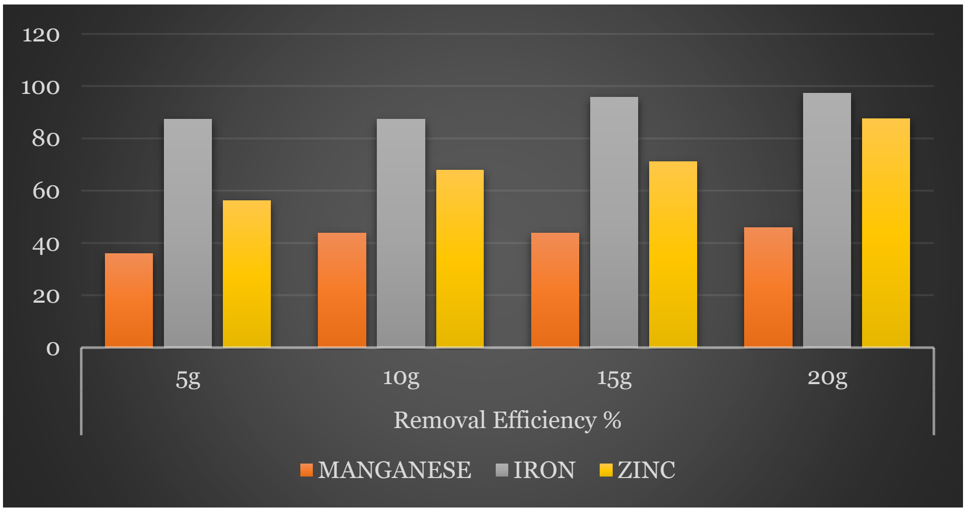

Figure 3.1: Graphical illustration of the Mean concentration

Figure 3.1 gives a graphical illustration of the mean concentration of heavy metals in treated and untreated paint wastewater. In all cases, heavy metal removal increased with adsorbent dosage. iron and zinc demonstrated exceptionally rapid uptake at 5g dosage. Over eighty percent iron was adsorbed by 5g dosage and higher affinity was achieved with iron. This is an indication that the active sites have rapid uptake rate for iron and zinc at 5g dosage. The result suggests strong interaction between the adsorbate and adsorbent. There is no increase in the percentage removal of manganese between 10g and 15g dosage, however when the dosage was increased to 20g the percentage removal was 46% which suggest that for manganese to be removed from wastewater, more active sites of adsorbent is needed. For other parameters tested (zinc and iron) though the percentage removal increase with increasing dosage 95% and 71% removal were gotten for iron and zinc respectively at 15g and at 20g dosage, there were 97% and 87% removal for iron and zinc respectively showing a slight difference in efficiency between 15g and 20g dosage. This discrepancies in the result obtained corroborate that removal sorbate from water or wastewater is a function of many factors such as sorbate type, detention time, activation, bio sorbent dose and adsorbent type.

CONCLUSION

The study has shown that adsorbent derived from Snail shell is a good adsorbent for manganese, iron and zinc in paint wastewater. A reduction of 87.6% and 97.3% at optimum dosage of 20g/l was achieved for Zinc and Iron respectively. At minimum dosage of 5g/l, about 87% of Iron was removed. The result suggests strong interaction between the adsorbate and adsorbent. As this study revealed, application of snail shell as adsorbent material can be a good alternative for industrial wastewater treatment due to its low cost media. Thence, the use of snail shell adsorbent could be effective in removal of iron and zinc in industrial wastewater.

REFERENCES

Carvalho, J., Ribeiro, A., Graça, J., Araújo, J., Vilarinho, C. and Castro, F (2011): Adsorption process onto an innovative eggshell-derived low-cost adsorbent in simulated effluent and real industrial effluents. *WASTES: Solutions, Treatments and Opportunities 1st International Conference* September 12th – 14th, 2011.

Badrealam, S., Roslan, F. S., Dollah1, Z., Bakar1, A. A. A. and Handan, R. (2020): Exploring the Eggshell from Household Waste as Alternative Adsorbent for Heavy Metal Removal from Wastewater. *Advances in Civil Engineering and Science Technology AIP Conf*. Proc. 2020, 020077-1–020077-6; https://doi.org/10.1063/1.5062703

Bhardwaj V., Kumar, P. and Singhal, G. (2014). Toxicity of heavy metals pollutants in textile mills effluents. Int. journals of scientific & engineering research, vol 5(7), pp 664-666

Reham. Q.AL-Shemary, Hanadi K.Ibrahim , Muneer A.AL-Da'amy, Eman Talib Kareem, Mahmood A. Albo Hay Allah (2020). Study the Azure a dye adsorption on the surface of the Snail shell modification. 2nd International Scientific Conference of Al-Ayen University (ISCAU-2020). IOP Conf. Series: Materials Science and Engineering IOP Publishing doi:10.1088/1757-899X/928/5/052021

Raikwar, M.K., Kumar, P., Singh, M., Singh, A. (2008): Toxic effect of heavy metals in livestock health, Veterinary World, vol.1, no. 1, p. 28-30.

Ajayi-Banji A., Sangodoyin A.Y., and Ijaola, O.O. (2015). Coconut husk char bio-absorptivity in heavy metal diminution from contaminated surface water. *Journal of engineering studies and research* – volume 21, no. 4 7, 169-215.

APHA (1998) “Standard methods for examination of waters and wastewater 20th Edition American Public health Association Washington (APHA) American water works association (AWWA), Water environment Federation (WEF) Washington DC, USA”.

Nese, T., Sivri, N. and Toroz, I. (2007). Pollutants of textile industry wastewater and assessment of its discharge limits by water quality standards. *Turkish Journal.,* 7: 97-103.

Bolade, O.O. and Sangodoyin, A.Y. (2018). Adsorption and Equilibrium Studies of Textile Effluent Treatment with Activated Snail Shell Carbon. *IOSR Journal of Environmental science, Toxicology and Food Technology*. Vol 12, issue 4, pp 26-11. Srivastav, R.K., Gupta, S.K., Nigam, K.D.P. and Vasudevan, P. (1994) Water Research, 28, pp. 1631.

Bolade, O.O. (2016). Treatment of local textile industry wastewater with snail shell activated carbon adsorbent: characterization and equilibrium studies. Unpublished M.sc thesis submitted to the department of Agricultural and Environmental Engineering, University of Ibadan.

EFFECT OF WASTE HEMP FIBER USE ON SOME CEMENTITIOUS SYSTEM PROPERTIES

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Abstract

The service life of cementitious systems decreases as a result of the different environmental effects they are exposed to. These environmental effects include freezing-thawing, abrasion, drying-shrinkage, wetting-drying, alkali silica reaction, sulfate attack, carbonation, corrosion, high temperature and acid attack. As a result of all these negativities, cracks occur in cementitious systems. The brittle behavior of cementitious systems increases the damage caused by these negativities. To increase the performance of cementitious systems, fiber is added to these systems. Fibers restrict crack propagation by absorbing some of the stresses occurring in the paste phase of the cementitious system and transferring some of them to the more durable region of the matrix. The mechanical and durability properties of fiber-containing cementitious systems vary largely depending on the interfacial bond between the fiber and matrix. The cement industry is seeking sustainability and environmentally friendly materials. In this context, the use of hemp waste fibers in cement systems has significant potential in the development of environmentally friendly building materials. The cannabis plant is a plant that has many potentials for industrial use. Hemp waste fibers are fibers obtained from the stems of the hemp plant. These fibers offer a number of advantages such as high strength, low density and inherent rot resistance. Additionally, hemp waste fibers can be biodegradable, meaning they can be made compatible with the cement matrix. Within the scope of this study, 6 and 12 mm long hemp fibers were substituted for aggregate at 0.75% and 0.1% by volume. In all mortar mixtures, water/cement and dispersion values were kept constant as 0.5 and 180±20 mm, respectively. In order to provide the desired spreading value, different amounts of uniform polycarboxylate-ether based high water reducing additives were added to the mixtures. CEM I 42.5 R type cement and river sand were used in all mixtures. According to the results, adding fiber to the mixture, regardless of fiber length and dosage, increased the PCE requirement for the target workability value and decreased the compressive strength performance. In addition, it was determined that adding fiber to the mixtures did not cause a significant change in the flexural strength.

Keywords: Cementitious systems, hemp fiber, compressive strength, spreading performance

INTRODUCTION

Although concrete can meet high compressive strengths, it has limited tensile and bending strength (Badugea et al., 2021), so it is a material that is very sensitive to crack formation (Tittelboom and De Belie, 2013; Khalilpour et al., 2019; Sidiq et al., 2021). 2019).

Micro-sized cracks occurring in concrete gradually reach macro size, negatively affecting the durability of the concrete. In addition, if these cracks are not prevented, the service life is shortened due to the increase in the permeability of the concrete (Tittelboom and De Belie, 2013; Scherer, 2015; Sidiq et al., 2019). In order to eliminate durability problems in cementitious systems, different fiber types have been used by researchers today, in addition to choosing appropriate materials such as cement and aggregate (Akid et al., 2021; Mostofinejad et al., 2021; De Maeijer et al., 2020; Zahedi et al., 2020). It has been reported that by incorporating fiber (steel, synthetic or glass fiber) into cementitious systems, the permeability of cementitious systems can be significantly reduced, as well as preventing crack formation and propagation. In this regard, natural fibers such as hemp, jute and linen are frequently preferred, as well as synthetic fibers such as polypropylene, polyamide and nylon. In addition to the low cost of synthetic fibers, high pollution and carbon dioxide emissions occur during fiber production. Natural fibers; They are fibers obtained from natural sources such as animals, plants and minerals. The advantage of using natural fibers as they are obtained is that it requires low energy consumption to extract the fibers from their source and is sustainable.

The use of hemp fibers as a natural fiber has attracted attention due to its many benefits such as being renewable, sustainable, biodegradable, high strength and low weight.

The effects of adding hemp fiber to cementitious systems on the mechanical properties of the mixtures have been studied by some authors. In a study conducted by Filazi et al., (2023), the effect of hemp fiber use on some fresh and hardened state properties of cementitious systems was investigated. The study shows that adding 1%, 2% and 4% hemp fiber to cement mortars gives the best results in terms of unit weight, water absorption, compressive strength and bending strength. It has been stated that as the hemp fiber content increases, the spreading performance of cementitious systems is negatively affected. It has been observed that adding 1% hemp fiber causes an increase in compressive strength of approximately 12%. As a result of the study, it was determined that by adding hemp fiber, matrix strength improved and crack formation decreased.

Similarly, in the study conducted by Bideci et al., (2018), hemp fiber reinforced cement mortars were produced in different proportions (0%, 1%, 2%, 3%) and different lengths (6 mm, 12 mm and 18 mm). It has been determined that cement mortars with a fiber usage rate of 2% and a length of 12 mm give optimum results.

When the studies in the literature were examined, it was observed that there were a limited number of studies on the examination of the cementitious system properties of waste hemp fibers. For this purpose, in the study in question, 0.75% and 1% hemp fiber mixtures of 6 and

12 mm length were prepared. The effect of fiber use in the prepared mixtures on the workability performance and compressive strength of cementitious systems was examined.

MATERYAL-METOT

MATERIALS

Within the scope of the study, CEM 42.5 R type cement was used as the binder. The chemical composition, physical and mechanical properties of cement are provided by the manufacturer and are given in Table 1.

Table 1. Chemical composition, physical and mechanical properties of cement

Item	**(%)**	**Physical properties**		
SiO_2	18.86	Specific gravity		3.15
Al_2O_3	5.71	**Mechanical properties**		
Fe_2O_3	3.09	Compressive Strength (MPa)	1-day	14.7
CaO	62.70		2-day	26.80
MgO	1.16		7-day	49.80
SO_3	2.39		28-day	58.5
Na_2O+0.658 K_2O	0.92	**Fineness**		
Cl^-	0.01	Blaine specific surface (cm^2/g)		3530
Insoluble residue	0.32	Residual on 0.045 mm sieve (%)		7.6
Loss on ignition (LOI)	3.20			
Free CaO	1.26			

In the production of mortar mixtures, river sand with dimensions in the range of 0-4 mm, water absorption capacity of 2.03% and specific gravity of 2.6 was used as aggregate. Water absorption and specific gravity of the aggregates used were calculated according to EN-1097 Standard. In order to reach the targeted spreading values in mortar mixtures, a single type of polycarboxylate-ether based high percentage water reducing additive was added. Some physical and chemical properties of the water reducing additive used, given by the manufacturer, are given in Table 2. Within the scope of the study, 6 and 12 mm long hemp fiber was used. Some properties of the hemp fiber used are given in Table 3.

Tablo 2. Some properties of the HRWRA

Type	**Density (gr/cm^3)**	**Solid Content (%)**	**pH**	**Chloride content (%)**	**Alkali ratio (%) Na_2O**
Polycarboxylate ether-based HWRA*	1.097	36.35	3.82	<0.1	<10

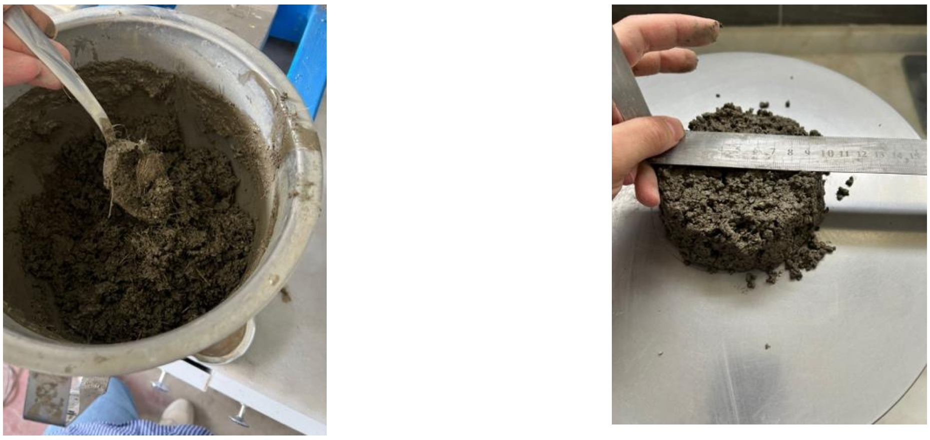
*HWRA: High-range water reducing admixture

Tablo 3. Physical and mechanical properties of hemp fiber used in mixtures

Density (g/cm^3)	Length (mm)	Tensile Strength (MPa)	Modulus of Elasticity (MPa)
1,48–1,50	0,5- 3	500–1.000	12,7

Preparation of mixtures

Mortar mixture calculations are made for 1 dm3 volume. In all mixtures, the water/binder ratio and spreading amount were kept constant as 0.5 and 180±20 mm, respectively. In addition to the fiber-free control mixture (C), the mortar mixture was prepared by substituting hemp fiber for aggregate at the rates of 0.75% and 1% of the total volume. Images of the prepared mixtures are shown in Figure 1. The naming of the mixtures was made according to the hemp fiber usage rate. For example, the mixture containing 0.75% of 6 mm hemp fiber is designated as 6-K-0.75%, while the mixture containing 1% of 6 mm hemp fiber is named 6-K-0.1%. The amount of material used in the production of 1 dm3 mortar mixtures and the amount of water reducing additive required to achieve the target spread value are shown in Table 4.



