ICHS – 2026

The International Conference on Herbs and Spices
(ICHS-2026)

ICHS-2026

PROCEEDINGS BOOK

ABSTRACTS & FULL PAPERS

EDITORS

Prof. Dr. Nazım ŞEKEROĞLU

Prof. Dr. İpek SÜNTAR

Assoc. Prof. Dr. Nadire Pelin BAHADIRLI

02.05.2026 FINAL

21-23 April 2026

Rimini - ITALY

ISBN: 978-625-98164-4-9 (PDF)

CHAIR OF ICHS-2026 CONFERENCE

Prof. Dr. Nazım ŞEKEROĞLU

Gaziantep University, Art and Sciences Faculty
Biology Department
Gaziantep - TÜRKİYE
President of AMAPMED
General Coordinator of GOFMAP

President of Local Committee of ICHS-2026

Andrea PRIMAVERA

President of Local Committee
FIPPO – Perugia, ITALY

HONORARY BOARD OF ICHS-2026

Bekir Karacabey
General Directorate of Forestry
Republic of TÜRKİYE

Prof. Dr. Zora Dajić Stevanović
President of AMAPSEEC
Belgrade, SERBIA

Prof. Dr. Milind Janrao Umekar
President of APTI
Nagpur, Maharashtra, INDIA

INTERNATIONAL ORGANIZING COMMITTEE

ROF. DR.	AGNIESZKA SZOPA	DEPARTMENT OF MEDICINAL PLANT AND MUSHROOM BIOTECHNOLOGY, JAGIELLONIAN UNIVERSITY MEDICAL COLLEGE KRAKÓW	POLAND
PROF. DR.	ANA PAULA DE ALMEIDA	DIRETORA CIENTÍFICA NO INSTITUTO IDEHIA	PORTUGAL
PROF. DR.	MÁTHÉ ÁKOS	UNIVERSITY OF WEST HUNGARY FACULTY OF AGRICUL TURE AND FOOD INDUSTRY VÁR 2, 9200 MOSONMAGYARÓVÁR	HUNGARY
PROF. DR.	ALEXIOS-LEANDROS SKALTSONIS	SCHOOL OF PHARMACY, NATIONAL AND KAPODISTRIAN UNIVERSITY OF ATHENS	GREECE
PROF. DR.	ERNAWATI SINAGA	RESEARCH AND COLLABORATION AFFAIR, UNIVERSITAS NASIONAL, CENTER FOR MEDICINAL PLANTS RESEARCH	INDONESIA
PROF. DR.	JEREMY J. JOHNSON	UNIVERSITY OF ILLINOIS CHICAGO, DEPARTMENT OF PHARMACY PRACTICE, CHICAGO	USA
PROF. DR.	HAFIDA BOUAMAMA	CADI AYYAD UNIVERSITY, UCA, FACULTY OF SCIENCES AND TECHNIQUES, LABORATORY OF SUSTAINABLE DEVELOPMENT AND HEALTH RESEARCH	MOROCCO
PROF. DR.	HÜSNÜ CAN BAŞER	NEAR EAST UNIVERSITY, PHARMACY FACULTY, PHARMACOGNOSY DEPARTMENT, NICOSIA	TRNC
PROF. DR.	ILKAY ERDOGAN ORHAN	LOKMAN HEKIM UNIVERSITY, PHARMACOGNOSY FACULTY, DEPARTMENT OF PHARMACOGNOSY	TÜRKİYE
PROF. DR.	IPEK SUNTAR	GAZI UNIVERSITY, PHARMACOGNOSY FACULTY, DEPARTMENT OF PHARMACOGNOSY	TÜRKİYE
PROF. DR.	IVAN SALAMON	UNIVERSITY OF PRESOV, DEPARTMENT OF ECOLOGY	SLOVAKIA
PROF. DR.	JIANBO XIAO	UNIVERSITY OF VIGO, FACULTY OF FOOD SCIENCES AND TECHNOLOGY	SPAIN
PROF. DR.	JITBANJONG TANGPONG	SCHOOL OF ALLIED HEALTH SCIENCES, WALAILAK UNIVERSITY	THAILAND
PROF. DR.	KOULA DOUKANI	UNIVERSITY OF IBN KHALDOUN TIARET, FACULTY OF NATURE AND LIFE SCIENCES	ALGERIA
PROF. DR.	KUNTAL DAS	KRUPANIDHI COLLEGE OF PHARMACY, DEPARTMENT OF PHARMACOGNOSY AND NATURAL PRODUCT CHEMISTRY, KRUPANIDHI COLLEGE OF PHARMACY, BANGALORE	INDIA
PROF. DR.	LEI SHI	KEY LABORATORY OF PLANT RESOURCES, INSTITUTE OF BOTANY, CHINESE ACADEMY OF SCIENCES, BEJING	CHINA
PROF. DR.	MARIA DAGLIA	UNIVERSITY OF THE NAPLES, DEPARTMENT OF PHARMACY, NUTRACEUTICAL LABORATORY	ITALY
PROF. DR.	MARINA SPÎNU	UNIVERSITY OF AGRICULTURAL SCIENCES AND VETERINARY MEDICINE, DEPARTMENT OF CLINICAL SCIENCES- INFECTIOUS DISEASES	ROMANIA
PROF. DR.	MARYNA KRYVTSOVA	UZHHOROD NATIONAL UNIVERSITY, DEPARTMENT OF GENETIC, PLANT PHYSIOLOGY AND MICROBIOLOGY	UKRAINE
PROF. DR.	MONICA HANCIANU	UNIVERSITATEA DE MEDICINA SI FARMACIE GRIGORE T. POPA IASI, PHARMACY FACULTY, DEPARTMENT OF PHARMACOGNOSY AND CHEMISTRY OF NATURAL PRODUCTS	ROMANIA
PROF. DR.	MURAT TUNÇTÜRK	YUZUNCU YIL UNIVERSITY, AGRICULTURAL FACULTY, FIELD CROPS DEPARTMENT, VAN	TÜRKİYE
PROF. DR.	NAZIM ŞEKEROĞLU	GAZIANTEP UNIVERSITY, FACULTY OF SCIENCE AND LITERATURE, DEPARTMENT OF BIOLOGY	TÜRKİYE
PROF. DR.	NOUREDDINE DJEBLI	ABDELHAMİD IBN BADİS UNİVERSİTY MOSTAGANEM	ALGERIA
PROF. DR.	PATRÍCIA RIJO	CBIOS – RESEARCH CENTER FOR BIOSCIENCES & HEALTH TECHNOLOGIES, UNIVERSIDADE LUSÓFONA DE HUMANIDADES E TECNOLOGIAS, CAMPO GRANDE, LISBOA	PORTUGAL
PROF. DR.	RAMAN DANG	KRUPANIDHI COLLEGE OF PHARMACY, BANGLORE, AL- AMEEN COLLEGE OF PHARMACY, DEPARTMENT OF PHARMACEUTICAL SCIENCES	INDIA
PROF. DR.	RANDOLPH ARROO	DE MONTFORT UNIVERSITY, SCHOOL OF PHARMACY, FACULTY OF HEALTH AND LIFE SCIENCES	UNITED KINGDOM

PROF. DR.	RICCARDO AMORATI	BOLOGNA UNIVERSITY, DEPARTMENT OF CHEMISTRY "G. CIAMICIAN", BOLOGNA	ITALY
PROF. DR.	ROJA RAHIMI	TEHRAN UNIVERSITY OF MEDICAL SCIENCES SCHOOL OF TRADITIONAL MEDICINE	IRAN
PROF. DR.	SEVGI GEZICI	GAZIANTEP UNIVERSITY, FACULTY OF MEDICINE, DEPARTMENT OF MEDICAL BIOLOGY AND GENETICS	TÜRKİYE
PROF. DR.	TAKASHI WATANABE	KUMAMOTO UNIVERSITY, GRADUATE SCHOOL OF PHARMACEUTICAL SCIENCES, DEPARTMENT OF MEDICINAL BOTANY	JAPAN
ASSOC. PROF. DR.	HAKAN ÇETİNKAYA	FACULTY OF AGRICULTURE, DEPARTMENT HORTICULTURE, KILIS 7 ARALIK UNIVERSITY	TÜRKİYE
ASSOC. PROF. DR.	HANEN NAJJAA	LABORATORY OF PASTORAL ECOSYSTEMS AND VALORIZATION OF SPONTANEOUS PLANTS AND MICROORGANISMS, INSTITUTE OF ARID REGIONS (IRA), MEDENINE	TUNISIA
ASSOC. PROF. DR.	HASENE KESKIN CAVDAR	GAZIANTEP UNIVERSITY, ENGINEERING FACULTY, FOOD ENGINEERING DEPARTMENT	TÜRKİYE
ASSOC. PROF. DR.	NADİRE PELİN BAHADIRLI	HATAY MUSTAFA KEMAL UNIVERSITY, AGRICULTURAL FACULTY, FIELD CROPS DEPARTMENT, HATAY	TÜRKİYE
ASSIST. PROF. DR.	ELMIRA ZIYA MOTALEBIPOUR	AGRONOMY AND PLANT BREEDING DEPT., MEDICINAL PLANTS RESEARCH CENTER, TRANSGENESIS CENTER OF EXCELLENCE, ISLAMIC AZAD UNIVERSITY, ISFAHAN	IRAN
DR.	AHMAD ALI	UNIVERSITY OF MUMBAI, DEPARTMENT OF LIFE SCIENCES	INDIA
DR.	LAMIA HAMROUNI	NATIONAL RESEARCH INSTITUTE FOR RURAL ENGINEERING, WATER AND FORESTRY (INRGREF), LABORATORY FOR FOREST ECOLOGY	TUNUSIA
DR.	NİLÜFER ORHAN	AMERICAN BOTANICAL COUNCIL, AUSTIN, TEXAS	USA
DR.	PRITI TAGDE	HEALTH CARE GLOBAL LEADER, PHARMA RATAN AWARDEE AND PEACE AMBASSADOR	INDIA
DR.	REHNI HOSSAIN	SCHOOL OF ALLIED HEALTH SCIENCES, WALAILAK UNIVERSITY	THAILAND