Şekil 1. 12 mm long mortar mixture containing 1% hemp fiber

Şekil 2. 6 mm long mortar mixture containing 1% hemp fiber

Tablo 4. Amount of material and spread value used in the production of 1 m3 mortar mixture

Mix	Cement (kg/m^3)	Water (kg/m^3)	Aggregate (kg/m^3)	HRWR* (wt% cement)	Fiber (kg/m^3)	Slump-Flow (mm)
C	450	225	1481,14	0,1	0	17,4
6-K-0,75%	450	225	1445,14	0,48	11,25	17,6
6-K-1%	450	225	1433,14	0,54	15	17,0
12-K-0,75%	450	225	1445,14	0,57	11,25	17,1
12-K-1%	450	225	1433,14	0,65	15	17,2

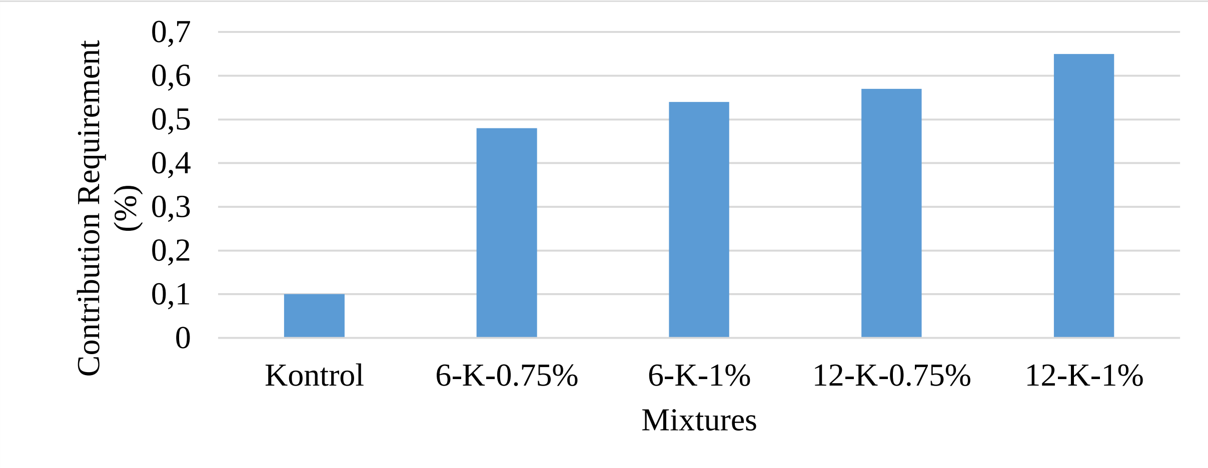
*High-range Water reducing admixture

Method

Spreading values and compressive strengths of mortar mixtures were determined in accordance with ASTM: C1437 and ASTM C109 Standards, respectively.

EXPERİMENTAL RESULTS AND DİSCUSSİON

The PCE parts required to provide the target temperature value within the scope of the study are shown in Figure 2, and the 7 and 28-day pressure values are shown in Table 5.



Şekil 2. . PCE requirements for target spread value of mixtures

It has been observed that with the addition of fiber to the mixtures and the increase in the usage rate, the demand for water reducing additives increases in order to achieve the desired target spread value. In this context, it seems that the mixture containing 1% hemp fiber exhibits the lowest performance.

Tablo 5. Compressive strength results

	Compressive strength (Mpa)	
	7 Day	28 Day
C	23,47	26,93
6-K-0.75%	18,56	22,1
6-K-1%	15,2	21,64
12-K-0.75%	15,63	19,4
12-K-1%	13,45	16,4

Significant decreases in compressive strength were measured with the addition of fiber to the mixture. In addition, the increase in fiber length negatively affected the compressive strength performance. It is thought that the reason for these situations is that hemp fiber makes the mixture cohesive due to its high water absorption capacity and entrains air during mixing.

CONCLUSION

The results obtained from the experiments carried out within the scope of the study are given below;

• It has been observed that the additive requirement of mortar mixtures increases as the fiber length increases, regardless of the fiber usage rate.

• It has been observed that as the fiber usage rate increases, regardless of fiber length, the additive requirement of mortar mixtures increases.

• It shows that the demand for water reducing additives increases to reach the target flow value by adding fiber to the mixture, regardless of fiber dosage and length.

• Significant decreases in compressive strength have been detected with increasing fiber length and usage rate.

REFERENCES

Akid, A. S. M., Hossain, S., Munshi, M. I. U., Elahi, M. M. A., Sobuz, M. H. R., Tam, V. W., & Islam, M. S. (2021). Assessing the influence of fly ash and polypropylene fiber on fresh, mechanical and durability properties of concrete. *Journal of King Saud University-Engineering Sciences*.

Awwad, E. A., Hamad, B., Mabsout, M., & Khatib, H. (2013). Sustainable concrete using hemp fibres. *Proceedings of the Institution of Civil Engineers-Construction Materials*, *166*(1), 45-53.

Awwad, E., Mabsout, M., Hamad, B., Farran, M. T., & Khatib, H. (2012). Studies on fiber-reinforced concrete using industrial hemp fibers. *Construction and Building Materials*, *35*, 710-717.

Banthia, N., & Bhargava, A. (2007). Permeability of stressed concrete and role of fiber reinforcement. *ACI materials journal*, *104*(1), 70.

Boulekbache, B., Hamrat, M., Chemrouk, M., & Amziane, S. (2010). Flowability of fibre-reinforced concrete and its effect on the mechanical properties of the material. *Construction and Building Materials*, *24*(9), 1664-1671.

Çomak, B., Bideci, A., & Bideci, Ö. S. (2018). Effects of hemp fibers on characteristics of cement based mortar. *Construction and Building Materials*, *169*, 794-799.

Filazi, A., Tortuk, S., & Pul, M. (2023, November). Determination of optimum blast furnace slag ash and hemp fiber ratio in cement mortars. In *Structures* (Vol. 57, p. 105024). Elsevier.

Grubeša, I. N., Marković, B., Gojević, A., & Brdarić, J. (2018). Effect of hemp fibers on fire resistance of concrete. *Construction and Building Materials*, *184*, 473-484.

Kaya, N., & Ramazanoğlu, B. (2024). Çelik Liflerin Hibritlenmesinin Betonun Mekanik Davranışına Etkisi. *Yüzüncü Yıl Üniversitesi Fen Bilimleri Enstitüsü Dergisi*, *29*(1), 221-235.

Khalilpour, S., BaniAsad, E., & Dehestani, M. (2019). A review on concrete fracture energy and effective parameters. *Cement and Concrete research*, *120*, 294-321.

Khan, M. S., Hashmi, A. F., Shariq, M., & Ibrahim, S. M. (2023). Effects of incorporating fibres on mechanical properties of fibre-reinforced concrete: a review. *Materials Today: Proceedings*.

Liew, K. M., & Akbar, A. (2020). The recent progress of recycled steel fiber reinforced concrete. *Construction and Building Materials*, *232*, 117232.

Madhavi, T. C., Raju, L. S., & Mathur, D. (2014). Polypropylene fiber reinforced concrete-a review. *International journal of emerging technology and advanced engineering*, *4*(4), 114-118.

Mostofinejad, D., & Arefian, B. (2021). Generic assessment of effective bond length of FRP-concrete joint based on the initiation of debonding: Experimental and analytical investigation. *Composite Structures*, *277*, 114625.

Scherer, G. W. (2015). Drying, shrinkage, and cracking of cementitious materials. *Transport in Porous Media*, *110*, 311-331.

Shah, I., Li, J., Yang, S., Zhang, Y., & Anwar, A. (2022). Experimental investigation on the mechanical properties of natural fiber reinforced concrete. *Journal of Renewable Materials*, *10*(5), 1307.

Sidiq, A., Gravina, R., & Giustozzi, F. (2019). Is concrete healing really efficient? A review. *Construction and Building Materials*, *205*, 257-273.

Şahin, H. G., Mardani, A., & Beytekin, H. E. (2024). Effect of Silica Fume Utilization on Structural Build-Up, Mechanical and Dimensional Stability Performance of Fiber-Reinforced 3D Printable Concrete. *Polymers*, *16*(4), 556.

Torgal, F. P., & Jalali, S. (2011). Natural fiber reinforced concrete. In *Fibrous and composite materials for civil engineering applications* (pp. 154-167). Woodhead Publishing.

Van Tittelboom, K., & De Belie, N. (2013). Self-healing in cementitious materials—A review. *Materials*, *6*(6), 2182-2217.

TAXONOMY OF CANNABIS

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Abstract

Scientific naming and classification of living creatures can be done thanks to taxonomy. Taxonomy (also known as the science of classification) names and classifies the rich world of the plant kingdom, as well as all living groups.

One of the plants of the plant kingdom that attracts people's most attention is hemp. Hemp, which has versatile uses (textile, industry, building materials, medicine, cosmetics, food, energy industry and more), has been used significantly by people for decades. Scientific name of hemp (Latin name); *Cannabis sativa* has had many naming and classifications from past to present.

The person who first introduced the name of the genus (*Cannabis*) and species (*C. sativa*) of the cannabis plant to the scientific world (in 1753) was the Swedish scientist Linné (Carl Linnaeus), who initiated the binary nomenclature. Different species of cannabis have been discovered since Linné and the systematics of the plant has changed from time to time. This study sheds light on the taxonomy of the genus and especially the species (*C. sativa*) by touching on the systematic changes in question. At the same time, this study also includes taxa belonging to the *Cannabis* genus that are accepted or not accepted in the international literature and plant lists, but are considered synonymous names (synonyms), and data on the numbers of these taxa. In this study, the cultivation and production of hemp, whose cultivation and sale is limited, in Turkey is also mentioned.

Today, the plant taxonomy is supported by progressive studies and updated in the light of new data. In this study, it is pointed out that taxonomy is a breathing branch of science, through the example of hemp.

Keywords: Hemp, *Cannabis*, Plant, Taxonomy, Botany

THE EFFECT OF DIFFERENT AMOUNTS OF PALM LEAF ASH ON INDICATORS RELATED TO GERMINATION OF WHEAT

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Abstract

Using the ash of pruned palm leaves can be a solution for the development of biological agriculture and reducing the use of chemical inputs. In order to evaluate the effects of different amounts of palm leaf ash (including levels of 0.5, 1, 2 and 4 gr of ash in 15 ml of distilled water) on the germination of two wheat cultivars (S78-11 and Verinak varieties), an experiment was conducted as a factorial experiment in Completely randomized design with 3 replications.

The results of the analysis of variance showed that there is a significant difference between the measured characteristics of germination percentage, germination speed, days to 10, 50 and 90% germination in the main effects of variety and palm leaf ash concentration and interaction effects.

For traits of number of days up to 10 and 50% of germination and percentage of germination among the studied concentrations and cultivars, there was a significant difference at the 1% level. No significant difference was observed among cultivars for traits of number of days up to 90% germination. The interaction effect of cultivar and date palm leaf ash concentration was observed for the germination speed and day quality up to 90% germination, a very significant difference was observed. Verinak cultivar was more successful in using the physical and chemical effects of palm leaf ash than S78-11 cultivar and had better establishment. Increasing the amount of ash also increases the physical and chemical effects of the environment, and the best values were obtained in 4, 2.1 and 0.5 g of palm leaf ash in 15 ml of water, respectively.

Keywords: Germination percentage, Germination speed, Ash, Palm.

THE INHIBITION OF LIPID DROPLET FORMATION BY CANNABINOIDS: A NEW APPROACH IN CANCER THERAPY

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Abstract

Cancer is a complex disease that occurs with uncontrolled division, proliferation and spread of cells. Tumor cells can change their metabolic pathways to survive and adapt to environmental stresses. Altered lipid metabolism is recognized as one of the key metabolic changes in tumor growth and metastasis. Because lipids function as structural components of the cell membrane, provide and store energy for energy-requiring processes, and are essential mediators of signaling processes in cell biology. Tumor cells increase lipid uptake and synthesis compared to normal cells. These lipids have been reported to be stored in the form of lipid droplets (LDs). Recent studies showed that increased LDs are associated with tumor aggressiveness and chemotherapy resistance. Compared to healthy cells, higher LD content has been shown in cancerous tissues such as glioblastoma, breast cancer, prostate cancer, colorectal cancer, and hepatocellular carcinoma. Cannabinoids are active compounds produced from *Cannabis sativa* L. and its species have been used in medicine since ancient times. It is divided into 3 main classes: phytocannabinoids, endocannabinoids and synthetic cannabinoids. Their use in medicine has become widespread due to the numerous studies on the therapeutic effects of these cannabinoids in various treatments. It has been known that cannabinoids have effects such as induction of apoptosis, arrest of the cell cycle, inhibition of cell migration and angiogenesis. Some researches found that endocannabinoids are present in fat tissue and other peripheral tissues involved in energy metabolism. The endocannabinoid system includes two cannabinoid receptors; cannabinoid receptor 1 (CB1) and cannabinoid receptor 2 (CB2). Activated CB1 has been shown to increase fatty acids by enhancing the expression of acetyl CoA carboxylase and fatty acid synthase. Hence, it is thought that cannabinoids can be used as a potential therapeutic agent for cancer treatment by affecting lipid droplet metabolism.

Keywords: Cancer, cannabinoid, lipid droplet

IMPACT OF VARIETIES ON GROWTH AND YIELD OF TOMATO THROUGH THE MANAGEMENT OF ORGANIC MANURE

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Abstract

A field experiment was carried out at the Crop Science Field Laboratory, Department of Crop Science and Technology, Faculty of Agriculture, University of Rajshahi, Bangladesh; from November 2021 to May 2022 to find out the effects of different varieties on the growth and yield of tomatoes by optimizing the application of organic manure. Five different varieties (V1: Ratan, V2: Maharaj, V3: Sufola, V4: Bahubali, V5: Brack1737) and three types of organic manure (cow dung, poultry manure, vermicompost) were used in the experiment. The experiment was structured using the Randomized Complete Block Design (RCBD) approach and included three replications. Selecting the right tomato variety and utilizing organic manure appropriately can have profound effects on plant growth, output, and fruit quality. Methods of managing organic manure, such as composting or vermicomposting, have the potential to impact soil health. The results showed that at 60 days after transplanting (DAT), the plant height was recorded as 88.55 cm for Bahubali (V4) and the shortest plant height (64.94 cm) was recorded for the Ratan variety (V1). Among the five tomato varieties, Brack1737 produced the largest fruit, but they were relatively lighter in weight compared to the Bahubali variety. The maximum number of leaves per plant (37.40) was recorded for Bahubali (V4), while the minimum (18.27) was found for Sufola (V3) at 45 DAT. Bahubali variety produced the highest yield (24.93 kg/plot), whereas Sufola produced the lowest yield (12.69 kg/plot). Therefore, cultivating the Bahubali tomato variety was more profitable compared to the other four varieties. Further implementation of these findings in other parts of the country may bring advancement to the country’s economy.

Keywords: Tomato; compost; organic manure; growth and yield; tomato variety

TRANSITION TO A SUSTAINABLE ECONOMY: A SCOPING REVIEW OF LITERATURE FOCUSED ON SUSTAINABLE GASTRONOMY

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Abstract

The economic sustainability of destinations has become an evolving study topic, specifically in the gastronomic tourism sector where new strategies are being applied to make destinations more competitive and sustainable through the proposal of models and strategies for transitioning to a sustainable economy, supported by eco-friendly production and consumption. However, there is a scarcity of synthesis studies associated with gastronomy tourism and sustainability, particularly regarding conceptualization, construct denominations, and fundamental factors for transitioning to a sustainable economy within the framework of gastronomic tourism. To address this research gap, the research objective of this study was to identify the factors of gastronomic tourism that condition the transition to an environmentally friendly economy. This was achieved through a scoping review, supplemented with a bibliometric study, to determine the background and theoretical foundations associated with the research topic, identify possible research gaps, and propose lines of future research. This research provides theoretical foundations regarding the fundamental aspects to consider in gastronomy tourism for transitioning to a sustainable economy. From the basic concepts of a sustainable economy within the framework of gastronomic tourism to the dimensions that support it, the research finds that the focus lies in the balance between the ambits of sustainable development and the special attention needed for the implementation of specific Sustainable Development Goals.

Keywords: Scoping review, gastronomy experience, sustainable economy, sustainable gastronomy, sustainable destination management.

SALT STRESS AFFECTED SEEDLING ESTABLISHMENT AND FORAGE PRODUCTION OF SOME HALO-FORAGE SPECIES

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Abstract

In recent decades increased attention has been paid to the use of saline soil and water resources for forage production. In order to introduce some halophytes as forage production, a field experiment was conducted at the Salinity Research Farm, Yazd, Iran. In this experiment, a number of 2-month old seedlings of 14 species (namely *Halostachys bellangeriana*, *Seidlitzia rosmarinus Nitraria schoberi, Sesbania aculeate*, *Kochia indica*, *Atriplex halimus*, *Atriplex nummularia*, *Atriplex canascen*, *Atriplex lentiformis*, *Halocnemum capsicum*, *Salsola abarghuensis*, *Salsola yazdiana*, *Atriplex bunburyana*, *Atriplex semibacata*) were planted at 1.5 ×1.5 m spacing in the form of complete randomized block design with three replicates. All seedlings were irrigated with saline well water with electrical conductivity of 8 dS/m for six months, then harvested and some characteristics were measured including seedling establishment, yield and yield components.

The results showed that some species such as *K. indica*, *N. schoberi*, *A. nummularia* and *A. canescens* had the highest seedling establishment, while both A. *halimus* and *A. lentiformis* showed a good establishment percentage (95.8%). The establishment of *S. rosmarinus* was relatively good (91.7%), but both *H. bellangeriana* and *S. aculeata* species showed lower the establishment (75% and 79.2%, respectively). Results showed that *Kochia indica* produced the highest forage fresh and dry yield (15.5 and 6.9 ton/ha, respectively). This species also had the highest seedling emergence percentage (100%) and emergence rate (5.5 seedling per day). After that, *Atriplex halimus* had the highest yield (9.7 ton/ha fresh forage and 3.5 dry forage), seedling emergence (95%) and emergence rate (4.83).

The results also showed that the yield of *Atriplex* species was about 4-10 ton/ha. Other studied species showed a similar forage yield when compared to *Atriplexes* (except *A. halimus*). The results also showed that *H. bellangeriana* with an annual production of 6.6 ton/ha had a higher performance than *Atriplexes* (except *A. halimus*). The results also showed that *S. aculeta* species had the same forage yield as *N. Schoberi*. Therefore, both *K. indica* and *A. halimus* are suitable species for forage production under saline conditions and may be suggested for forage production and rehabilitation of rangelands under saline conditions.

Keywords: forage, biosaline agriculture, halophytes, salinity, yield, haloculture

INTERACION OF CHITOSAN MONOMER WITH Ti^{+2}, Al^{+2}, Pb^{+2} AND As^{+3} IONS: A COMPUTATIONAL STUDY

KİTOSAN MONOMERİNİN Ti^{+2}, Al^{+2}, Pb^{+2} VE As^{+3} İYONLARI İLE ETKİLEŞİMİ: HESAPLAMALI BİR ÇALIŞMA

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Abstract

Chitosan can be obtained from shellfish products and has stable properties that make it suitable for environmental remediation applications, especially in the removal of metal ions from industrial wastewater. Chitosan's ability to effectively remove metal ions from industrial wastewater due to its stable properties and covalent interactions is promising for environmental remediation efforts. The molecular structure modeling and analysis study discusses equilibrium studies performed to examine the adsorption process between chitosan (CS) and ions, considering these metals as electron donors. Using density functional theory (DFT) at the B3LYP level with the basis groups 6-31G(d,p) and LANL2DZ were calculated by GaussView 6 software. Solvent effects were included using the polarizable continuum model (PCM) with water. It was shown that the interaction between CS and metals is predominantly covalent in nature in almost all cases. Based on the analysis of the interaction between the structure of chitosan and metals, a stable structural model was identified for chitosan and the metal ions with varying electronic energy values depending on the position of chitosan relative to the metal, and two different positions were examined: one between the hydroxyl group OH and the amine group NH_2, and the other in a ring structure between three oxygen atoms, leading to differences in adsorption energy, and the result is a stable structure with lower energy. Overall, this study underscores the versatility and potential of chitosan in various environmental applications, particularly in the removal of metal ions from wastewater, which is essential for mitigating pollution and protecting ecosystems.

Keywords: Chitosan, adsorption energy, DFT, Titanium, Aluminum, Arsenic, Metal ions

Özet

Kitosan, kabuklu deniz ürünlerinden elde edilebilir ve endüstriyel atık sularından metal iyonlarının uzaklaştırılması gibi çevresel iyileştirme uygulamalarını uygun hale getiren kararlı özelliklere sahiptir. Kitosan'ın kararlı özellikleri ve kovalent etkileşimleri nedeniyle endüstriyel atık sularından metal iyonlarını etkili bir şekilde uzaklaştırma yeteneği, çevresel iyileştirme çabaları için umut vericidir. Moleküler yapı modelleme ve analiz çalışması, Kitosan (CS) ile iyonlar arasındaki etkileşme sürecini incelemek için gerçekleştirilen denge çalışmaları bu metalleri elektron vericileri olarak ele alır. GaussView 6 yazılımı ile B3LYP seviyesinde yoğunluk fonksiyonel teorisi (DFT) kullanılarak 6-31G(d,p) ve LANL2DZ baz gruplarıyla hesaplamalar yapılmıştır. Çözücü etkileri, su ile polarize edilebilir devamlı modeli (PCM) kullanılarak hesaba katılmıştır. CS ve metaller arasındaki etkileşimin neredeyse tüm durumlarda temelde kovalent olduğu gösterilmiştir. Kitosan yapısı ile metaller arasındaki etkileşimin analizine dayanarak, Kitosan ve metal iyonları için çeşitli elektronik enerji değerlerine sahip kararlı bir yapısal model belirlenmiştir. Bu enerji değerleri, Kitosan'ın metal ile olan konumuna bağlı olarak değişmektedir ve iki farklı konum incelenmiştir: biri hidroksil grubu OH ve amin grubu NH_2 arasında, diğeri ise üç oksijen atomu arasında bir halka yapısında, bu durum etkileşme enerjisinde farklılıklara yol açmaktadır ve sonuç daha düşük enerjili kararlı bir yapıdır. Genel olarak, bu çalışma Kitosan'ın çeşitli çevresel uygulamalarda, özellikle atık sulardan metal iyonlarının uzaklaştırılmasında, gösterdiği çok yönlülüğü ve potansiyeli vurgulamaktadır, bu da kirliliğin azaltılması ve ekosistemlerin korunması için hayati önem taşımaktadır.

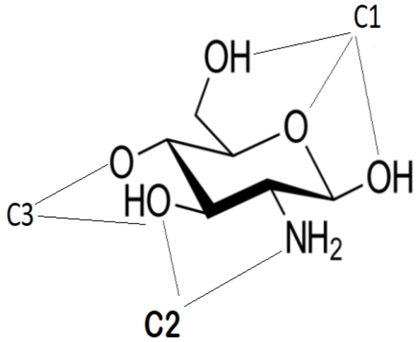
Anahtar Kelimeleri: Kitosan, Adsorption energy, DFT, Geometry optimization, Titanum, Aluminum, Arsenic, Metal ions.

GİRİŞ

Kitosan, çok yönlü doğası, mükemmel biyobozunurluğu, biyouyumluluğu, antimikrobiyal aktivitesi, toksik olmaması ve geniş uygulamaları nedeniyle 21. yüzyılın en umut verici biyomalzemelerinden biri olarak kabul edilmektedir. Kitosan, selülozdan sonra en bol bulunan ikinci doğal polimer olan kitinden elde edilmektedir. Kitin, doğada yengeç ve karides gibi deniz kabuklularının dış iskeletinde ve mantar, maya ve diğer mikroorganizmaların hücre zarlarında bulunur. Kitin, seyreltik asitlerde çözünmezken, kitosan seyreltik asitlerde çözünür ve bu durum sulu ortamlarda kullanılabilirliğini sağlayan en önemli özelliklerden biridir. Kitosan, rastgele dağılmış β-(1→4)-bağlı D-glukozamin (deasetile edilmiş birim) ve N-asetil-D-glukozamin (asetile edilmiş birim) içeren lineer bir polisakkarittir. Karides ve diğer kabukluların kitin kabukları, (sodyum hidroksit) gibi alkali bir madde ile işlenerek yapılır [1]. Kitosan hakkında gözden geçirilebilecek gerçeklerden biri, kitinden elde edilmesidir. Bilim insanları tarafından, selülozun keşfinden bile önce tanımlanan ilk polisakkarit olmuştur. Henri Bracono, 1811 yılında kitini ilk kez mantardan izole etti. "Kitin" ismi, Yunanca "kaplama" anlamına gelen "Chiton" kelimesinden türetilmiştir. 1859 yılında, Profesör C. Roget, kitini ilk kez alkali bir ortamda ısıtarak "kitosan"ı keşfetti. "Kitosan" kelimesi, 1894 yılında Hoppe-Seyler tarafından icat edilmiştir. Kitinden kitosan elde edilmesi: Kitosan üretim süreci, kitin ekstraksiyonu için uygun bir kaynağın seçilmesiyle başlar. Kitin, kabuklular gibi hayvan kaynaklarından veya mantar gibi hayvansal olmayan kaynaklardan elde edilebilir. Kitosan'ın fiziksel ve kimyasal özellikleri, kaynağına bağlı olarak büyük ölçüde değişebilir. Kitin, doğal kaynaklardan minerallerin ve proteinlerin uzaklaştırılması yoluyla çıkarılır. Saflaştırılmış kitin daha sonra kitosan elde etmek için konsantre alkaliler (örneğin sodyum hidroksit) ile işlenir. Bu işlemeye deasetilasyon denir ve kitosan'ın nihai özelliklerini, örneğin pozitif yükün kapsamını (polimerdeki amin gruplarının oranı) ve moleküler ağırlığını etkiler. Kitosan'ın çok yönlü özellikleri nedeniyle, tıp, sanayi ve çevre koruma gibi birçok alanda kullanılır. Özellikle suyu titanyum, arsenik, alüminyum ve kurşun gibi toksik ve ağır metallerden arındırma yoluyla çevre koruma alanında önemlidir ve bu çalışma da bu amaca yöneliktir [2].

Son zamanlarda potansiyel bir polisakkarit kaynağı olarak kitosan'a artan ilgi gösterilmiştir. Literatürlerin çoğu kitosanın olumlu faydalar ve işlevler sunduğunu göstermektedir; Bu nedenle kitosan ve türevleri çeşitli endüstrilerde, su mühendisliği ve geleneksel olarak (WEEE veya E-atık) olarak adlandırılan atık elektronik ve elektrikli ekipmanlarla temsil edilen kirleticilerden suyun arıtılması gibi alanlarda yaygın olarak kullanılmaktadır [3].