*Alphabetically ordered

INTERNATIONAL SCIENTIFIC COMMITTEE

PROF. DR.	AGNIESZKA SZOPA	DEPARTMENT OF MEDICINAL PLANT AND MUSHROOM BIOTECHNOLOGY, JAGIELLONIAN UNIVERSITY MEDICAL COLLEGE KRAKÓW	POLAND
PROF. DR.	ÁKOS MÁTHÉ	UNIVERSITY OF WEST HUNGARY, DEPARTMENT OF AGRICULTURAL AND FOOD SCIENCES	HUNGARY
PROF. DR.	ALEXIOS-LEANDROS SKALTSONIS	SCHOOL OF PHARMACY, NATIONAL AND KAPODISTRIAN UNIVERSITY OF ATHENS	GREECE
PROF. DR.	ALEKSANDAR Ž. KOSTIĆ	UNIVERSITY OF BELGRADE, FACULTY OF AGRICULTURE- INSTITUTE FOR FOOD TECHNOLOGY AND BIOCHEMISTRY	SERBIA
PROF. DR.	ALBAN IBRALIU	AGRICULTURAL UNIVERSITY OF TIRANA, DEPARTMENT OF CROP PRODUCTION	ALBENIA
PROF. DR.	AYLA KAYA	ANADOLU UNIVERSITY, DEPARTMENT OF PHARMACEUTICAL BOTANY, FACULTY OF PHARMACY	TÜRKİYE
PROF. DR.	AYŞE BETÜL AVCI	EGE UNIVERSITY, ÖDEMİŞ VOCATIONAL SCHOOL, MEDICINAL AND AROMATIC PLANTS	TÜRKİYE
PROF. DR.	BERAAT ÖZÇELİK	UNIVERSITY OF ISTANBUL TECHNICAL, FACULTY OF CHEMISTRY METALLURGY, DEPARTMENT OF FOOD ENGINEERING	TÜRKİYE
PROF. DR.	BILJIANA BAUER	UNIVERSITY OF SS CYRIL AND METHODIUS, FACULTY OF PHARMACY, UNIVERSITY OF SS CYRIL AND METHODIUS	MACEDONIA
PROF. DR.	CHARAFEDDINE JAMA	UNIVERSITÉ DE LILLE (ENSCL), NATIONAL GRADUATE SCHOOL OF ENGINEERING CHEMISTRY OF LILLE	FRANCE
PROF. DR.	DURMUŞ ALPASLAN KAYA	UNIVERSITY OF MUSTAFA KEMAL, DEPARTMENT OF MEDICINAL AND AROMATIC PLANTS	TÜRKİYE
PROF. DR.	ELACHOURI MOSTAFA	MOHAMMED FIRST UNIVERSITY, DEPARTMENT OF BIOLOGY, LABORATORY OF PHYSIOLOGY, GENETIC AND ETHNOHARMACOLOGY	MOROCCO
PROF. DR.	EMİNE BAYRAM	UNIVERSITY OF EGE, DEPARTMENT OF FIELD CROPS	TÜRKİYE
PROF. DR.	EMINE SEKURE NAZLI ARDA	DEPARTMENT OF MOLECULAR BIOLOGY AND GENETICS, FACULTY OF SCIENCES, ISTANBUL UNIVERSITY, ISTANBUL, TÜRKİYE	TÜRKİYE
PROF. DR.	ESRA EROĞLU ÖZKAN	UNIVERSITY ISTANBUL, PHARMACY FACULTY	TÜRKİYE
PROF. DR.	FATMA PINAR KAFA	UNIVERSITY ANADOLU, PHARMACY FACULTY	TÜRKİYE
PROF. DR.	FRANCESCO EPIFANO	DEPARTMENT OF PHARMACY, UNIVERSITY "GABRIELE D'ANNUNZIO" OF CHIETI-PESCARA VIA DEI VESTINI 31	ITALY
PROF. DR.	GOVIND P. RAO	ICAR-EMERITUS SCIENTIST (CROP PROTECTION) DIVISION OF PLANT PATHOLOGY, INDIAN AGRICULTURAL RESEARCH INSTITUTE	INDIA
PROF. DR.	GÜLSÜM YALDIZ	ABANT IZZET BAYSAL UNIVERSITY, FACULTY OF AGRICULTURE, DEPARTMENT OF FIELD CROPS	TÜRKİYE
PROF. DR.	HAFIDA BOUAMAMA	CADI AYYAD UNIVERSITY, UCA, FACULTY OF SCIENCES AND TECHNIQUES, LABORATORY OF SUSTAINABLE DEVELOPMENT AND HEALTH RESEARCH	MOROCCO
PROF. DR.	HARI PRASAD DEVKOTA	UNIVERSITY OF KUMAMOTO, DEPARTMENT OF MEDICINAL PLANT, SCHOOL OF PHARMACY	JAPAN
PROF. DR.	HYTHAM AHMED	UNIVERSITY OF MENOUFIA, FACULTY OF PHARMACY	EGYPT
PROF. DR.	IBRAHIM TUMEN	BANDIRMA 17 EYLÜL UNIVERSITY, FACULTY OF HEALTH SCIENCE, DEPARTMENT OF FOREST PRODUCTS CHEMISTRY	TÜRKİYE
PROF. DR.	ILKAY ERDOGAN ORHAN	UNIVERSITY OF LOKMAN HEKİM, FACULTY OF PHARMACY, DEPARTMENT OF PHARMACOGNOSY	TÜRKİYE
PROF. DR.	IRFAN ALI KHAN	ALIGARH MUSLIM UNIVERSITY, DEPARTMENT OF STATISTICS	INDIA
PROF. DR.	IVAN SALAMON	UNIVERSITY OF PRESOV, DEPARTMENT OF ECOLOGY	SLOVAKIA
PROF. DR.	IVİCA BLAŽEVİĆ	FACULTY OF CHEMISTRY AND TECHNOLOGY UNIVERSITY OF SPLIT	CROATIA
PROF. DR.	JIANBO XIAO	UNIVERSITY OF VIGO, FACULTY OF FOOD SCIENCES AND TECHNOLOGY	SPAIN