Teorik hesaplamalar yoğunluk fonksiyonel teorisi (DFT) yöntemlerinin geliştirilmesinden büyük ölçüde faydalanmıştır. Bugüne kadar, DFT'den türetilmiş birçok hesaplama yöntemi olmasına rağmen, bunlar genellikle yarı deneysel yöntemlerde, Hartree-Fock veya Hartree-Fock sonrası yöntemlerde kullanılmıştır. Ancak, son zamanlarda DFT, teorik kimyada moleküler yapıların ve fizikokimyasal özelliklerinin doğru bir şekilde modellenmesini mümkün kılmıştır. Bu nedenle, DFT hesaplamalarından doğrudan belirlenen fayda göstergelerine daha fazla önem verilmelidir. Elektronik yapı yöntemlerinin geliştirilmesi, eski çalışmalarda erişilemeyen şeker özelliklerini ortaya çıkarabilir [4]. Bu çalışma, kitosan ve ilgili metallerin temel özelliklerinin, yoğunluk fonksiyonel teorisi kullanılarak, metal ile bağlanma ve sulu çözeltilere yönelik bağlanma yeteneklerini hesap etmektedir. Teorik yaklaşımın, gelişmeye açık bir birinci sınıf yaklaşım olduğu söylenebilir. Kitosan ve türevlerinin teorik hesaplamaları, bu molekülün yapıları, özellikleri ve çevresel etkileşimleri hakkında temel bilgiler sağlar. Bu çalışmada, kitosanın Ti^{+2}, Al^{+2}, Pb^{+2} ve As^{+3} iyonları ile yaptığı bileşiklerin doğası, etkileşme enerjisi, enerji boşlukları ve polaritesi gibi temel özellikleri hesaplanmıştır.
Kitosan üzerine yapılan benzer çalışmalar incelendiğinde, kitosan ile Cu^{2+} ve Ni^{2+} bağlarının DFT ile yapılan çalışmalar, geçiş metalleri ve kitosan biyopolimerleri arasında hidroksi ve nitrojen grupları etrafında koordinasyon bağlarının varlığını göstermektedir [0]. Başka bir çalışma, B3LYP/6-31+G DFT temel seti kullanılarak kitosan ve kitinin Ni, Cu ve Zn metal iyonları ile etkileşimini araştırmış, sonuçlar metal iyonları ile hidroksil ve amin grupları arasındaki etkileşimler vermektedir. Kararlılık analizi, Ni(I)'in kitosan'a bağlandığında Cu(I) ve Zn(I)'den daha kararlı olduğunu göstermiş, ayrıca bu çalışmada Cu(II), Ni(II) ve Zn(II) iyonlarının kitosan ile etkileşmeside incelenmiştir [6]. Cu(II), Ni(II) ile kitosan arasındaki etkileşim deneysel olarak ele alınmış, etkileşim enerjisinin, HOMO ve LUMO enerjilerinin ve enerji boşluklarının değerleri verilmiştir [7]. Kitosan monomeri ve atomik gümüş kompleksinin yapısal, elektronik ve optik özelliklerinin belirlenmiştir [0]. Kitosan ve kurşun (II) iyonlarının biyopolimer kitosan ve türevleri ile etkileşimine ilişkin DFT çalışmaları yapılmıştır [0]. Kitosanın monomer, dimer ve oligomer geometrik yapılar çalışılmıştır [0]. Önceki çalışmalar aynı zamanda metal iyonları ile kitosan arasında bir bağ olduğunu vr hesaplamalarda temel setin farklı varyasyonları kullanılsa da kitosan'ın metali adsorbe etme yeteneğini göstermiştir.
Bu çalışmada, B3LYP DFT modeli ile, kitosan için 6-31G(d,p) ve metal kompleks bileşikleri için LanL2DZ temel setini ve metal iyonu olarak Ti^{+2},Al^{+2} , Pb^{+2} ve As^{+3} kullanılarak hesaplamalar yapılmıştır.
Metalin kitosanla ilgili bağlanma konumunu Şekil 1 de gösterildiği gibi, üç oksijen atomu arasında bir yarım halka oluşturduğunda C1, hidroksit OH ve NH2 amino grupları arasındaysa C2, iki oksijen atomu arasında C3 sembolüyle ifade edilmektedir.



Şekil 1: Kitosan-Ağır metal komplekslerinin çalışılan farklı konfigürasyonları için C1,C2 ve C3 etiketleme şeması.

HESAPLAMA YÖNTEMLERİ

Taban durumdaki kitosanın moleküler yapısı (monomer formlarında), Gaussian 09 paket programı ve Gaussview moleküler görselleştirme programı kullanılarak 6–31G (d, p)/ LanL2DZ temel setleri ile yoğunluk fonksiyonel teorisi (B3LYP) yöntemiyle optimize edilmiştir. B3LYP, Lee, Yang ve Parr'ın (LYP) gradyanla düzeltilmiş korelasyonel fonksiyoneli (LYP) ile birleştirilmiş hibrit fonksiyonel ve Becke'nin üç parametreli fonksiyoneli (B3) kullanılarak temel setler daha önce elde edilmiştir [11, 12]. DFT-B3LYP ile PCM fonksiyoneli kullanılarak B3LYP solvent (su) etkileri de hesaba katılmıştır.

HESAPLAMA UYGULAMALARI

Etkileşme Enerji:

Etkileşme enerjisi, kompleks moleküler yapı (kitosan + metal) ile sadece kitosan ve adsorbe metalin elektronik enerjilerinin toplamı arasındaki farktan kaynaklanan enerjidir, metal iyonlarının kitosan moleküllerine bağlandığı zaman meydana gelen enerji değişimini ifade eder. Etkileşme enerjisinin negatif değeri, ilgili etkileşme durumunun bağlanmamış durumdan termodinamik olarak daha kararlı olduğunu gösterir. Süreç aşağıdaki denklemle açıklanabilir:

$$\mathbf{E_{int} = E_{komplex} - [E_{ligand} + E_{metal\ ion}]} \qquad \textbf{(1)}$$

E_{int}, kitosan ve metal iyonları arasındaki etkileşimi anlamak için bağlanma kuvvetini gösterir. Daha yüksek bir etkileşme enerjisi tipik olarak kitosan ve metal iyonları arasında daha güçlü bir etkileşime işaret eder ve bu da çözeltilerden metal iyonlarının uzaklaştırılması gibi uygulamalarda sıklıkla arzu edilir [0]. Etkileşme enerji değerindeki negatif işaretin anlamına dikkat edilmelidir çünkü kitosan ile metaller arasında meydana gelen reaksiyonun kendiliğinden bir reaksiyon olduğunu gösterir. Kendiliğinden reaksiyon, metal ile kitosan arasındaki bağın, aktivasyon enerjisine ihtiyaç duymadan doğrudan oluşabileceği anlamına gelir. Negatif bir değer ayrıca metal alüminyum, titanyum, kurşun veya arsenik ile bağlanan kitosanın, kendisinden daha kararlı olduğunu gösterir. Yapılan çalışmalar, kitosanın endüstriyel atık çözeltilerden metalleri absorbe edebilmek için adsorban olarak kullanılabileceğini göstermektedir.
Bu araştırmada kitosan ile Ti^{+2} (Ti-Cs), Al^{+2} (Al-Cs), Pb^{+2} (Pb-Cs) ve As^{+3} (As-Cs) bileşiklerinin etkileşmeleri incelenmiştir. Yapılan hesaplamalar sonucunda bulunan değerler sırası ile Tablo1-Tablo3 de, daha önceki benzer çalışmalar ile karşılaştırılmalı olarak verilmiştir.

Tablo 1: Ni-Cs, Cu-Cs etkileşme enerjileri.

Kompleksin Bağ Şekli	Metal	E_{int} kj/mol [6]	E_{int} kj/mol [14]	E_{int} kj/mol
C1	Cu-Cs	-1179.5		-1161.9
C1	Ni-Cs	-1074.3		-873.9
C2	Cu-Cs	-1165.7	-885.6	-1186.2
C2	Ni-Cs	-1050.7	-703.4	-902.2

Tablo 2: Pb-Cs etkileşme enerjileri.

Kompleksin Bağ Şekli	E_{int}kj/mol [9]	E_{int}kj/mol
C1		-672.9
C2		-706.4
C3	-862.7	-673

Tablo 3: As-Cs etkileşme enerjileri.

Kompleksin Bağ Şekli	E_{int}kj/mol [14]	E_{int}kj/mol
C1		-2252.7
C2	-1929.7	-2309.9

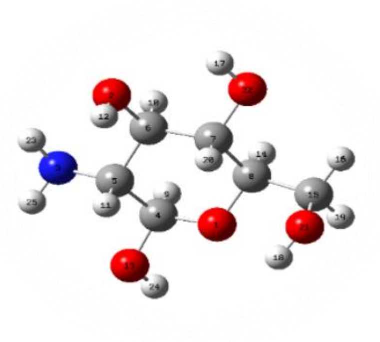
Kitosanın metallere bağlanmadan önceki enerji değeri, B3LYP-631G(d,p) baz seti ile yapılan hesap sonucunda -667.330724 hartree, bakır atomu hidroksit ile NH_2 amino grupları arasında olduğunda (C2 konumunda) Cu-Cs enerji değeri, B3LYP-LANL2DZ baz seti ile yapılan hesap sonucunda -863.391305 hartree olarak hesaplanmıştır. Bakır atomu üç oksijen atomu arasında olduğunda (C1 konumunda) Cu-Cs kompleksinin enerjisi, B3LYP-LANL2DZ baz seti ile yapılan hesap sonucunda -863.382124 shartree olarak hesaplanmıştır. Daha önceki çalışmalarla tutarlı olarak ikinci yapının (C2 konumunda) en kararlı yapı olduğunu söylenebilir.
Cu-Cs etkileşme enerji değeri, denklem(1) de verildiği gibi, kitosan ve bakırın +2 iyonunun enerji değerlerinini Cu-Cs kompleks yapının enerji değerinden fark alınarak hesaplanır. Hesaplama sonuçları Tablo 1'den görüleceği gibi Ni metali ile karşılaştırıldığında C2 pozisyonundaki metalin hidroksit ve amine grupları arasında açık bir halka oluşturduğunu görüyoruz. Dolayısıyla Cs-C1 yapısı Hartree soğurma enerjisi değeri -873,9 olan en kararlı yapıdır. Hesaplamalar C1 konumunda olduğundan önceki çalışmayla tutarlıdır [6]. Cs-Ti, Cs-Al, Cs-Pb ve Cs-As C1 ve C2 pozisyonlarında incelenmiştir. C2 yapısı en düşük enerjiye sahip ve dolayısıyla en kararlı yapıdır. C2 konumunda yapılan hesap sonucu bulunan enerji değerleri hartree olarak, CS-Ti =-725.2170, Cs-Al = -669.2160, Cs-Pb = -670.6978 ve Cs-As = -673.1649 dir.
Sonuç olarak bu metallerden hangisinin kitosan'a daha hızlı bağlandığını görmek amacıyla etkileşme enerjisi hesaplandı. Hesaplana enerji değerleri sırası ile As^{+3}>Al^{+2}>Pb^{+2}>Ti^{+2} dir (Tablo 4).

Tablo 4: Ti-Cs, Al-Cs etkileşme enerjileri.

Kompleksin Bağ Şekli	Metal	E_{int}kj/mol
C1	Cs-Ti	-371.8
C1	Cs-Al	-1153.1
C2	Cs-Ti	-373.1
C2	Cs-Al	-1173.1

2.1.Yapısal Modelleme, Moleküler Geometri ve Moleküler Etkileşimin Optimizasyonu:

İncelenen bileşiğin yapısının görselleştirilmesine yardımcı olmak için moleküler yapı modellemesi kullanılır. Kitosan molekülü ve bunların metallerle olan komplekslerinin üç boyutlu modellerini oluşturmak için Gauss View 06 uygulamasından yararlanıldı. Yapısal modellemenin ardından Gaussian 09 yazılımı kullanılarak geometri optimizasyonu yapıldı.



Şekil 2:Kitosan bileşiği teorik olarak B3LYP yöntemi ile elde edilen molekül yapısı.

Yoğunluk Fonksiyonel Teorisi (DFT) yöntemi, toplam elektronik enerji ile toplam elektron yoğunluğu arasındaki korelasyona dayanır. Kompleks moleküler geometrilerin optimizasyonu, B3LYP/LANL2DZ temel seti ile DFT yöntemi kullanılarak gerçekleştirildi. Geometri oluşumu, kompleks molekülü oluşturan atomlar arasındaki yük değerinden ve bağ uzunluğundan etkilenmiştir. Ek olarak kompleks moleküler geometri için çeşitli optimizasyon parametreleri DFT yöntemi kullanılarak hesaplandı; bağ uzunluğu temel parametrelerden biridir. Cs-M bileşikleri için (M ağır metalleri göstermektedir) bağ uzunlukları ve açıları aşağıdaki tabloda verilmiştir.

Tablo 5: Cs bağ uzunluğu ve bağ açıları değeri.

İşaretlemeler	**Bağ uzunlukları(Å)[10]**	**Bağ uzunlukları(Å)**
O(1)-C(8)	1.431	1.432
O(1)-C(4)	1.414	1.427
O (2)-C (6)	1.440	1.421
O (22)-C (7)	1.412	1.427
N (3)-C (5)	1.461	1.463
Note: Ortalama bağ uzunlukları: Re(C-H) = 1.099; Re(O-H) = 0.968; Re(N-H) = 1.019; Re(C-C) = 1.534		
İşaretlemeler	**Bağ açıları(º)[10]**	**Bağ açıları(º)**
C (4)-O (1)-C (8)	113.9	112.9
C (6)-C (5)-C (4)	109.2	110.0
C (7)-C (6)-C (5)	110.7	111.2
C (7)-C (8)-O (1)	112.3	110.2
C (5)-C (4)-O (1)	110.8	111.1
C (5)-C (6)-O (2)	106.8	112.4
C (6)-C (7)-O(22)	109.6	108.1
C (8)-C (7)-O(22)	112.1	109.8
C (13)-C (4)-O(1)	112.0	108.1
C (4)-C (5)-N (3)	111.9	113.7
C (7)-C (8)-C(15)	116.5	113.2

Tablo 6: CS-Ni, Cs-Cu, Cs-Pb bağ uzunluğu değeri (Å).