PROF. DR.	JITBANJONG TANGPONG	SCHOOL OF ALLIED HEALTH SCIENCES, WALAILAK UNIVERSITY	THAILAND
PROF. DR.	K. HÜSNÜ CAN BAŞER	EAR EAST UNIVERSITY, PHARMACY FACULTY, PHARMACOGNOSY DEPARTMENT, NICOSIA	TRNC
PROF. DR.	KOULA DOUKANI	UNIVERSITY OF IBN KHALDOUN TIARET, FACULTY OF NATURE AND LIFE SCIENCES	ALGERIA
PROF. DR.	KRYSTYNA SKALICKA-WOZNIAK	MEDICAL UNIVERSITY OF LUBLIN, DEPARTMENT OF PHARMACOGNOSY WITH MEDICINAL PLANT UNIT	POLAND
PROF. DR.	KUNTAL DAS	KRUPANIDHI COLLEGE OF PHARMACY, DEPARTMENT OF PHARMACOGNOSY AND NATURAL PRODUCT CHEMISTRY, KRUPANIDHI COLLEGE OF PHARMACY, BANGALORE	INDIA
PROF. DR.	LEI SHI	KEY LABORATORY OF PLANT RESOURCES, INSTITUTE OF BOTANY, CHINESE ACADEMY OF SCIENCES, BEJING	CHINA
PROF. DR.	MARINA SPÎNU	UNIVERSITY OF AGRICULTURAL SCIENCES AND VETERINARY MEDICINE, DEPARTMENT OF CLINICAL SCIENCES - INFECTIOUS DISEASES	ROMANIA
PROF. DR.	MARIO LICATA	UNIVERSITÀ DEGLI STUDI DI PALERMO, PALERMO, ITALY, RESEARCH CONSORTIUM FOR THE DEVELOPMENT OF INNOVATIVE AGRO-ENVIRONMENTAL SYSTEMS, DEPARTMENT OF AGRICULTURAL, FOOD AND FOREST SCIENCES	ITALY
PROF. DR.	MARYNA KRYVTSOVA	UZHHOROD NATIONAL UNIVERSITY, DEPARTMENT OF GENETIC, PLANT PHYSIOLOGY AND MICROBIOLOGY	UKRAINE
PROF. DR.	MOHAMMAD RAIS MUSTAFA	UNIVERSITY OF MALAYA, HEAD OF CENAR (CENTRE FOR NATURAL PRODUCTS RESEARCH AND DRUG DISCOVERY), DEPARTMENT OF PHARMACOLOGY, FACULTY OF MEDICINE	MALAYSIA
PROF. DR.	MOHAMMAD SANAD ABU- DARWISH	AL-BALQA APPLIED UNIVERSITY & AQABA UNIVERSITY OF TECHNOLOGY, DEPARTMENT OF PHARMACEUTICAL SCIENCES	JORDAN
PROF. DR.	MONICA HANCIANU	UNIVERSITATEA DE MEDICINA SI FARMACIE GRIGORE T. POPA IASI, PHARMACY PHACULTY, DEPARTMENT OF PHARMACOGNOSY AND CHEMISTRY OF NATURAL PRODUCTS	ROMANIA
PROF. DR.	MUHSİN KONUK	UNIVERSITY OF USKUDAR, FACULTY OF SCIENCE AND LITERATURE, DEPARTMENT MOLECULAR BIOLOGY AND GENETICS	TÜRKİYE
PROF. DR.	MURAT TUNÇTÜRK	UNIVERSITY OF VAN YUZUNCU YIL, FACULTY OF AGRICULTURE, DEPARTMENT OF FIELD CROPS	TÜRKİYE
PROF. DR.	NOUREDDINE DJEBLI	UNIVERSITY OF MOSTAGANEM,DEPARTMENT OF BIOLOGY FSNV	ALGERIA
PROF. DR.	PATRÍCIA RIJO	CBIOS – RESEARCH CENTER FOR BIOSCIENCES & HEALTH TECHNOLOGIES, UNIVERSIDADE LUSÓFONA DE HUMANIDADES E TECNOLOGIAS, CAMPO GRANDE, LISBOA	PORTUGAL
PROF. DR.	RACHID BELHATTAB	UNIVERSITY OF FERHAT ABBAS SETIF, DEPARTMENT OF BIOCHEMISTRY, FACULTY OF NATURE AND LIFE SCIENCES	ALGERIA
PROF. DR.	SALAH AKKAL	UNITÉ DE VALORISATION DES RESSOURCES NATURELLES, MOLÉCULES BIOACTIVES ET ANALYSES PHYSICO-CHIMIQUES ET BIOLOGIQUES UNIVERSITY OF CONSTANTINE 1 FACULTÉS DES SCIENCES EXACTES DÉPARTEMENT DE CHIMIE	ALGERIA
PROF. DR.	SALVATORE LA BELLA	UNIVERSITÀ DEGLI STUDI DI PALERMO, DEPARTMENT OF AGRICULTURAL, FOOD AND FOREST SCIENCES, UNIVERSITÀ DEGLI STUDI DI PALERMO, PALERMO	ITALY
PROF. DR.	SEVGI GEZICI	UNIVERSITY OF GAZIANTEP, FACULTY OF MEDICINE, DEPARTMENT OF MEDICAL BIOLOGY AND GENETICS	TÜRKİYE
PROF. DR.	TAKASHI WATANABE	UNIVERSITY OF KUMAMOTO, GRADUATE SCHOOL OF PHARMACEUTICAL SCIENCES, DEPARTMENT OF MEDICINAL BOTANY	JAPAN
PROF. DR.	TULAY ILTER BAKIREL	UNIVERSITY OF ISTANBUL, DEPARTMENT OF PHARMACOLOGY AND TOXICOLOGY	TÜRKİYE
PROF. DR.	YAVUZ BAĞCI	UNIVERSITY OF SELÇUK, DEPARTMENT OF BIOLOGY	TÜRKİYE

PROF. DR.	ZORA DAJIC STEVANOVIC	UNIVERSITY OF BELGRADE, DEPARTMENT OF FACULTY OF AGRICULTURE	SERBIA
PROF. DR.	AKBAR PIRESTANI	ANIMAL SCIENCE DEPT., MEDICINAL PLANTS RESEARCH CENTER, TRANSGENESIS CENTER OF EXCELLENCE, ISLAMIC AZAD UNIVERSITY, ISFAHAN	IRAN
ASSOC. PROF. DR.	ALEXANDAR Ž. KOSTIĆ	FACULTY OF AGRICULTURE, UNIVERSITY OF BELGRADE, INSTITUTE FOR FOOD TECHNOLOGY AND BIOCHEMISTRY	SERBIA
ASSOC. PROF. DR.	DEJAN PLJEVLJAKUŠIĆ	INSTITUTE FOR MEDICINAL PLANTS RESEARCH "DR. JOSIF PANČIĆ", TADEUŠA KOŠĆUŠKA 1, 11000, BELGRADE	SERBIA
ASSOC. PROF. DR.	ELA NUR ŞİMŞEK SEZER	SELCUK UNIVERSITY, FACULTY OF SCIENCE, DEPARTMENT OF BIOLOGY	TÜRKİYE
ASSOC. PROF. DR.	HAKAN ÇETİNKAYA	FACULTY OF AGRICULTURE, DEPARTMENT HORTICULTURE, KILIS 7 ARALIK UNIVERSITY	TÜRKİYE
ASSOC. PROF. DR.	HANEN NAJJAA	LABORATORY OF PASTORAL ECOSYSTEMS AND VALORIZATION OF SPONTANEOUS PLANTS AND MICROORGANISMS, INSTITUTE OF ARID REGIONS (IRA), 4119, MEDENINE	TUNISIA
ASSOC. PROF. DR.	HASENE KESKIN CAVDAR	GAZIANTEP UNIVERSITY, ENGINEERING FACULTY, FOOD ENGINEERING DEPARTMENT	TÜRKİYE
ASSOC. PROF. DR.	KAI WANG	CHINESE ACADEMY OF AGRICULTURAL SCIENCES, INSTITUTE OF APICULTURAL RESEARCH	CHINA
ASSOC. PROF. DR.	MERYEM BOZKURT	SELCUK UNIVERSITY, FACULTY OF SCIENCE, DEPARTMENT OF BIOLOGY	TÜRKİYE
ASSOC. PROF. DR.	MUHAMMET ALI GUNDESLI	GAZIANTEP UNIVERSITY, NURDAGI VOCATIONAL SCHOOL, PLANT AND ANIMAL DEPARTMENT	TÜRKİYE
ASSOC. PROF. DR.	SURIYAN SUKATI	SCHOOL OF ALLIED HEALTH, WALAILAK UNIVERSITY	THAILAND
ASSIST. PROF. DR.	AYŞE ESRA KARADAĞ	MEDIPOL UNIVERSITY, FACULTY OF PHARMACY, DEPARTMENT OF PHARMACOGNOSY	TÜRKİYE
ASSIST. PROF. DR.	CEYLAN AKA DÖNMEZ	SELCUK UNIVERSITY, PHARMACY FACYLTY, PHARMACOGNOSY DEPARTMENT	TÜRKİYE
ASSIST. PROF. DR.	HATİCE BANU KESKİNKAYA	NECMETTİN ERBAKAN UNIVERSİTY, DEPARTMENT OF BIOTECHNOLOGY	TÜRKİYE
ASSIST. PROF. DR.	HASNA BOUHENNI	UNIVERSITY OF IBN KHALDOUN TIARET, DEPARTMENT OF NATURE AND LIFE SCIENCES, LABORATORY OF BIOTECHNOLOGY AND AGROFOOD PROCESSES	ALGERIA
ASSIST. PROF. DR.	PORNANAN KUEAKHAI	FACULTY OF ALLIED HEALTH SCIENCES, BURAPHA UNIVERSITY	THAILAND
DR.	DAVIDE FARRUGGIA	DEPARTMENT OF AGRICULTURAL, FOOD AND FORESTRY SCIENCES, UNIVERSITÀ DEGLI STUDI DI PALERMO	ITALY
DR.	LAMIA HAMROUNI	NATIONAL RESEARCH INSTITUTE FOR RURAL ENGINEERING, WATER AND FORESTRY (INRGREF), LABORATORY FOR FOREST ECOLOGY	TUNISIA
DR.	NİLÜFER ORHAN	AMERICAN BOTANICAL COUNCIL, AUSTIN, TEXAS	USA
DR.	REHNI HOSSAIN	SCHOOL OF ALLIED HEALTH SCIENCES, WALAILAK UNIVERSITY	THAILAND

*Alphabetically ordered

Dear Colleagues,

The International Conference on Herbs and Spices (ICHS-2026) was succeeded on April 21–23, 2026 in Rimini, Italy, represents a major interdisciplinary platform uniting researchers, industry stakeholders, and policymakers in the field of herbs and spices. Organized in conjunction with the MACFRUT Herbs & Spices Global Expo, the conference emphasized the scientific innovation, sustainable production, and global trade integration in herbs and spices.