İşaretlemeler	**Bağ uzunlukları[6]**	**Bağ uzunlukları[14]**	**Bağ uzunlukları[7]**	**Bağ uzunlukları[9]**	**Bağ uzunlukları**
N(3)-Cu(26)	2.020	1.919	1.959		2.110
O(13)-Cu(26)	2.100	2.226	1.880		2.490
N(3)-Ni (26)		1.818	1.903		
O(13)-Ni(26)		2.004	1.820		
N (3)-Pb(26)		2.065			2.506
O(13)-Pb(26)		2.413			2.607
O(22)-Pb(26)				2.272	2.599
O (2)-Pb(26)				2.063	2.485

Tablo 7: CS-Al bağ uzunluğu ve bağ açıları değeri.

İşaretlemeler	**Bağ uzunlukları(Å)**
O(13)-Al(26)	2.332
N(3)-Al(26)	2.255
	Bağ açıları (º)
C(5)-N(3)-Al(26)	108.7
C(5)-O(13)- Al(26)	115.2
H(25)-O(13)- Al(26)	120.1
H(23)- N(3)- Al(26)	109.4
H(24)- N(3)- Al(26)	108.4

Tablo 8: CS-As bağ uzunluğu ve bağ açıları değeri.

İşaretlemeler	**Bağ uzunlukları(Å)**
O(13)-As(26)	2.133
N(3)-As(26)	2.087
	Bağ açıları (º)
C(5)-N(3)-As(26)	106.7
C(5)-O(13)- As(26)	114.5
H(24)-O(13)- As(26)	119.4
H(23)- N(3)- As(26)	111.6
H(25)- N(3)- As(26)	119.2

Tablo 9: CS-Pb bağ uzunluğu ve bağ açıları değeri.

İşaretlemeler	**Bağ uzunlukları(Å)**
O(13)-Pb(26)	2.067
N(3)- Pb (26)	2.507
	Bağ açıları (º)
C(5)-N(3)- Pb(26)	108.5
C(5)-O(13)- Pb(26)	114.5
H(24)-O(13)- Pb(26)	118
H(23)- N(3)- Pb(26)	109.2
H(25)- N(3)- Pb(26)	107.7

Bağ uzunluğu değeri birbirine bağlı atomlar arasındaki mesafeyi gösterir ve sonuç olarak bağ mesafesi kompleks moleküllerdeki atomlar arasındaki bağların gücünü etkileyecektir. Daha düşük bir değer gösteren atomlar arasındaki bağ mesafesi, daha güçlü bir bağ kuvveti ile sonuçlanır. Örneğin alüminyum için optimizasyon sonuçlarına göre N(3)-Al(26) bağı, Tablo 1'de gösterildiği gibi O(13)-Al(26) bağından daha güçlüdür.

Elektronik özellikler ve Enerji gap değeri (ΔE) :

HOMO adı verilen en yüksek dolu yörünge ve LUMO adı verilen en düşük boş yörünge sınır moleküler yörüngeler (FMO'lar) adı verilen en önemli iki yörüngedir. FMO'lar kuantum kimyasının yanı sıra elektriksel, elektromanyetik ve optik özelliklerin belirlenmesinde de önemli bir rol oynamaktadır[16]. Enerji gap, LUMO enerji ile HOMO enerji değerleri arasındaki farktır. Küçük bir sınır yörünge boşluğuna sahip bir molekül daha polarize edilebilir ve genellikle düşük kinetik stabilite ve yüksek kimyasal reaktivite ile ilişkilendirilir[17]. FMO değerleri molekül içi enerji transferinden biyoaktiviteyi belirlemek için kullanılır. Yapılan hesaplamalar sonucunda bulunan değerler sırası ile Tablo11-Tablo14 de, daha önceki benzer çalışmalar ile karşılaştırılmalı olarak verilmiştir.

Tablo 10:Cs HOMO–LUMO orbital enerjileri, enerji gap, yumuşaklık ve sertlik değerleri

Parametreleri	[14]	[15] [1]	[6]	
E_{LUMO}	1.77	-0.09		1.81
E_{HUMO}	-6.64	-6.82		-6.44
E_{GAP}	8.41	6.76	0.407	8.26
Dipole momenti (μ)	4.642			3.93
Sertlik (η)	4.20		0.203	4.13
Yumuşaklık (s)	0.24			0.24

[1] Deneysel değer

Tablo 11: Cs-Cu HOMO–LUMO orbital enerjileri, enerji gap, yumuşaklık ve sertlik değerleri

Parametreleri	[14]	[7] [1]	
E_{LUMO}	-1.99		-1.55
E_{HUMO}	-7.32		-5.30
E_{GAP}	5.33	0.074	3.77
Sertlik (η)	2.67	0.037	1.89
Yumuşaklık (s)	0.37		0.53

[1] Deneysel değer

Tablo 13: Cs-As HOMO–LUMO orbital enerjileri, enerji gap, yumuşaklık ve sertlik değerleri

Parametreleri	[14]	
E_{LUMO}	-5.72	-2.90
E_{HUMO}	-7.80	-5.62
E_{GAP}	2.08	2.72
Sertlik (η)	1.04	1.36
Yumuşaklık (s)	0.96	0.74

Tablo 14: Cs-Ti, Cs-Al, Cs-Pb HOMO–LUMO orbital enerjileri, enerji gap, yumuşaklık ve sertlik değerleri

Molekül Yapı	E_{Lumo}	E_{Homo}	ΔE	η	S
$Cs\text{-}Ti^{+2}$	-0.24	-2.06	1.82	0.91	1.10
$Cs\text{-}Al^{+2}$	-0.64	-5.29	4.65	2.33	0.43
$Cs\text{-}Pb^{+2}$	-1.29	-3.19	1.9	0.95	1.05

Yukarıdaki tablodaki değerler, enerji ne kadar büyük olursa, moleküler yapının kararlılığını büyük ölçüde ifade eden HOMO ve LUMO enerjilerinin değerlerini, enerji boşluklarını ve bunlarla ilişkili yumuşaklık ve sertlik gibi sonuçları göstermektedir. Enerji gap değeri ne kadar stabil olursa yapı o kadar kararlı olur. Bu nedenle moleküler yapılar stabilitelerine göre sırası ile, CS > Cs-Al > Cs-Pb > Cs-Ti dir.

Doğrusal Olmayan Optik (NLO):

(NLO), malzemenin ışıkla etkileşimini tanımlayan bir alanı ifade eder. Bu alan, malzemenin ışıkla etkileşiminde doğrusal olmayan etkilerin ortaya çıkmasını inceler. Doğrusal olmayan etkiler, geleneksel optikte görülmeyen veya çok zayıf olan etkilerdir. Bu etkiler, malzemenin elektrik alan gibi dış etkenlere verdiği tepkileri içerir [18].
Dipol moment molekül boyunca enerji hareketinin bir göstergesi olarak kullanılır. Bu nedenle, bir molekülde dipol moment önemli bir özelliktir. Dipol momentin yönü pozitif ve negatif enerji merkezlerine bağlıdır. Bir molekülün lineer olmayan optik özelliği olan hiperkutupsallık, birim hacim başına düşen ikinci derece elektrik duyarlılığını ifade etmektedir. Kutupsallık etkinliği enerji transferini belirlemede önem-li bir rol oynayan itici ve çekici gruplar arasındaki enerji transferine bağlıdır. Cs'ın toplam statik dipol momenti, kutupsallık DFT/B3LYP yöntemleriyle LANL2DZ ve 6-31G(d,p) baz setiyle hesaplandı ve Tablo 15'de gösterilmiştir [19].

Tablo 12: Cs, Cs-Cu, Cs-Ti, Cs-Al, Cs-Pb, Cs-As Dipol momenti ve Kutupsallık değerleri

Molekül	Dipol Momenti [14]	Dipol Momenti	Kutupsallık
Cs	4.642	4.976	99.544
$Cs\text{-}Cu^{+2}$	9.288	5.960	199.975
$Cs\text{-}Ti^{+2}$		2.993	654.68
$Cs\text{-}Al^{+2}$		7.745	162.883
$Cs\text{-}Pb^{+2}$	7.604	5.739	136.315
$Cs\text{-}As^{+3}$		7.292	125.225

Dipol momentler için literatürdeki değerler hesaplanan dipol momentlerle karşılaştırılmıştır. Kutupsallık değerleri, molekül içindeki elektronik dağılımın harici bir elektrik alanı tarafından nasıl bozulabileceğini gösterir. Tek başına Cs'nin dipol momenti, komplekslerine kıyasla nispeten düşüktür, bu da metal iyonlarıyla etkileşimin dipol momentini önemli ölçüde değiştirdiğini düşündürür. Kutupsallık değerleri Cs-Ti için en yüksektir; bu, harici bir elektrik alanında elektronik bulutunun güçlü bir şekilde bozulduğunu gösterilmiştir. Bu özellikler kitosan ve komplekslerinin doğrusal olmayan optik davranışlarını anlamak için önemlidir.

Sonuçlar

Bu çalışmada, geometrik ve elektronik özellikler ile doğrusal olmayan optik(NLO) özellikler incelenildi. İncelenen bileşiğin geometrik yapısı, Gaussian 09 paket programında DFT/B3LYP yöntemi, 6-31G(d,p) temel seti kullanılarak optimize edilip Cs bileşiğinin kompleksleri için DFT/B3LYP yöntemi ve LANL2DZ temel seti kullanıldı. DFT kullanılarak Cs bileşiğinin geometrik yapısı ve optimize edilmiş enerjisi hesaplandı. İlk olarak, Titanyum, Kurşun, Alüminyum ve Arsenik metallerinin kitosan ile etkileşme enerjisi hesaplandı ve hangi metalin kitosan ile daha hızlı bağlandığını belirlemek için sonuçlar önceki çalışmalarla karşılaştırıldı. Tablolar 1-4'te gösterildiği gibi, Arsenik (As) en hızlı bağlanan, Titanyum ise kitosanla bağlanma açısından en yavaş olan metaldir. Cs bileşiği ve komplekslerinin yapısal parametreleri (bağ uzunluğu, bağ açıları) elde edilmiş ve sonuçlar önceki çalışmalarla karşılaştırıldı, tablolar 5-9'da gösterildiği gibi literatürle uyumlu olduğu gözlemlendi. Ayrıca, bileşiklerin HOMO ve LUMO enerjileri, enerji gap, sertlik ve yumuşaklık özellikleri hesaplanmış ve tablolar 10-14'te gösterildi. Burada hesaplanan enerji değerinin bileşiğin stabil bir yapıda olduğunun bir göstergesi olduğu söylenebilir, kitosanın en stabil yapıya sahip olduğu ve Cs-Ti bileşiğinin en az stabil olduğu fark edildi. Son olarak, bileşiklerin dipol momenti ve kutupsallık değerleri incelenmiş ve Cs-Ti için Kutupsallık değerlerinin en yüksek olduğu hesaplandı . Genel olarak, DFT yöntemlerinin deneysel sonuçlarla daha uyumlu olduğu bilinmektedir ve bu çalışmada da doğrulandı.

KAYNAKÇA

Choi, C., Nam, J. P., & Nah, J. W. (2016). Application of chitosan and chitosan derivatives as biomaterials. *Journal of Industrial and Engineering Chemistry*, *33*, 1-10.

Cheung, R. C. F., Ng, T. B., Wong, J. H., & Chan, W. Y. (2015). Chitosan: an update on potential biomedical and pharmaceutical applications. *Marine drugs*, *13*(8), 5156-5186.

Marinello S, Gamberini R. Multi-criteria decision-making approaches applied to waste electrical and electronic equipment (WEEE): A comprehensive literature review. Toxics. 2021;9(1):13.

Chen M, Avarmaa K, Taskinen P, Klemettinen L, Michallik R, O'Brien H, et al. Handling trace elements in WEEE recycling through copper smelting-an experimental and thermodynamic study. Miner Eng. 2021;173:107189.

Braier, N. C., & Jishi, R. A. (2000). Density functional studies of Cu2+ and Ni2+ binding to chitosan. Journal of Molecular Structure: THEOCHEM, 499(1-3), 51-55.

Gomes, J. R., Jorge, M., & Gomes, P. (2014). Interaction of chitosan and chitin with Ni, Cu and Zn ions: A computational study. The Journal of Chemical Thermodynamics, 73, 121-129.

Mardani, H. R., Ravari, F., Kalaki, A., & Hokmabadi, L. (2020). New Schiff-base's modified chitosan: Synthesis, characterization, computational, thermal study and comparison on adsorption of Copper (II) and Nickel (II) metal ions in aqueous. Journal of Polymers and the Environment, 28(9), 2523-2538.

Rodríguez-Juárez, A., Carmona-Álvarez, V., Díaz-Monge, F., Chigo-Anota, E., & Zaca-Moran, O. (2023). Understanding of the Effect of the Adsorption of Atom and Cluster Silver on Chitosan: An In Silico Analysis. Molecules, 28(15), 5809.

Hassan, B., Muraleedharan, K., & Mujeeb, V. A. (2015). Density functional theory studies of Pb (II) interaction with chitosan and its derivatives. International journal of biological macromolecules, 74, 483-488.

Onoka, I., Pogrebnoi, A. M., & Pogrebnaya, T. P. (2014). Geometrical structure, vibrational spectra and thermodynamic properties of chitosan constituents by DFT method.

Tomberg, A. (2013). Gaussian 09w tutorial. An introduction to computational chemistry using G09W and Avogadro software, 1-36.

Lee, C., Yang, W., & Parr, R. G. (1988). Development of the Colle-Salvetti correlation-energy formula into a functional of the electron density. Physical review B, 37(2), 785.

De Proft, F., Sablon, N., Tozer, D. J., & Geerlings, P. (2007). Calculation of negative electron affinity and aqueous anion hardness using Kohn–Sham HOMO and LUMO energies. Faraday Discussions, 135, 151-159.

Promkatkaew, M., Kitjaruwankul, S., Baiya, S., Tongwanichniyom, S., Boonsri, P., & Hannongbua, S. (2022). A DFT-Based Analysis of Metals Adsorption on Chitosan Monomer. SWU. Sci. J, 38, 37-47.

Wang, B., Bai, Z., Jiang, H., Prinsen, P., Luque, R., Zhao, S., & Xuan, J. (2019). Selective heavy metal removal and water purification by microfluidically generated chitosan microspheres: Characteristics, modeling and application. Journal of hazardous materials, 364, 192-205.

Pir, H., Günay, N., Avcı, D., & Atalay, Y. (2012). Molecular structure, vibrational spectra, NLO and NBO analysis of bis (8-oxy-1-methylquinolinium) hydroiodide. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy, 96, 916-924.

Fleming, I., Frontier orbitals and organic chemical reactions, (ed); John Wileyu. Sons, London/ New York/ Syndney/ Toronto, pp. 249, 1976.

Kunduracıoğlu, A., Tamer, Ö., Avcı, D., Kani, I., Atalay, Y., & Çetinkaya, B. (2014). 1-Pentamethylbenzyl-3-nbuthylbenzimidazolesilver (I) bromide complex: Synthesis, characterization and DFT calculations. *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy*, *121*, 35-45.

Prasad, P. a. (1991). Introduction to nonlinear optical effects in molecules and polymers. 272-273.

VALORIZATION OF USED WATER IN IRRIGATION, CASE OF THE STEP OF SIDI MEROUANE, WILAYA OF MILA, EAST ALGERIA

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Abstract

Water is an increasingly scarce commodity in Algeria. Currently, it is the subject of a competitive exploitation between domestic, agricultural and industrial needs, which compete for a very limited availability. Knowing that water is a limiting factor of development, scarcity is supported in terms of water stress by the spatio-temporal irregularity of rainfall and the pollution of mobilized resources, two factors likely to increase with climate change. The pollution of surface water is due to the discharge of domestic and industrial wastewater. Pollution is likely to constitute, in the short term, a risk of water shortage accentuated imposing the need to protect this resource against any alteration and irrational use.

Faced with the challenge of ensuring the coverage of water needs for agriculture in Algeria, an active policy of mobilization of non-conventional water resources has been implemented, through the reuse of purified wastewater in agriculture. Wastewater treatment has thus become a necessity to preserve the quality of natural environments and especially surface waters as an adequate solution to alleviate the scarcity of water in our country.

The wastewater from the centers of Mila, Sidi Merouane and Grarem Gouga are essentially of domestic origin and previously discharged directly into the lake of the dam of Beni Haroun. The water treatment plant (WTP) of Sidi Merouane was built to mitigate the pollution of the lake of the largest hydraulic complex in the country, the first of a series of three scheduled in the watershed of the dam Beni Haroun. The National Sanitation Office received the station in 2009.

According to the results of the analyses carried out at the WTP of Sidi Merouane, we have reached a very important and promising conclusion. The purified waters of the station are globally suitable for reuse in the agricultural field, this suitability is confirmed by the purifying efficiency of the WTP signified by important abatements superior to 95% for the BOD_5, the COD and the suspended matter (SM).

The calculation of the sodium absorption ratio (S.A.R) and the percentage of sodium (% Na) and their projection on the Wilcox and Richards diagrams confirm the above mentioned results. In addition, the risk by bicarbonates and chlorides is low to moderate. According to the microbiological results, purified water is recommended for specific crops and with a localized irrigation technique.

Overall and according to the results we obtained, the purified water of the Sidi Merouane WTP is suitable for irrigation but with restrictions; it can be used for the cultivation of fruit and forest trees, fodder crops, cereals and flowering plants.

Keywords: Beni-Haroun, water treatment plant, wastewater, SAR, agriculture.

SYNTHESIS OF ACTIVATED CARBON FROM HEMP STALK

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Abstract

Increasing environmental problems and the demand for competitive, cost-effective products are becoming the basic principles in new material research. Although previously developed methods are successful in obtaining a porous carbon structure, they cannot meet the sustainability criteria. Various fields, such as fuel cells, batteries, and supercapacitors employ carbon compounds as electrode materials. Nevertheless, the majority of current carbon compounds are derived from fossil fuels through synthetic processes with significant expenses. Renewable sources like biomass offer significant potential as carbon materials to overcome this problem. With its abundance, sustainability, and affordable cost, biomass garners attention as a promising option for creating efficient carbon-based components for energy systems. Moreover, the development of carbon materials produced from biomass enables the commercialization of alternative energy storage technologies, while the efficient and low-cost production of activated carbon encourages the widespread use of energy systems. In this regard, the synthesis of activated carbon from waste biomass is a subject of great interest today in terms of sustainability. The properties of the resulting activated carbon generally vary depending on the material used and the nature of the carbonization process. This study aimed to synthesize and electrochemically evaluate high surface area activated carbon from hemp stalks, a significant biomass waste globally. To achieve this goal, evaluating hemp stalks is critical in terms of sustainability. We synthesised activated carbon using the hydrothermal process. We aim to increase the surface area of activated carbon by heat treating hemp stalks and activating them using KOH. Post-synthesis analysis clarified the surface morphology of activated carbon, revealing its high surface area. Electrochemical measurements revealed that the synthesized activated carbon can be used as a support material in fuel cells.

Keywords: Hemp, Biomass waste, Activated carbon, Electrocatalyst.

INTRODUCTION

The growing population and rising living standards in our world cause an increase in demand for energy resources. Increasing fossil fuel consumption contributes to global warming, which poses a threat to human health and environmental safety. Addressing global warming is crucial due to its expected serious consequences. For this reason, it has become important to expand the use of renewable energy for energy efficiency. Potentially offering a solution to the global energy crisis and pollution-related issues, renewable energy sources are highly promising. Wind, geothermal, hydraulic, solar, and biomass energy are all examples of renewable sources.

Scientists have developed a number of energy storage and conversion technologies, including supercapacitors, solar cells, supercapacitors, batteries, and fuel cells to efficiently use renewable energy sources. Fuel cells can produce electricity using hydrogen, with water being the sole byproduct, making hydrogen one of the most appealing renewable energy sources to replace fossil fuels. PEMFC, the most advanced fuel cells, exhibit remarkable energy efficiency since they utilize hydrogen at the anode and oxygen at the cathode. The oxygen reduction reaction (ORR) at the fuel cell cathode electrode is slow and has a high overpotential, which restricts the application of these technologies on a large scale. Because of its slow kinetics, the oxygen reduction reaction (ORR) requires electrocatalysts to lower its high overpotential. Platinum has a wide range of uses due to its excellent ORR electrocatalytic performance, but its high cost and limited availability on Earth hinder the development of fuel cells (Dessalle et al., 2023). Nanostructured carbons also always have problems, like being expensive to make, difficult to prepare, and bad for the environment. To answer these problems, scientists have looked into the development of non-precious metal electrocatalysts supported on carbon materials and metal-free carbon catalysts doped with heteroatoms. Several recent investigations have yielded valuable insights into carbon-based electrocatalysts produced from biomass, both with and without the presence of metal. The intrinsically porous structure of carbons synthesized from biomass materials decreases ion diffusion distance and enables electrolyte penetration (Dessalle et al., 2023; Tang et al., 2017).

Hemicellulose primarily composes biomass, a sustainable and carbon-rich renewable energy source. Activated carbon production from biomass makes a significant contribution to solving economic and environmental problems. Researchers have been studying the use of carbon materials from biomass in electrochemical energy storage and conversion devices in recent years. Consequently, according to these studies, the pore diameter and size distribution of biomass-based carbon materials have a significant effect on their electrochemical performance. In this regard, hemp stalks, which can grow rapidly in various climates and whose structure consists mostly of hemicellulose, are a good choice as a biomass source. After harvesting the planting areas, we often burn the almost useless hemp stalks. This situation also brings waste and environmental pollution. Therefore, using hemp stalks to synthesize activated carbon from various biowastes is crucial for the environment, economy, and assessment of agricultural wastes. In this study, activated carbon with a high surface area was synthesized from waste hemp stalks by the chemical activation method. We examined the electrochemical activity of the obtained activated carbon for energy applications and the development of renewable and green energy.

MATERIALS AND METHODS

We used hemp stalks from Bartın province as biomass, the starting material for the production of activated carbon. First, washed the hemp stalks with pure water to remove various soil residues, and then dried them in an oven at 80°C. The dried sample was subjected to crushing, grinding, and sieving processes, respectively, and was brought to the desired particle size (500 µm). The ground version of the biomass used (500 µm) is shown in Fig.1.

µm)

Fig.1. Image of ground hemp stalks

The carbonization process involved placing the biomass in a quartz boat and subjecting it to heat treatment in a horizontal furnace under an Ar atmosphere. We carried out this heat treatment at 500°C for 2 hours in an inert environment, allowing it to cool back to room temperature. We weighed the carbonization process after it was complete. Next, we applied a chemical pretreatment to enhance the surface area of the activated carbon for synthesis. We mixed carbonized hemp stalks with KOH (potassium hydroxide) and pure water in a 1:2 ratio, then kept this mixture at room temperature for 72 hours. Then, it was kept in an oven at 80 ºC for 12 hours. It filled the quartz boats with the resulting mixture and positioned them correctly in the horizontal furnace. It left the reactor inside for a 15-minute period to remove the existing oxygen before starting the heating process. Passed argon (Ar) gas through the reactor for a specified period, set the oven temperature to 800 °C at the end of the period and waited for it to reach this temperature at a heating rate of 10 °C/min. After maintaining this temperature for two hours, turned off the oven and allowed it to cool down to room temperature. After cooling, washed the sample from the oven several times with 1 M HCl (hydrochloric acid) solution and then pure water, until the pH reached neutral, to eliminate the activation chemical from the structure. After the washing processes, dried the activated carbon sample at 80 °C for 12 hours, and then stored it in a lidded container (Fig.2).

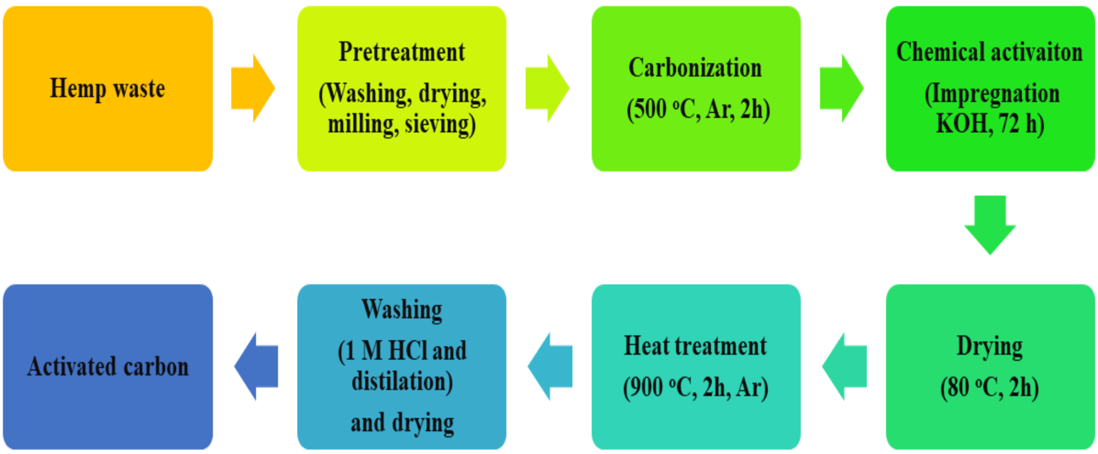

Fig. 2. Schematic representation of activated carbon synthesis steps

RESEARCH AND FINDINGS

Fig.3 presents the XRD results for activated carbon. Examining the synthesized activated carbon's XRD results reveals a largely amorphous sample with crystalline structures. When the peak intensity is examined, the broad and weak peaks located at approximately 23°, with the important diffraction peak occurring in the 20-30° range, coincide with the diffraction (002) plane. The high intensity in low-angle scattering confirms the presence of predominantly micro/mesopores. Additionally, the inconspicuous (101) peak located at approximately 40° can be attributed to the hexagonal planes of graphite.

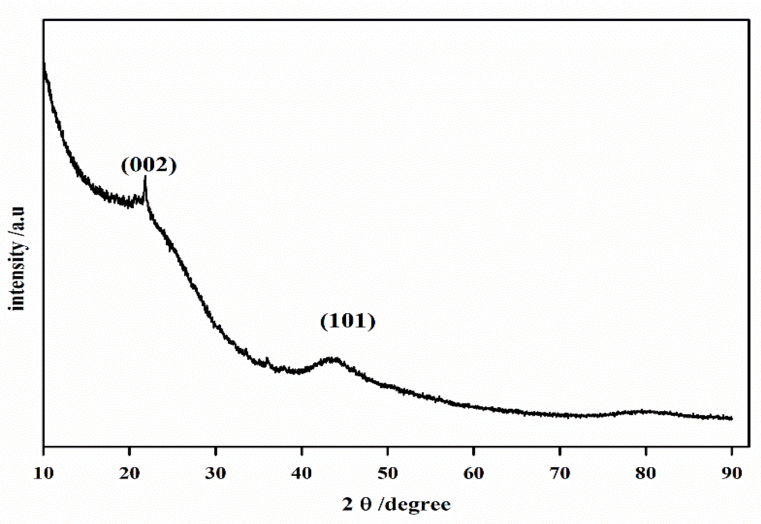

Fig. 3. XRD pattern of synthesized activated carbon

Table 1 gives the BET surface areas, micro and mesopore volumes, and fractions of the synthesized activated carbon. The BET surface area of activated carbon was found to be 971.7 m^2/g. Accordingly, it can be said that the produced activated carbon has both a micro- and mesoporous structure

Table 1. BET analysis results of hemp stalk derived activated carbon

Activated carbon	**Surface are [m^2g^{-1}]**	**Total porosity volume [$cm^3\ g^{-1}$]**	**Porosity size [nm]**
H-AC	971.7	0.148	2.25

The electrochemical activity of the synthesized activated carbon was examined by cyclic voltammetry analysis in a three-electrode system. Cyclic voltammetry measurements were conducted in the media of an electrolyte containing 0.1 M $HClO_4$. Measurements were made in the range of 20-100 mV/s scanning speed in the -0.28-1.0 V. It can be seen that the peak current increases as the scan rate is increased. This situation can be explained by the internal resistance occurring in the electrode material due to the increasing scan rate.