The conference attracted participants around sixteen different countries around the world. Invited speakers and registered participants were from already from USA, Morocco, India, Portugal, Spain, Romania, Tunisia, Serbia, Albania, Italy, Türkiye, Greece, Algeria, Libya, Switzerland and South Africa. The conference program covered a wide range of topics including agricultural practices, phytochemistry, essential oils, biotechnology, ethnobotany, functional foods, and regulatory frameworks. This breadth reflects the growing importance of herbs and spices in addressing global challenges such as sustainable agriculture, health innovation, and biodiversity conservation. A key strength of ICHS-2026 lies in its hybrid format (face-to-face and online participation), enabling broader geographic inclusion and facilitating knowledge exchange across regions. The integration with an international trade expo like MACFRUT - Herbs and Spices EXPO further enhanced opportunities for academia–industry collaboration, technology transfer, and market development. In these meetings worldwide known scientists and researchers found in the international organizing and scientific committees and distinguished research results were presented as keynote, invited, plenary, oral and poster presentations. All the series presentations and full papers are being published here in the PROCEEDINGS BOOK with ISBN. In conclusion, ICHS-2026 is anticipated to serve as a critical global forum for advancing research, fostering international collaboration, and promoting innovation in herbs and spices. The expected scale and diversity of participation highlight its growing significance within the global herbs and spices community.

We are delighted to announce that the second edition of the ICHS will be scheduled to take place **in April 2027** under MACFRUT - Herbs and Spices EXPO **in Rimini**. It would be our honor to welcome you once again to the ICHS-2027 Conference.

Sincerely,

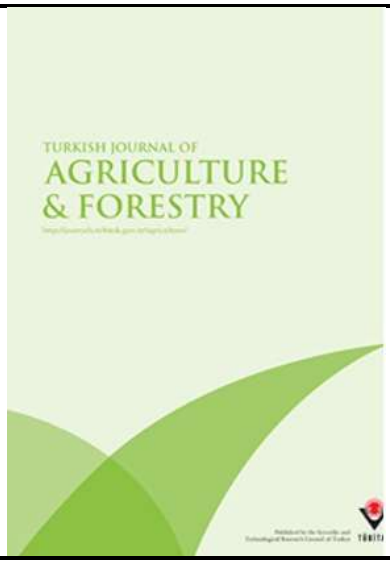
Conference Chair
Prof. Dr. Nazım ŞEKEROĞLU
President of AMAPMED, General Coordinator of GOFMAP
www.nazimsekeroglu.info; www. https://www.herbsandspices.org/

ICHS-2026
SUPPORTERS & SPONSORS

The organizing committee would like to sincerely thanks the supporters and sponsors for their valuable support and contributions to the ICHS - 2026. This symposium has been organized by academicians and researchers from distinguished world universities, research institutions, non-governmental organizations, and agencies. Main organizers, supporters and sponsors are;

- General Directorate of Forestry, Republic of Türkiye
- KUAD – Cosmetic Producers and Researchers Associations
- APTI – Association of Pharmaceutical Teachers of India
- AMAPMED – Association of Medicinal and Aromatic Plants of Mediterranean
- AMAPSEEC – Association for Medicinal and Aromatic Plants of Southeast European Countries
- SILAE – Società Italo-Latinoamericana di Etnomedicina
- CTFC – Centre Forestal Centre Tecnològic Forestal de Catalunya
- INRGREF – National Research Institute of Rural Engineering, Water and Forests
- FIARNS09 – Free International Association of Researchers on Natural Substances 2009
- ESCORENA – The European System of Cooperative Research Networks in Agriculture
- Societa Botanica Italiano
- Iranian Medicinal Plants Society
- NS Herbal Company
- Altın HUZME Olive Oil
- Research Institute for Medicinal Plants and Herbs, Ltd. Hungary

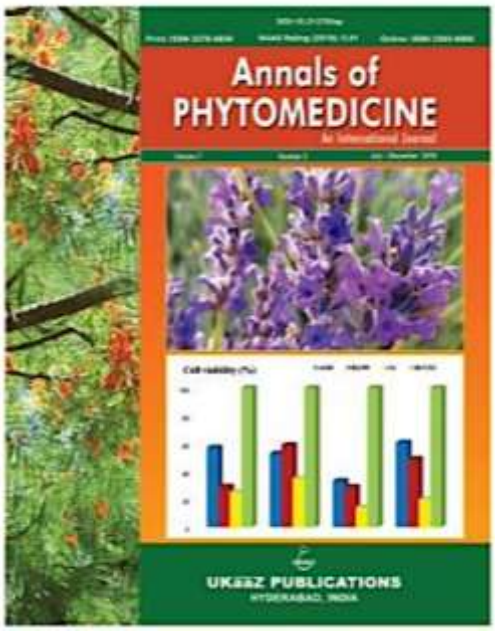
"Contracted Journals"



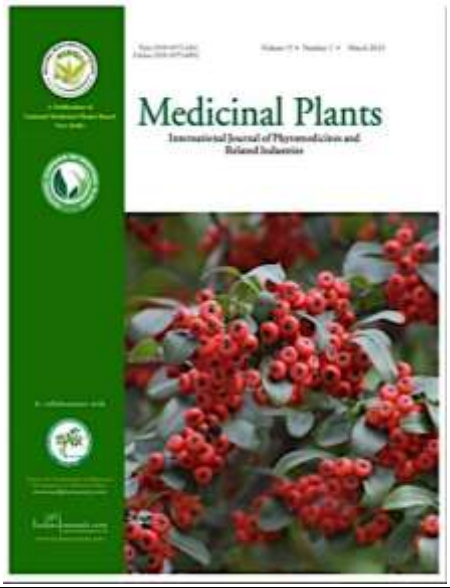
The Turkish Journal of Agriculture and Forestry (Q1)
(Free)

Acta Veterinaria Eurasia
(Free)

Journal of Applied Research on Medicinal and Aromatic Plants
(Free)



Annals of Phytomedicine
(Chargeable)



Medicinal Plants International Journal of Phytomedicines and Related Industries
(Free)

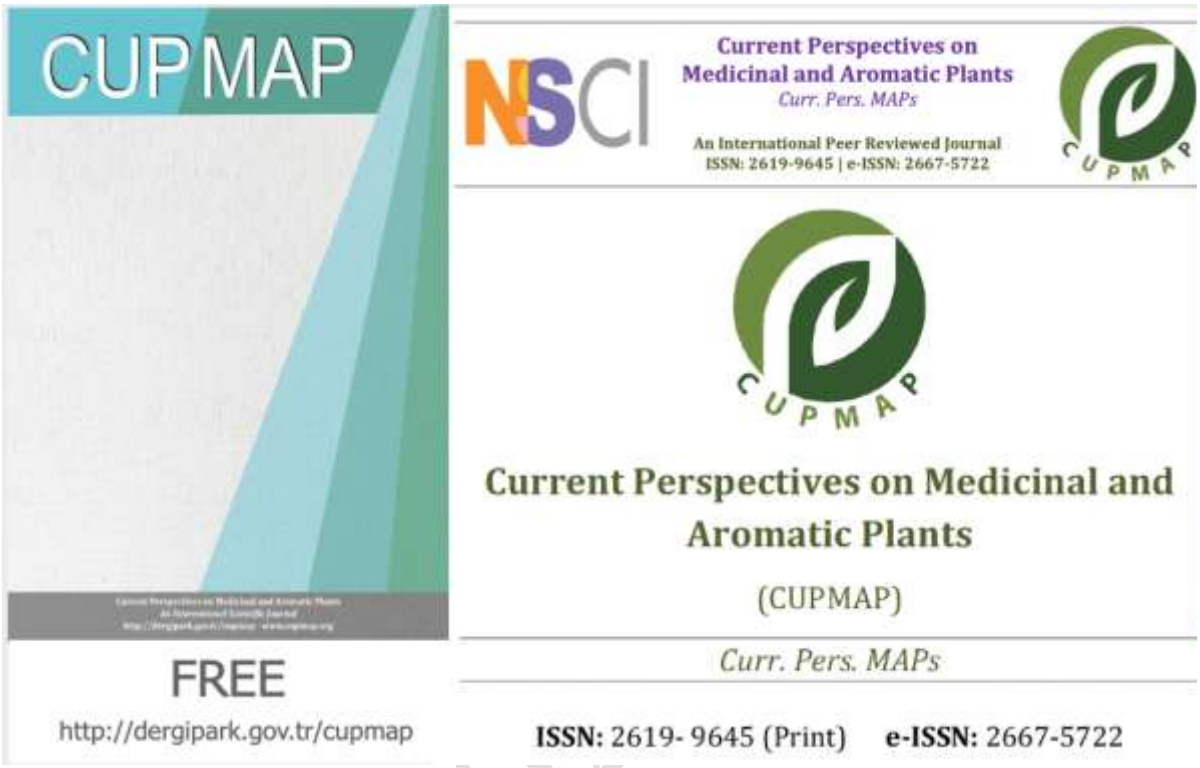
International Journal of Agriculture, Environment and Food Sciences
(Free)