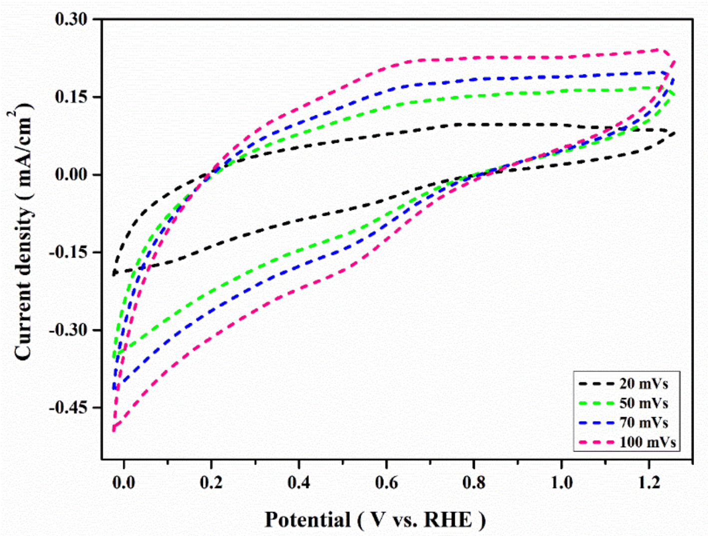

Figure 4. CV curves of synthesized activated carbon at different scan rates.

CONCLUSION

The results showed that the activated carbon from hemp stalks activated with KOH had a higher surface area than commercial carbon black. This suggests that it is a potential alternative to improve electrochemical performance. In particular, increased oxygen reduction reaction activity can increase the efficiency of PEMFC systems. As a result, it is thought that the synthesized carbon material can be used in fuel cells and energy storage devices as a renewable, cost-effective, and environmentally friendly electrocatalyst material. In addition, the use of hemp stalks has significant potential in terms of being easy and abundant in terms of accessibility and being used for a more scientific and environmentally beneficial purpose by preventing them from being released into nature as waste.

ACKNOWLEDGEMENTS

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REFERENCES

Dessalle, A., Quílez-Bermejo, J., Fierro, V., Xu, F., & Celzard, A. (2023). Recent progress in the development of efficient biomass-based ORR electrocatalysts. *Carbon, 203*, 237-260.

Tang, W., Zhang, Y., Zhong, Y., Shen, T., Wang, X., Xia, X., & Tu, J. (2017). Natural biomass-derived carbons for electrochemical energy storage. *Materials research bulletin, 88*, 234-241.

THE ROLE OF HEMP IN ELECTROCHEMICAL STUDIES

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Abstract

Globally, approximately ten billion tons of biomass waste are generated each year, but most of this waste cannot be recycled effectively. In particular, waste generated as a result of agricultural production is generally destroyed by direct burning by agricultural operators, which reduces the efficiency of biomass use and also increases environmental pollution. Biomass is deemed a plentiful carbon reservoir, and therefore, recently, emphasis has been placed on the utilization of biomass waste both for energy generation and the manufacture of valuable carbon-derived products. These synthesized carbon materials have widespread use in many applications and devices, due to their impressive properties such as unique surface properties, structural stability and excellent electrocatalytic activity. These carbon structures produced from biomass can be acquired through simple and economical physical and chemical processes and can be widely used as functional materials in various environmental and energy problems. In addition, the surface characteristics and porous structure of carbon materials derived from biomass can be finely adjusted and enhanced by altering the parameters involved in pyrolysis, carbonization, and activation procedures. The superior shell structure of hemp stalks makes them one of the most well-known biomasses for making high-quality porous activated carbon. In recent years, frequently hemp stalks are proposed as a biomass source for preparing electrode structures for supercapacitors. However, research on their applications in sensors and batteries is still limited. This research summarizes electrochemical studies that utilize hemp waste as biomass. We hope that this research will lead to new studies by mentioning existing ones and increasing the interest of researchers in this field.

Keywords: Hemp, Biomass, Carbon material, Electrocatalyst

INTRODUCTION

Industrial hemp, among the world's most ancient plants, is a variety of the plant type that can generally reach a height of 1-5 m. With a wide range of applications, from food to fuel, this multi-purpose plant has a range of once-popular uses. However, due to various factors, most countries have not cultivated it for years. The most important of these is that hemp and marijuana have similar leaf shapes. However, the most obvious difference between these two types of plants is the amount of tetrahydrocannabinol (THC) they contain. Industrial hemp strains generally have less than 3% THC content, while the marijuana plant can contain up to

20 % THC. Therefore, the distinction between industrial uses of hemp and the psychoactive effects of marijuana is based on THC levels (Small, 2015). In recent years, with the changes in legal regulations in various countries, the use of hemp has attracted attention again. It has once again become the focus of interest for various research endeavors and industrial entities, especially with its carbon-negative features. Its affordability and ability to decompose naturally make it more appealing in the current environmental emergency. Contrary to conventional energy crops, hemp can be cultivated on less fertile soil, eliminating the necessity to allocate valuable agricultural area for food and animal feed production. This feature may enable the plant to regain popularity and take a greater place in the global market. Textiles and apparel made from hemp are one of the oldest and most well-known uses. However, 25000 different products, from foods to toiletries, claim to use hemp. Until the 19 th century, hemp was used in 90 % of ships' sails, rigging, and netting. Today, hemp fiber is replacing fiberglass in automotive components and is made into fabric for window coverings, shower curtains, and upholstery. Other products made from hemp fibers include insulation, particleboard, chipboard, rope, twine, thread, newsprint, cardboard, and paper. Hemp seeds are used to make methanol, heating oil, salad oil, medicine, soap, paint, and ink. In addition to the widespread use of hemp in different areas, its more innovative applications also attract attention (Aydoğan et al., 2020). Researchers have specifically focused on using hemp as an economical and efficient biomass waste materialfor electrochemical applications. Converting hemp stalks into carbon as a biomass source provides three-dimensional hierarchical structures with great potential in terms of high conductivity, surface area, and porosity. Thermal carbonization and activation typically achieve this transformation. Through additional research and development, this material becomes electrochemically and environmentally suitable and could become the industry standard for fuel cells, batteries, and supercapacitors. This study will mention the present researches conducted on this subject and demonstrate why it is important to solidify the position of hemp as a prime source for carbon materials in the field of electrochemistry.

USE OF HEMP IN ELECTROCHEMISTRY

Advances in the current energy system depend significantly on the development of supercapacitors, batteries and fuel cells. With the increasing need for these devices that store and convert energy, there is a developing need to manufacture sustainable, economically viable, and high efficient components for them. Electrodes, one of the components in these systems, play a critical role in determining the electrochemical activity of these technological devices. Therefore, the materials chosen for the electrodes must possess specific properties. For this purpose, materials with high surface area and electrical conductivity are preferred in the construction of electrodes. In this regard, generally developed carbon forms such as carbon nanofibers, porous/activated carbon, and graphite/graphene-like carbon structures are used. However, these carbon structures are often synthesized through energy- and lengthy procedures involving the incomplete burning of heavy petroleum products or coal. A greener, sustainable alternative is the use of the biomass precursor of the hemp plant (Dos Reis et al., 2020). Various components of hemp biomass, such as husk (short inner stem fibers) and hurd (long outer stem fibers), can be used as carbon sources. Activated carbons, particularly as electrochemistry materials, provide a high specific surface area, such as activated carbons monoliths, activated carbon fibers, and interconnected nanosheets. Processes transform them into various morphologies. Generally, hemp undergoes carbonization and activation processes to achieve these morphologies. Important parameters in these processes are activation agent, heating rate, activation agent-carbon material ratio, and activation temperature. These parameters influence the synthesized carbon structure by influencing its internal pore structure, specific surface area, and surface functional groups (Chunlan et al., 2005). Some electrochemical application areas where hemp-based carbon structures are commonly used are summarized in the following subsections.

Fuel Cell

Carbon materials, particularly carbon blacks, are frequently preferred as electrocatalysts supports in low-temperature fuel cells due to their excellent electrical conductivity and high surface areas and electrical conductivity. When the existing studies in the literature are examined, hemp waste is not widely used as an electrocatalyst in proton exchange membrane fuel cells, and there is only one study. Zhang et al. (Zhang et al., 2020) examined the activity of the porous carbon structure with a surface area of 1251 $m^2\ g^{-1}$, which they synthesized from hemp stalks, as an ORR catalyst. In the study, the Co/N-doped carbon structure formed in hemp waste was prepared by the hydrothermal method, using melamine as the nitrogen source, Co precursor as the metal, and $NaHCO_3$ for activation. This synthesized porous nanostructure exhibited high ORR performance with exceptional durability and methanol tolerance, due to its active sites.

Supercapacitor

The use of hemp as an alternative, cost-effective, and eco-friendly carbon source in supercapacitor uses has become popular in recent years. Materials such as activated carbon and carbon black are commonly preferred as electrodes in supercapacitors. However, the carbons synthesized from hemp stalks have enabled the structures to stand out in this field with their high performance potential. The specific capacitance value of activated carbon with a large surface area was found to be 318 Fg^{-1} after hemp stalks were heated at low temperatures to make carbon and then activated with KOH (Wang et al., 2015). This value proved that the low-cost alternative carbon structure has superior electrochemical performance. In another study (Wang et al., 2013), graphene-like carbon nanostructures were synthesized from hemp stalks. A specific capacitance value of this structure, which has an adjustable pore size distribution, was determined as 142 Fg^{-1}. Furthermore, a maximum energy density of 12 Wh kg^{-1} was achieved with the double-layer capacitor structure in the study. Pseudocapacitors, which use materials like metal oxides capable of faradaic charge storage processes, have garnered significant attention due to the limited energy density of EDLC devices. Hemp-based carbon compounds, when combined with these metal oxides, play a crucial role as a conductive support structure for anchoring redox active substances in double-effect electrodes. These electrodes can simultaneously utilize both electrostatic and faradaic charge storage mechanisms. These electrodes offer a three-dimensional structure with a high surface area, excellent electrical conductivity, and efficient ion diffusion properties at an afford. MnO_2 nanowires were uniformly deposited on the surface of activated carbon produced from hemp waste by a simple hydrothermal method to form a conductive porous structure exhibiting significant specific performance. In the supercapacitor system, where active carbon structure was used as the anode and MnO_2 composite structure was deposited on active carbon as the cathode, a capacitance of 340 F g^{-1} was obtained at 1 A g^{-1} current (Yang et al., 2017). In a similar study (Zhang et al., 2021), RuO_2 was distributed homogeneously on hemp-based activated carbon, and they achieved an impressive performance of 652.79 Fg^{-1} at 5 mV s^{-1}. It has been stated that the high electrochemical performance obtained accelerates the movement of electrons and ensures electrical contact that is uniform due to the presence of lignocellulose fibers in the structure of hemp stalks. These studies emphasized that activated carbon obtained from hemp provides excellent support for metal oxides in supercapacitor systems, due to its structural properties.

Batteries

The demand for rechargeable batteries for a diverse array of uses, spanning from electric cars to handheld gadgets is increasing day by day. This increasing demand has made the use of more sustainable and economical electrode materials mandatory. Graphite, currently the industrial standard for rechargeable lithium-ion battery anodes, requires intensive processing. Furthermore, to meet current demands, electrode materials need specific attributes, like high capacity, faster charging, and a longer cycle life. Therefore, in recent years, researchers emphasis is on synthesizing graphite and economically significant carbon-based materials from biomass. Among the studies carried out, high performance values were also achieved in studies using hemp as biomass. Hemp stalks, which have a more porous structure than graphite, offer increased capacity for storing lithium ions. Moreover, hemp stalks generally have a larger interlayer space, facilitating swifter ion transportation within the electrode. This leads to heightened power density and consequently, accelerated charging. Hemp stalks offer significant advantages in applications in this field and attract great attention due to these structural features. A study in which carbon material synthesized from hemp was used as the anode material in a sodium-ion battery was conducted by Wang *et al*. (Wang et al., 2016). In the study, hemp stalks underwent activation using potassium hydroxide to synthesize carbon nanosheets, followed by hydrothermal treatment with urea to introduce nitrogen to their surface. The carbonaceous structure they synthesized exhibited an excellent activity of 162/173 mAh g^{-1} at 1 A g^{-1}, excellent rate capability, and a long cycle life of 2000 cycles. In a study conducted by Liao *et al*. (Liao et al., 2016), carbon material synthesized from hemp stalks was tested in the anode part of the sodium-ion battery. This synthesized structure demonstrated excellent electrochemical activity of 250 mAh g^{-1}. Raghunandanan *et al*. (Raghunandanan et al., 2018) tested the carbon structure synthesized from hemp stalks in a lithium-sulfur battery system. In the research, composites of hemp-based carbonaceous material with MnO_2 were synthesized and used as a sulfur carrier in the cathode. In the study, it was stated that hemp stems activated with KOH have a large surface area, and thus, it is easier for MnO_2 nanoparticles to be absorbed onto this surface. It was emphasized in the study that, due to this synthesized structure, the conductivity of sulfur improved and an excellent performance of 926 mAh g^{-1} was achieved. Guan *et al.* (Guan et al., 2019) tested hemp stalks activated with $ZnCl_2$ at different temperatures (500 to 800°C) under lithium-ion battery conditions. Among the synthesized materials, the material synthesized at 600°C exhibited the most substantial capacity in a lithium ion half-cell of approximately 500 mAh g^{-1} at a rate of 74 mA g^{-1} for 100 cycles. In a recent study (Shao et al., 2020) obtained products with different structures from the hydrothermal reaction of carbonized hemp sticks and Co_3O_4 between 8 and 18 hours and subsequently evaluated for their performance in a lithium-ion battery system. Co_3O_4 particles were formed into nanoneedles in 8 hours, nanowires in 10 hours, nanoneedles again in 12 hours, microparticles in 16 hours, and finally the carbonized hemp stalks were coated with a 2-µm-thick Co_3O_4 layer for 18 hours. It has been suggested that the hollow channel structure of hemp should provide easy access to electrolyte. Additionally, as a result of the tests, the nanoneedles-structured material provided the the long durability and excellent performance, with a capacity of 450 mAh g^{-1} at a rate of 55 mA g^{-1} for 50 cycles. In another study (Wang et al., 2021) synthesized sulfur-doped carbonized hemp stalk and evaluated its capacity in a potassium ion battery operating at elevated temperatures of 60 °C. It is highlighted in the charge/discharge graph that the plateaus are more pronounced for high temperature conditions, providing an excellent capacity of 450 mAh g^{-1} at a rate of 40 mA g^{-1} for 175 cycles.

CONCLUSION

As a result, hemp's wide range of applications and potential in the circular economy make it more important. The plant's sustainable and environmentally friendly design, particularly its capacity to cultivate on marginal lands and its efficacy as a precursor derived from biomass for electrochemical energy systems, bode well for its future applications. This study significantly proves hemp's effectiveness as a biomass-derived material for electrochemical energy devices due to its properties such as high specific surface area, rate capability, cyclicity, and semiconductor potential. However, there are some challenges to continuing progress. In particular, issues such as uncertainty about the mechanism in the carbonization process may limit some research. Such issues may affect the overall performance of biomass precursors, and more test data are needed under application conditions. The studies in the literature and briefly mentioned in the above sections are expected to strengthen the importance of hemp in the field of electrochemistry and lead to future research.

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REFERENCES

Aydoğan, M., Terzi, Y. E., Gizlenci, Ş., Mustafa, A., Alpay, E., & Meral, H. (2020). Türkiye'de kenevir yetiştiriciliğinin ekonomik olarak yapılabilirliği: Samsun ili Vezirköprü ilçesi örneği. *Anadolu Tarım Bilimleri Dergisi, 35*(1), 35-50.

Chunlan, L., Shaoping, X., Yixiong, G., Shuqin, L., & Changhou, L. (2005, 2005/09/01/). Effect of pre-carbonization of petroleum cokes on chemical activation process with KOH. *Carbon, 43*(11), 2295-2301.

Dos Reis, G. S., Larsson, S. H., de Oliveira, H. P., Thyrel, M., & Claudio Lima, E. (2020). Sustainable biomass activated carbons as electrodes for battery and supercapacitors—A mini-review. *Nanomaterials, 10*(7), 1398.

Guan, Z., Guan, Z., Li, Z., Liu, J., & Yu, K. (2019). Characterization and preparation of nano-porous carbon derived from hemp stems as anode for lithium-ion batteries. *Nanoscale Research Letters, 14*, 1-9.

Liao, Y., Huang, Y., Shu, D., Zhong, Y., Hao, J., He, C., Zhong, J., & Song, X. (2016). Three-dimensional nitrogen-doped graphene hydrogels prepared via hydrothermal synthesis as high-performance supercapacitor materials. *Electrochimica Acta, 194*, 136-142.

Raghunandanan, A., Mani, U., & Pitchai, R. (2018). Low cost bio-derived carbon-sprinkled manganese dioxide as an efficient sulfur host for lithium–sulfur batteries [10.1039/C8RA03793K]. *Rsc Advances, 8*(43), 24261-24267.

Shao, S., Wang, P., Gong, Z., Ye, K., Zhu, K., Yan, J., Wang, G., & Cao, D. (2020). Cobalt Oxide Grown on Biomass Carbon as a Three-Dimensional Self-Supporting Negative Electrode with High Area Specific Capacity. *ChemistrySelect, 5*(29), 8998-9004.

Small, E. (2015). Evolution and classification of Cannabis sativa (marijuana, hemp) in relation to human utilization. *The botanical review, 81*, 189-294.

Wang, H., Xu, Z., Kohandehghan, A., Li, Z., Cui, K., Tan, X., Stephenson, T. J., King'ondu, C. K., Holt, C. M. B., Olsen, B. C., Tak, J. K., Harfield, D., Anyia, A. O., & Mitlin, D. (2013, 2013/06/25). Interconnected Carbon Nanosheets Derived from Hemp for Ultrafast Supercapacitors with High Energy. *ACS nano, 7*(6), 5131-5141.

Wang, H., Yu, W., Mao, N., Shi, J., & Liu, W. (2016, 2016/06/01/). Effect of surface modification on high-surface-area carbon nanosheets anode in sodium ion battery. *Microporous and Mesoporous Materials, 227*, 1-8.

Wang, P., Gong, Z., Ye, K., Gao, Y., Zhu, K., Yan, J., Wang, G., & Cao, D. (2021, 2021/04/01/). Sulfur-doped biomass carbon as anode for high temperature potassium ion full cells. *Electrochimica Acta, 374*, 137920.

Wang, Y., Yang, R., Li, M., & Zhao, Z. (2015, 2015/03/01/). Hydrothermal preparation of highly porous carbon spheres from hemp (Cannabis sativa L.) stem hemicellulose for use in energy-related applications. *Industrial Crops and Products, 65*, 216-226.

Yang, M., Kim, D. S., Hong, S. B., Sim, J.-W., Kim, J., Kim, S.-S., & Choi, B. G. (2017, 2017/05/30). MnO2 Nanowire/Biomass-Derived Carbon from Hemp Stem for High-Performance Supercapacitors. *Langmuir, 33*(21), 5140-5147.

Zhang, C., Shu, J., Shi, S., Nie, J., & Ma, G. (2020, 2020/02/01/). Hemp derived N-doped highly porous carbon containing Co nanoparticles as electrocatalyst for oxygen reduction reaction. *Journal of Colloid and Interface Science, 559*, 21-28.

Zhang, J., Duan, Y., Jiang, Z., Chen, T., Wang, K., Wang, K., Zhang, W., & Hu, J. (2021, 2021/06/01/). Investigation of the supercapacitance of ruthenium-based/ hemp stem activated carbon. *Journal of Physics and Chemistry of Solids, 153*, 110019.

A CLINICAL PHARMACY PERSPECTIVE ON MEDICAL CANNABIS

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Abstract

Pharmacists are considered well-equipped to play a crucial role in ensuring the safe and effective use of medical cannabis. Pharmacists must actively provide clinical advice and oversight in the safe management, production, and dispensing of medical cannabis. In locations where the use of medical cannabis is illegal, pharmacists face unique challenges in providing care to patients who may be seeking alternative treatments. Despite the legal restrictions, pharmacists can still play a crucial role in ensuring patient safety and education regarding medical cannabis. While they may not be able to dispense medical cannabis directly, pharmacists can offer valuable guidance on potential risks, interactions, and alternative therapies to patients in need. Pharmacists in regions where medical cannabis is illegal must stay informed about the latest research and regulations surrounding cannabis to provide evidence-based information to patients and other healthcare professionals. In areas where medical cannabis use is prohibited, pharmacists can advocate for policy changes and work toward increasing awareness among policymakers and the public about the potential benefits of medical cannabis. By engaging in discussions and promoting education on the topic, pharmacists can contribute to advancing the conversation around medical cannabis legalization, especially within therapies that need new approaches. In the context of antiepileptic therapy, emerging modalities such as medical cannabis represent a promising avenue for expanding the repertoire of alternative active ingredients. Traditional pharmacotherapeutic options for epilepsy management often confront limitations in efficacy and tolerability, particularly in refractory cases where conventional treatments prove inadequate. Medical cannabis, with its diverse array of cannabinoids and their interactions with the endocannabinoid system, presents a novel therapeutic paradigm that holds the potential for addressing unmet clinical needs. By harnessing the pharmacological properties of cannabinoids, medical cannabis offers a nuanced approach to epilepsy management, potentially affording patients access to adjunctive therapies with distinct mechanisms of action.

Keywords: Medical cannabis, clinical pharmacy, patient education, antiepileptic therapy.

References

1. Adebisi YA, Quazeem Olaoye D. Medical Use of Cannabis in Africa: The Pharmacists' Perspective. Innov Pharm. 2022 Apr 2;13(1):10.24926/iip.v13i1.4430. doi: 10.24926/iip.v13i1.4430. PMID: 36304681; PMCID: PMC9598981.
2. Clarke R, Merlin M. Cannabis: evolution and ethnobotany. Univ of California Press; 2016 Jun 28.
3. Hinson JL. Role of the pharmacist in the care of patients using cannabis. Journal of the American Pharmacists Association, Volume 60, Issue 3, 2020, Pages 428-429, ISSN 1544-3191, https://doi.org/10.1016/j.japh.2020.04.003.

4. Isaac S, Saini B, Chaar BB. The Role of Medicinal Cannabis in Clinical Therapy: Pharmacists' Perspectives. PLoS One. 2016 May 12;11(5):e0155113. doi: 10.1371/journal.pone.0155113. PMID: 27171490; PMCID: PMC4865212.
5. Jaffal LH, Lahoud N, Zein S, et al. Lebanese Pharmacists' Knowledge and Attitude toward Cannabis Medical Use Legality. Dr. Sulaiman Al Habib Med J 2, 106–114 (2020). https://doi.org/10.2991/dsahmj.k.200507.001
6. Rosenberg EC, Patra PH, Whalley BJ. Therapeutic effects of cannabinoids in animal models of seizures, epilepsy, epileptogenesis, and epilepsy-related neuroprotection. Epilepsy Behav. 2017 May;70(Pt B):319-327. doi: 10.1016/j.yebeh.2016.11.006. Epub 2017 Feb 9. PMID: 28190698; PMCID: PMC5651410.

A CASE STUDY ON WET-SPUN HEMP YARN PROPERTIES FOR SUSTAINABLE FASHION APPLICATIONS

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Abstract

Hemp has a rich history dating back to 8,000-7,000 BC, where it was used in the earliest known woven fabrics. It has been used not only in clothing fabrics but also in architectural structures, demonstrating its versatility and durability. Hemp is gaining popularity as a potential alternative to conventional textiles due to its sustainable cultivation methods. The increasing awareness of environmental issues such as pollution and climate change has led to a resurgence in hemp usage. Compared to traditional crops like cotton, hemp requires less water, pesticides, and fertilizers, making it an environmentally friendly choice.

This study aims to explore the mechanical and physical properties of 100% wet-spun hemp yarn, including tensile strength, elongation, and moisture absorption. Additionally, it examines the yarn's performance after bleaching to assess any changes in its properties. The findings of this study provide valuable insights into the potential of 100% wet-spun hemp yarn as a sustainable material for fashion applications. By investigating these properties, the research aims to demonstrate the suitability of hemp yarn for various applications such as fashion accessories. The findings of this study have the potential to contribute to the broader textile industry, offering insights into the performance and versatility of hemp yarn and paving the way for its increased use in sustainable textile production.

Keywords: Wet-spun hemp yarn, Sustainable fashion, Mechanical properties, Physical properties, Bleaching.

EMERGING VALUE CREATION AT OSTIM INDUSTRIAL ZONE; THE ECONOMIC IMPORTANCE AND STRATEGIC ROLE OF 'INDUSTRIAL GREEN CAMPUSES IN PRACTICE'

OSTİM SANAYI BÖLGESINDE YÜKSELEN DEĞER YARATMA; 'UYGULAMADA ENDÜSTRIYEL YEŞIL KAMPÜSLERIN' EKONOMIK ÖNEMI VE STRATEJIK ROLÜ

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ABSTRACT

In today's rapidly evolving economic landscape, the concept of value creation has taken on new dimensions, particularly in industrial zones such as the Organized Industrial Zone of Ankara (OSTİM). This study delves into the strategic economic importance and role of industrial and institutional green campuses in practice within OSTİM, focusing on the sustainable practices of industrial hemp in the architecture sector and the potential of manufacturing buildings in clusters. By leveraging industrial hemp in construction projects within OSTİM, companies can reduce their carbon footprint and contribute to a more sustainable built environment. By clustering manufacturing facilities together, companies can benefit from economies of scale, shared resources, and enhanced collaboration. This approach not only improves operational efficiency but also fosters innovation and knowledge sharing among industry players within the industrial zone. The focus of the research is on increasing sustainable practices of industrial hemp in the architecture sector and evaluating the potential of manufacturing buildings in clusters within the OSTIM Organized Industrial Zone. The study also explores the business models of OSTIM industrial zone clusters to demonstrate how innovations can be converted into value to support sustainable development and aims to promote innovative and economic practices and investments in the sector, provide factual information, and enhance organizational capabilities for compliance with international standards. Within this scope, qualitative researches are used to analyze the current situation in the sector as a method and recommendations are developed.

Keywords: Corporative Sustainability, Industry, Industrial Hemp, Sustainable Economy, Industrial Campuses

ÖZET

Günümüzün hızla gelişen ekonomik ortamında değer yaratma kavramı, özellikle Ankara Organize Sanayi Bölgesi (OSTİM) gibi sanayi bölgelerinde yeni boyutlar kazanmıştır. Bu çalışma, OSTİM'deki endüstriyel ve kurumsal yeşil kampüslerin stratejik ekonomik önemini ve uygulamadaki rolünü araştırmakta, endüstriyel kenevirin mimarlık sektöründeki sürdürülebilir uygulamalarına ve kümeler halinde bina üretme potansiyeline odaklanmaktadır. Şirketler, OSTİM'deki inşaat projelerinde endüstriyel kenevirden yararlanarak karbon ayak izlerini azaltabilir ve daha sürdürülebilir bir yapılı çevreye katkıda bulunabilirler. Şirketler, üretim tesislerini bir arada kümeleyerek ölçek ekonomilerinden, ortak kaynaklardan ve gelişmiş işbirliğinden faydalanabilir. Bu yaklaşım sadece operasyonel verimliliği artırmakla kalmaz, aynı zamanda sanayi bölgesindeki sektör oyuncuları arasında inovasyonu ve bilgi paylaşımını da teşvik eder. Araştırmanın odak noktası, mimarlık sektöründe endüstriyel kenevirin sürdürülebilir uygulamalarının artırılması ve OSTİM Organize Sanayi Bölgesi içindeki kümelerde üretim binalarının potansiyelinin değerlendirilmesidir. Çalışma ayrıca, sürdürülebilir kalkınmayı desteklemek için yeniliklerin nasıl değere dönüştürülebileceğini göstermek amacıyla OSTİM sanayi bölgesi kümelerinin iş modellerini araştırmakta ve sektördeki yenilikçi ve ekonomik uygulamaları ve yatırımları teşvik etmeyi, gerçeklere dayalı bilgi sağlamayı ve birlikte çalışma için organizasyonel yetenekleri geliştirmeyi amaçlamaktadır.

Anahtar Kelimeler: Kurumsal Sürdürülebilirlik, Sanayi, Endüstriyel Kenevir, Sürdürülebilir Ekonomi, Endüstriyel Kampüsler