Igdır University, Journal of the Institute of Science and Technology
(Free)

Arabian Journal of Medicinal and Aromatic Plants
(Free)

Current Perspectives on Medicinal and Aromatic Plants (CUPMAP)

https://dergipark.org.tr/en/pub/cupmap



CUPMAP is an open access, peer-reviewed and refereed international journal published by MESMAP scientific group. The main objective of the CUPMAP is to provide an intellectual outlook on the scientific researches on Medicinal and Aromatic Plants. CUPMAP have distinguished goals to promote interdisciplinary scientific studies in which results could easily be used in industrial production on MAPs. This international scientific journal publishes research papers related to Medicinal and Aromatic Plants in the fields of science and technology such as Biology, Molecular Biology and Genetics, Chemistry, Agriculture, Biochemistry, Botany, Ethnobotany, Environmental Science, Forestry, Horticulture, Health Care & Public Health, Nutrition and Food Science, Pharmaceutical Sciences, and so on. CUPMAP publishes original research papers, applied studies, and review articles in MAPs science and technology. Special Issues devoted to important topics in the MAPs science and technology could also be published. ***CUPMAP Journal follows a continuous publication model and is published exclusively online.*** The publication language of the journal is English. Journal of CUPMAP welcomes article submissions and does not charge any article submission or processing charges. CUPMAP is inviting your valuable scientific papers and reviews.

ICHS-2026 Konferansında **toplam 47 bildiri** sunulmuş olup, bunların 37 tanesi sözlü, 10 tanesi ise poster sunum şeklindedir. Sunulan **sözlü bildirilerin %67,57'lik kısmı yabancı katılımcılar** tarafından sunulmuştur. Konferansa yaklaşık **16 farklı ülkeden** bilim insanı katılım sağlamıştır. **Konferansa katılım sağlayan ülkeler şunlardır:** USA, Morocco, India, Portugal, Spain, Romania, Tunisia, Serbia, Albania, Italy, Türkiye, Greece, Algeria, Libya, Switzerland and South Africa. **Konferansa katılım sağlayan katılımcılar ve sunum başlıkları 'ICHS-2026 Abstracts & Proceedings Book' kitabının içindekiler kısmında ayrıntılı olarak sunulmuştur. ICHS-2026 Konferansında, aşağıda yer alan YÖK Akademik Teşvik ve Yükselme kriterlerini sağlamaktadır.**

İlgili YÖK akademik teşvik yönetmeliği; 17/1/2020 tarihli ve 31011 sayılı Resmî Gazete'de yayımlanan 16/1/2020 tarihli ve 2043 sayılı Cumhurbaşkanı Kararı uyarınca:

(9) (Değişik: RG-17/1/2020-31011-CK-2043/3 md.) 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. Ayrıca etkinliğin uluslararası niteliği haiz olup olmadığı hususunda, ödemeye esas teşkil etmek üzere üniversite yönetim kurulu kararının olması gerekir. Tebliğlerin değerlendirilmesinde tebliğin ilgili etkinlikte sunulmuş ve bunun belgelendirilmiş olması (etkinlik programı ve etkinliğe tebliğde ismi yer alan en az bir araştırmacının katılım sağladığını gösterir belge) esastır. Ayrıca değerlendirme için tebliğin elektronik veya basılı olarak etkinlik tebliğ kitapçığında yer alması ve yayımlanmış tam metninin sunulması gerekir.

Contents

CONTENTS

Keynote & Invited Speakers

KEYNOTE SPEAKER

VSEPR ENGINEERED HERBACEOUS ORGANICS AS ANTIDOTES TO NEUROTOXICANT ANTHROPOGENICS

Mahesh Narayan

Department of Chemistry and Biochemistry, The University of Texas at el Paso, El Paso, TX USA 79968
correspondence: mnarayan@utep.edu

Environmental agents such as pesticides, weedicides and herbicides (collectively referred to as pesticides) are associated with the onset and pathogenesis of neurodegenerative disorders such as Parkinson's (PD) and Alzheimer's (AD) diseases. The development of blood-brain barrier (BBB)-penetrating therapeutic candidates to both prevent and treat the aforementioned xenotoxicant-induced neurodegenerative disorders remains an unmet need. Here, we examine whether VSEPR-engineered coffee derivatives can intervene in antropogen-associated onset and progress of the PD phenotype. Our findings suggest that the VSEPR-engineering of BBB-penetrating food derivatives hold promise for mitigating neurodegenerative disorders associated with environmental neurotoxicants. Importantly, the proposed represents a sustainable, green chemistry platform for generating interventional candidates in neurodegeneration.

Key Words: Neurodegenerative disorders, VSEPR-engineering, coffee, by-product, neurotoxicants

KEYNOTE SPEAKER

WILD COLLECTION OF MEDICINAL PLANS IN SOUTHEAST EUROPE:NEEDS AND CHALLENGES TO PRESERVE BIODIVERSITY

Zora Dajić Stevanović

University of Belgrade – Faculty of Agriculture, 11080 Belgrade, Serbi
Correspondance: dajic@agrif.bg.ac.rs

High plant and habitat diversity in Southeast Europe (SEE), as well as the expressed rate of endemism reaching near 30% of the total flora, make the region specific and very valuable in regard of qualitative and quantitative traits of medicinal and aromatic plant (MAP) resources. Sustainability of SEE herbal sector, particularly the wild collection, depends on both size and structure of natural MAP populations, and MAP value-chain, namely the position of its most vulnerable element, the MAP collectors. Despite the rich and mostly under-utilized MAP resources, the region faces with intensive depopulation of rural areas resulting in serious loss of MAP collectors, whose number dropped to about one third comparing to peak in nineties of the last century. The former period of free access to MAP resources lacking in restriction mechanisms and standards for sustainable wild collection, as well as the current population reduction of number of MAP species due to the depopulation and diminishing of traditional agricultural practices, resulted in significant weakening of sector's economic power. In addition to socio-economic impacts, the actual status of MAP resources in SEE is highly affected by habitat loss (especially in the Mediterranean), habitat fragmentation and alteration, over-harvesting (in limited areas, usually in rural hilly/mountain and other semi-rural regions, with old practices and tradition in use and collection of MAPs), improper collecting practices, pollution, and climate change. In order to preserve the MAP biodiversity and develop the SEE herbal sector, there is a need for sustainable and complex strategy, able to ensure implementation of standards, certification and quality control. Moreover, it is important to establish a regular MAP monitoring system using advanced tools, such as remote sensing, IoT, and AI-driven prediction modelling. Post-harvest standards and modern processing technologies ensure best product quality and product diversification, forcing entrepreneurship, smart specialization and start-up business for young.

Key Words: herbal sector, sustainability, wild harvesting standards

KEYNOTE SPEAKER

NATURAL COMPOUNDS: EXTRACTION APPROACHES AND PATHWAYS TO VALUABLE APPLICATIONS

Sónia A.O. Santos

Department of Chemistry, CICECO-Aveiro Institute of Materials, University of Aveiro
3810-193, Aveiro, Portugal
Correspondance: santos.sonia@ua.pt

Among the variety of promising high-value compounds that can be obtained from natural resources, lipophilic compounds such as sterols, terpenes and fatty acids, as well as phenolic compounds, have attracted considerable attention due to their health-promoting properties, including anti-inflammatory, antibacterial and antiproliferative activities.[1,2] These features make them highly promising for nutraceutical, cosmetic and pharmaceutical applications. However, a major challenge remains: the development of environmentally friendly and efficient extraction methodologies. Different methodologies have been explored to recover these bioactive compounds from natural resources, namely supercritical fluid extraction (SFE),[3] high-pressure assisted extraction (HPE),[4] microwave-assisted extraction (MAE), and more recently, extraction with alternative solvents such as switchable, bio-based and eutectic solvents.[5] Some of these solvents are particularly interesting, as they can be used not only as extraction media but also as formulation systems, enhancing the biological activity of the extracted compounds.
In this work, different natural resources have been explored as sources of bioactive compounds, including leaves of *Eucalyptus globulus*, marine algae, grape pomace, among others. Case studies using the aforementioned methodologies will be presented, involving both lipophilic and phenolic compounds obtained from these matrices. The rationale behind the selection of different extraction techniques, the selectivity of each method, the use of predictive models for the selection of alternative solvents, and strategies to improve bioactivities will be discussed.
Overall, this work aims to highlight effective strategies that can pave the way for the sustainable exploitation of natural compounds in high-value applications.

Key Words: Phytochemicals, Sterols, Terpenic compounds, Phenolic compounds, green solvents

Acknowledgements: This work was developed within the scope of the project CICECO-Aveiro Institute of Materials, UID/50011/2025 (DOI 10.54499/UID/50011/2025) & LA/P/0006/2020 (DOI 10.54499/LA/P/0006/2020) & UID/PRR/50011/2025 (DOI 10.54499/UID/PRR/50011/2025); financed by national funds through the FCT/MCTES (PIDDAC).co-financing, by FEDER under the PT2020 Partnership Agreement, within the project (ALGREEN, 2022.04670.PTDC), financially supported by national funds (OE), through FCT/MCTES.

References

[1] Pais, A. C. S., Saraiva, J. A., Rocha, S. M., Silvestre, A. J. D., & Santos, S. A. O., 2019. Current Research on the Bioprospection of Linear Diterpenes from *Bifurcaria bifurcata*: From Extraction Methodologies to Possible Applications. *Marine Drugs*, ***17***(10), 556. https://doi.org/10.3390/md17100556
[2] Santos, S. A. O., Félix, R., Pais, A. C. S., Rocha, S. M., & Silvestre, A. J. D., 2019. The Quest for Phenolic Compounds from Macroalgae: A Review of Extraction and Identification Methodologies. *Biomolecules*, *9*(12), 847. https://doi.org/10.3390/biom9120847

KEYNOTE SPEAKER

SUSTAINABLE COLLECTION OF NWFPS AND CHALLENGES OF INNOVATION IMPLEMENTATION IN ALBANIA

Alban Ibraliu

Department of Crop Production, Agricultural University of Tirana, Tirana, ALBANIA
Correspondance: albanibraliu@ubt.edu.al

This presentation explores the sustainable collection of non-wood forest products (NWFPs), particularly medicinal and aromatic plants (MAPs), and the challenges of implementing innovation in Albania. Albania is recognized for its exceptionally rich flora, with more than 3,600 plant species, including many endemic and medicinal species. The MAP sector represents one of the country's most important export industries, generating between 50 and 60 million USD annually and supporting over 20,000 families. The presentation highlights the importance of maintaining quality throughout the value chain, from accurate species identification and proper harvest timing to post-harvest processing, drying, storage, and quality control. Particular attention is given to the risks associated with wild collection, such as species misidentification, contamination, aflatoxins, pesticide residues, heavy metals, and pyrrolizidine alkaloids. A central focus is placed on innovative drying technologies powered by solar energy, including tunnel dryers and flat-bed greenhouse dryers. These technologies are presented as practical solutions for reducing post-harvest losses, improving product quality, lowering microbial contamination, and increasing sustainability in rural areas. However, the implementation of such innovations in Albania still faces several challenges, including limited infrastructure, fragmented supply chains, insufficient technical knowledge, and the need for stronger quality standards and monitoring systems. Overall, the presentation emphasizes that sustainable management of NWFPs and the adoption of innovative technologies are essential for preserving Albania's biodiversity, strengthening export competitiveness, and supporting rural livelihoods.

Key Words: Non-wood forest products (NWFPs), Albania, quality control , innovation, implementation

INVITED SPEAKER

BIOPHYTOSTIMULANTS FROM THE SEA

Alfonso Trezza[1,3], Lisa Ammannati[1,3], Michela Geminiani[1,2], Annalisa Santuicci[1,2,3]

[1] Department of Biotechnology, Chemistry, and Pharmacy, University of Siena, 53100, Siena, Italy
[2]SienabioACTIVE, Via A. Moro 2, 53100 Siena, Italy
[3]ARTES 4.0, Viale Rinaldo Piaggio 34, 56025 Pontedera, Italy
Correspondance: alfonso.trezza2@unisi.it

The accumulation of macroalgal biomass, notably *Chaetomorpha linum*, and seagrass residues, such as *Posidonia oceanica*, poses significant ecological and logistical challenges for coastal management. Within the framework of a circular bioeconomy, these materials serve as strategic, underexploited feedstocks for the recovery of high-value bioactive compounds. The valorization of such marine residues into functional bio-based products represents a viable pathway for innovation, with significant potential for their application as natural biostimulants. Owing to their complex biochemical profiles, formulations derived from these species offer a sustainable means to enhance seed germination, seedling vigor, and overall plant resilience. Beyond biostimulation, these biomasses constitute a critical resource for nutrient cycling and the development of low-impact agricultural inputs. Shifting the management paradigm from waste disposal to resource recovery facilitates the mitigation of environmental pressures on coastal ecosystems while providing the agricultural sector with eco-friendly alternatives to synthetic chemicals. Ultimately, the integration of C. linum and P. oceanica into the production value chain promotes a resilient, closed-loop system, illustrating the vital role of marine-derived resources in fostering sustainable development and innovation within the global bioeconomy.

Key Words: Circular bioeconomy; marine biomass valorization; *Chaetomorpha linum*; *Posidonia oceanica*; natural biostimulants; sustainable agriculture

Acknowledgements: Bando2022PNRRProt. P2022RYR5W; F-Cur funds to M.G.; UE—FSE REACT-EU, PONRicerca e Innovazione 2014–2020; Progetto ERICA ARTES 4.0, E87G23000100001 - Agenzia Coesione Territoriale; Progetto “Bioeconomia circolare di Posidonia oceanica spiaggiata” Prot. - NS0000021; and Progetto OMNIALGAE—Ministero dell’Ambiente e della Tutela del Territorio e del Mare (MATTM).

References

[1] Trezza, A.; Frusciante, L.; Barua, P.; Lamponi, S.; Geminiani, M.; Santucci, A. From Lagoons to Biostimulants: Chaetomorpha linum Extracts Enhance Germination Dynamics and Early Seedling Development. Appl. Sci. 2026, 16, 2931. https://doi.org/10.3390/app16062931

INVITED SPEAKER

NATURAL PRESERVATIVES FROM MEDICINAL AND AROMATIC PLANTS: SUSTAINABILITY AND APPLICATIONS

Naïma Zehhar[1], Meriem Rafya[1,2], Lamia Laadani[1,2], Hafida Bouamama[2]
Aouatif Aboudia[1], Fatiha Benkhalti[2]

[1]Cadi Ayyad University, UCA, Faculty Of Sciences and Techniques, Center for Agrobiotechnology and Bioengineering, CNRST Labeled Research Unit., Bd Abdelkrim Khattabi, BP 549, 40000 Marrakesh, Morocco
[2]Cadi Ayyad University, UCA, Faculty Of Sciences and Techniques, Sustainable Development and Health Research Laboratory, Bd Abdelkrim Khattabi, BP 549, 40000 Marrakesh, Morocco
Correspondance: n.zehhar@uca.ac.ma

The increasing demand for natural, safe, and sustainable alternatives to synthetic preservatives has led to growing interest in medicinal and aromatic plants (MAPs) as effective biopreservatives. MAPs such as rosemary (*Salvia rosmarinus*), thyme (*Thymus vulgaris*), oregano (*Origanum vulgare*), and sage (*Salvia officinalis*) are rich in bioactive compounds, including phenolic acids, flavonoids, terpenes, and essential oils, known for their antioxidant, antimicrobial, and anti-inflammatory activities. These properties make MAPs highly suitable for extending the shelf life and improving the safety of food, cosmetic, and pharmaceutical products. The extraction of essential oils from these plants generates by-products, including residual water and solid residues, which are often undervalued or discarded but contain valuable molecules such as rosmarinic acid, carnosic acid, carnosol, thymol, and carvacrol. These compounds have demonstrated promising preservative effects and represent an underexploited resource for natural biopreservation. Valorizing these residues not only supports a circular and sustainable approach but also adds economic value to plant processing industries, reducing waste and enabling the efficient use of natural resources. This presentation will explore the analysis of the chemical composition, bioactive potential, and practical applications of MAPs and their by-products in natural preservation. It will also highlight innovative extraction techniques, including hydrodistillation, supercritical CO_2 extraction, and other green technologies, as well as formulation strategies such as encapsulation and nanoemulsions to enhance stability and efficacy. By integrating these approaches, MAP-based biopreservatives can serve as effective, eco-friendly alternatives to synthetic preservatives, offering sustainable solutions for industry and contributing to the valorization of plant resources.

Key Words: Aromatic and medicinal plant, sustainability, natural preservatives, essential oils, by-products valorization

INVITED SPEAKER

FROM ECOSYSTEMS TO PHARMACY: AGRONOMIC EVOLUTION OF "WILD" BIODIVERSITY

Stefano Benvenuti

Department of Agricultural and Food Sciences, Bologna University, Italy
Correspondence: stefano.benvenuti8@unibo.it

The various modes of propagation of the wide biodiversity of medicinal plant species were illustrated. The first step in sourcing wild germplasm for domestication is understanding the different ecosystems and the timing of seed maturation. Many plant species that are now domesticated and available for medicinal purposes occur both as "wild" species in natural ecosystems and as "weeds" in various agroecosystems. The first agronomic challenge in domestication arises from the frequent occurrence of seed dormancy. Annual species are necessarily propagated by seed, although perennial species may also be propagated sexually. In this context, the mechanisms for breaking seed dormancy—an adaptive trait that has evolved in many species as a survival strategy in natural ecosystems—were examined. Species belonging to the botanical families Malvaceae and Fabaceae frequently exhibit physical dormancy that can be overcome through seed scarification and/or exposure to thermal shocks. Endozoochorous species (particularly those dispersed by birds, such as *Atropa belladonna*) germinate following exposure of seeds to oxidizing agents that mimic conditions in the digestive tract of frugivorous birds. Other species, especially within the Apiaceae, show increased germination rates after seed washing, which removes germination inhibitors. In this context, understanding the dispersal mechanisms of different species plays a crucial role, as it may inform effective strategies for overcoming seed dormancy. Finally, species belonging to the Ranunculaceae are among the most difficult to germinate, as they require prolonged periods of cold stratification to allow proper embryo development. The evolution of a seed production activity focused on newly domesticated species requires an understanding of gene flow mechanisms, especially in cases of frequent entomophily. In the latter case, it is essential to identify the types of pollinators (honeybees, solitary bees, bumblebees, hoverflies, lepidopterans, etc.), as their presence plays a crucial role in the successful transfer of pollen to the flower stigmas. The very small seeds of some species can also be pelleted to enable sowing with pneumatic seeders. The progeny of germinated plants is then selected based on morphological, phenological (e.g., earliness), and/or phytochemical traits (i.e., the quantity and quality of bioactive compounds with marked medicinal activity). Some perennial species are sterile (such as certain members of the genera *Lavandula*, *Mentha*, and *Thymus*) and are therefore propagated vegetatively by cuttings, rhizomes and/orclump division. This approach allows the production of clones identical to the mother plants, making them particularly suitable for specific pharmaceutical purposes. Finally, other species can be micropropagated to enhance the multiplication potential of selected genotypes.

Key Words: Medicinal and aromatic crops, plant propagation, seed dormancy, domestication, wild flora

INVITED SPEAKER

MEDICINAL AND EDIBLE PLANTS OF THE MENA REGION: NEW INSIGHTS INTO HEALTH-PROMOTING AND NUTRITIONAL PROPERTIES

Hanen Najjaa, Gatran Rim, Abdelkrim ben Arfa

Laboratory of Pastoral Ecosystems and Valorization of Spontaneous Plants and Microorganisms
Institute of Arid Regions, Medenine, Tunisia
Correspondance: hanen.najjaa@yahoo.fr

Medicinal and edible plants from the Middle East and North Africa (MENA) region represent an important and highly diverse source of plant genetic resources, well known for their nutritional value and health-promoting properties. Growing under arid and semi-arid climatic conditions, these species have developed specific adaptive traits and a strong ability to produce a wide variety of bioactive secondary metabolites. A large number of studies report that MENA flora is particularly rich in phenolic compounds, flavonoids, terpenoids, and other phytochemicals that are linked to antioxidant, anti-inflammatory, antimicrobial, and nutraceutical effects. In addition, ethnobotanical knowledge shows that these plants have long been integrated into traditional food practices and medicinal uses across different communities in the region. Overall, these plants offer strong potential for applications in the pharmaceutical, food, and cosmetic sectors. Their ability to tolerate harsh environmental conditions also makes them interesting genetic resources for improving resilience to climate change and supporting sustainable development in vulnerable ecosystems.

Key Words: MENA region; medicinal and edible plants; phytochemicals; secondary metabolites; ethnobotany; nutraceuticals;

INVITED SPEAKER

FOREST SCIENCE AND TECHNOLOGY CENTRE OF CATALONIA (CTFC): 25 YEARS OF RESEARCH ON THE SUSTAINABLE WILD COLLECTION OF MAPs

Eva Moré I Palos

Forest Sciences and Technology Centre of Catalonia (CTFC), Specialist of the Group of Medicinal and Aromatic Plants /Bioeconomy and Governance Program, Solsona, Spain
Correspondance: eva.more@ctfc.cat, eva.more@ctfc.es

The Forest Science and Technology Centre of Catalonia (CTFC) (https://ctfc.cat/en/) is a reference institution on Forestry topics in the Mediterranean and international context. Based in Solsona (Catalonia, Spain), near the Pyrenees, it conducts applied scientific research on forest management, landscape resilience, biodiversity conservation, rural development and the circular bioeconomy. Within the Bioeconomy, Health, and Governance Program, the Medicinal and Aromatic Plants (MAPs) Research Group (https://apsb.ctfc.cat/?lang=en) has been working since 1997 on both the cultivation and sustainable wild collection of MAPs. Its activities include applied research, the development of knowledge-transfer tools and technical publications, and the delivery of training programs targeted at producers and field technicians. Most of the work related to sustainable wild collection has been carried out within the framework of international projects (LIFE97 ENV/E/000260, INTERREG III Silvapyr, GRUNDTVIG Lifelong Learning Program Plant Wild, H2020 INCREDIBLE Forest, INTERREG SUDOE ValuePAM, EuropeAid TRUMAP, EIP-AGRI Focus Group 35, INTERREG POCTEFA Gestes), as well as through national funding initiatives. The species studied are those of commercial interest naturally occurring in the north-western Iberian Peninsula, including *Gentiana lutea, Arctostaphylos uva-ursi, Arnica montana, Thymus vulgaris, Pistacia lentiscus*, among others. Research activities have focused on assessing the resource availability and the ecological impact of wild collection on natural populations, determining sustainable extraction rates, developing and disseminating innovative methodologies, designing sustainable management plans, producing training materials, and publishing technical guidelines on good collection practices.

The most relevant results obtained over these 25 years of work will be presented.

Key Words: Wild collection, MAPs, forest research, CTFC, Catalonia

INVITED SPEAKER

PA-FREE CULTIVATION OF MEDICINAL AND AROMATIC PLANTS: MYTH OR ACHIEVABLE REALITY?

Nadire Pelin Bahadirli[1*], Ramazan Gürbüz[2], Harun Alptekin[3], Mehmet Salih Nas[4], Nazım Şekeroğlu[5]

[1]Department of Field Crops, Faculty of Agriculture, University of Hatay Mustafa Kemal, Hatay, Türkiye
[2]Department of Plant Protection, Faculty of Agriculture, Iğdır University, Iğdır 76000, Türkiye
[3]Iğdır University, Faculty of Agriculture, Department of Animal Science, Iğdır, Türkiye
[4]Iğdır University, Faculty of Applied Sciences, Department of Emergency Aid and Disaster Management, TR-76000, Iğdır, Türkiye
[5]Department of Biology, Faculty of Arts and Sciences, University of Gaziantep, Gaziantep, Türkiye
Correspondance: pelinbahadirli@gmail.com

Medicinal and aromatic plants (MAPs) are high-value commodities for multiple industries, yet their safety is increasingly threatened by contamination with pyrrolizidine alkaloids (PAs), toxic compounds primarily originating from co-occurring weed species. Recent evidence, supported by regulatory data such as RASFF notifications, highlights oregano (*Origanum* spp.) and cumin (*Cuminum cyminum*) among the most frequently affected products, with contamination largely linked to PA-producing genera including *Senecio*, *Heliotropium*, *Echium*, and *Crotalaria*. Beyond co-harvesting, emerging findings suggest that additional pathways, including soil and post-harvest processes, may contribute to contamination risk. These complexities challenge the feasibility of absolute PA-free production under open-field conditions. However, integrated weed management (IWM), combined with improved post-harvest control, offers a realistic pathway to substantially reduce contamination levels. Rather than a strict zero-contamination paradigm, a shift toward achievable, regulation-compliant production systems appears both necessary and attainable.

Key Words: Pyrrolizidine alkaloids; PA-producing weeds; co-harvesting contamination; risk mitigation; MAP safety; Regulatory compliance

INVITED SPEAKER

FROM BENCH TO BEDSIDE: ADDRESSING THE PHARMACEUTICAL CHALLENGES OF NUTRACEUTICALS

Kuntal Das

Professor and HOD, Department of Pharmacognosy, Sree Siddaganga College of Pharmacy,3rd Block, Mahalakshmi Nagar, Batawadi, Tumkur-572013, Karnataka, India
Correspondance: drkkdsd@gmail.com

Lifestyle diseases are the major challenges in human life which due to food habits. Consumption of junk food has increased manifold, which has led to a number of diseases related to nutritional deficiencies. Hence, they are shifting from synthetic ingredients towards organic foods and ingredients from natural sources. Of late, Nutraceuticals can play an important role in controlling them and also fulfil all the health requirements. They are incredible dietary supplements that help in prevention or treatment of disease, which is made from raw herbals. After, Covid-19 situation, this is a rapidly growing industry with more than 100 million people using these natural products but as like drugs, there should be strict regulatory control for nutraceuticals. With extensive anecdotal data on exciting health results, nutraceutical promise significant contributions to disease prevention and allow human to maintain an overall good health. Nearly two thirds of the world's 6.1 billion people rely on the healing power of plant based materials for many reasons-availability, affordability, safety or their belief in traditional cures. Hence, the demand is irreversibly increasing. According to a new market research, global nutraceuticals market was valued at US$165.62 billion in 2014 and is expected to reach US$223.56 billion during the forecast period of 2022-2027. The global *nutraceuticals market* grew from $372.27 billion in 2022 to $409.12 billion in *2023* with compound annual growth rate (CAGR) of 9.9%. Indian market is growing at the rate of 21% per year and among that Amay, Dabur and Pfizer are well recognized. This indicates the people are accepting Nutraceuticals as medicine to make life healthy.

Key Words: Disease, herbals, life style, nutraceuticals, regulation, market

INVITED SPEAKER

ADULTERATION OF ESSENTIAL OILS

Prabodh Satyal

Aromatic Plant Research Center, Lehi Utah, USA
correspondence: prabodhsatyal@gmail.com

The global essential oil industry is navigating a complex landscape, with particular challenges around the authenticity and quality of its products. As demand for essential oils continues to rise, the market is plagued by issues like economic adulteration. This can range from simply diluting oils with carrier substances to more intricate methods where natural components are recreated using synthetic means or petrochemical products. Alarmingly, many of the essential oils available on the market today undergo some form of manipulation in their composition. This presentation dives into the world of essential oil adulteration, exploring not only the scientific principles behind these practices but also the economic factors driving them. It's essential to understand how these issues can affect therapeutic benefits, consumer safety, and the broader global market. We will look at advanced analytical techniques used to detect adulteration, such as gas chromatography-mass spectrometry (GC–MS), chiral analysis, radiocarbon testing, deuterium NMR, chemometric modeling, and the identification of synthetic markers. Key points of focus will include the disappearance of natural biomarkers and the formation of synthetic markers, along with the challenges we face in differentiating between naturally sourced and petrochemical components.
Through case studies of lavender, peppermint, cinnamon, birch, thyme, and citrus oils, we'll see how sophisticated the methods of adulteration have become and why some synthetic markers are difficult to avoid due to their similar properties and methods of creation. We'll wrap up the lecture by discussing the regulatory implications and the forensic analysis of chromatography data, emphasizing the role of chemometrics in validating authenticity. Grasping the intricate interplay of chemistry, economic factors, and detection methods is vital for maintaining quality, ensuring fair trade, and upholding trust in the essential oil industry. Sizing the role of chemometrics in validating authenticity. Grasping the intricate interplay of chemistry, economic factors, and detection methods is vital for maintaining quality, ensuring fair trade, and upholding trust in the essential oil industry.

Key Words: Essential oil, adulteration, GC–MS, validation, synthetic markers

ORAL PRESENTATION

Oral Presentations

ORAL PRESENTATION

SMOKE WATER AND SMOKE-DERIVEDKARRIKINOLIDE, KAR1, IMPROVED GERMINATION IN SOME MEDICINAL AND AROMATIC PLANTS

Simonnet Xavier[1], Norgrove Lindsey[2], Sutter Louis[1], Dienes-Nagy Agnes[3], Bergoënd Annabelle[4], Rolando Stefano Sella[1, 2]

[1]Agroscope, Plant Production Systems, 1964, Conthey, Switzerland
[2]School of Agricultural, Forest and Food Sciences (HAFL), Bern University of Applied Sciences, Zollikofen, Switzerland
[3]Agroscope, Method Development and Analytics, 1260, Nyon, Switzerland
[4]iteipmai, Technical Institute for Perfume, Aromatic and Medicinal Plants 49120, Chemillé en Anjou, France
Correspondance: xavier.simonnet@agroscope.admin.ch

Seed dormancy challenges medicinal and aromatic plant (MAP) cultivation, often requiring lengthy cold stratification or application of germination stimulants such as gibberellic acid (GA_3). We evaluated if karrikinolide (KAR_1) and smoke water (SW) would break dormancy of five MAPs - *Alchemilla xanthochlora, Lavandula angustifolia*, *Rhodiola rosea*, *Verbena officinalis* and *Veronica officinalis*. KAR_1 treatments at 10 µM significantly improved final germination percentage (FGP) in lavender, with cultivar 'Rapido' reaching 65.5%, and cultivar 'Carla' achieving 31.5%, compared to GA_3 which produced 67% and 49.5% FGP respectively. For *Veronica*, KAR_1 treatments from 0.001 to 10 µM consistently yielded very high FGP (94.5–100%), comparable to GA_3 treatment at 94.5%, indicating near-complete dormancy alleviation. SW treatments yielded variable results: while *Veronica officinalis* responded positively to 1:10 and 1:1000 dilutions, Lavandula angustifolia showed no response at these concentrations, and undiluted SW inhibited germination in all species. For other species (*Alchemilla xanthochlora, Rhodiola rosea, Verbena officinalis*) that did not respond positively to KAR1 and smoke water, further research (different treatment concentrations, other smoke water profiles) is needed before concluding that these treatments are not beneficial for these species. The results of this study were published in early 2026 [1].

Key Words: Medicinal and aromatic plants, Germination, Seed dormancy, Karrikin, KAR1, Smoke water

References

[1] Rolando, S.S., Norgrove, L., Sutter, L., Dienes-Nagy A., Bergoënd A. & Simonnet X.. Smoke water and smoke-derived karrikinolide, KAR_1, improved germination in some medicinal and aromatic plants. *Sci Rep* **16**, 865 (2026). https://doi.org/10.1038/s41598-025-30823-7

ORAL PRESENTATION

ANCIENT USES OF MEDICINAL PLANTS IN THE MEDITERRANEAN: AN EXAMINATION OF *MELISSA OFFICINALIS*

Maria Christodoulou

Clinical Herbalist and Independent Researcher, 11635 Athens, Greece,
Correspondance: maria@thegreekherbalist.com

Surviving medical texts written by ancient physicians from the Mediterranean region offer valuable insight into how people applied medicinal plants for healing. Many of these ancient uses have not been closely examined to determine continuity of use and potential applications for modern needs. Medicinal plants endemic to the Mediterranean region are especially important for their strong therapeutic value, as indicators of ecosystem health, and as markers of cultural heritage. *Melissa officinalis* (Lemon balm), a medicinal and culinary herb native to the Mediterranean region and parts of Africa and Asia, is an important example of continuity of therapeutic applications since antiquity. The plant was written about by Pedanius Dioscorides (1st century CE) in his influential text, *De Materia Medica*, in which he described uses for the respiratory, digestive, and muscular systems, and topical applications, many of which are no longer considered. The plant continues to be recommended to support the recovery and healing of these systems in addition to ailments not mentioned or known in antiquity, including for anxiety, viral infections, and fever. From the perspective of a clinical herbalist, these ancient and modern applications will be cross-referenced to determine to what extent ancient medicines compare to modern uses and how ancient uses can inform modern applications for home healthcare and pharmaceutical application. The examination of *Melissa officinalis* can demonstrate the importance of ancient medical knowledge, provide broader understanding of the plant's therapeutic benefits, and suggest additional research for modern therapies. It can also demonstrate the possibilities of uncovering new information on other medicinal plants native to the Mediterranean region written about by ancient physicians.

Key Words: *Melissa officinalis,* Dioscorides, ancient medicine, herbal medicine, mediterranean region

ORAL PRESENTATION

COMPARATIVE HPLC ANALYSIS OF *FERULA ELAEOCHYTRIS* KOROVIN AND *FERULA COMMUNIS* L. SUBSP. *COMMUNIS*: FOCUS ON FERUTININ AND FERULENOL CONTENT

Irmak Alev Çetinkaya[1,2,3], Şeyma Ulusoy[4], Murat Kartal[4,5]

[1]*Department of Pharmacognosy and Natural Products Chemistry, Institute of Health Sciences, Bezmialem Vakif University, 34093, İstanbul, Türkiye*
[2]*Department of Pharmacognosy, Faculty of Pharmacy, Altınbaş University, 34147, İstanbul, Türkiye*
[3]*Altınbaş University Natural Products Research and Development Center (DÜAGEM), Altınbaş University, İstanbul 34147, Türkiye*
[4]*Department of Pharmacognosy, Faculty of Pharmacy, Bezmialem Vakıf University, 34093, İstanbul, Türkiye*
[5]*Bezmialem Center of Education, Practice, and Research in Phytotherapy, Bezmialem Vakif University 34093, Istanbul, Türkiye*
Correspondance: E-mail: irmak.alev1@altinbas.edu.tr

The roots of *Ferula* L. species are commonly used as aphrodisiacs in traditional medicine in various countries, including Türkiye. It is suggested in the literature that the major compound responsible for the aphrodisiac effect in plants of the genus *Ferula* is ferutinin, a daucan-type sesquiterpene ester [1]. However, some species such as *Ferula communis* L. subsp. *communis* are known to be toxic due to their prenylated coumarin content, such as ferulenol [2]. The study aimed to perform preliminary comparative chemical analysis of *Ferula elaeochytris* Korovin and *Ferula communis* L. subsp. *communis* ethanolic root extracts, with a focus on their ferutinin and ferulenol contents. Plant materials were collected from their natural habitats in Türkiye. The ethanolic root extracts of the plants were prepared. The ferutinin and ferulenol contents were determined by HPLC-PDA using calibration curves created with the relative reference standards. According to the results of our study, 10.48±0.007% ferutinin is detected in the extract of *F. elaeochytris* while ferulenol was not detected. In contrast, *F. communis* subsp. *communis* extract did not contain ferutinin but contained 3.35±0.002% ferulenol. Significant differences in chemical composition were observed between the two *Ferula* species. In conclusion, the presence of ferulenol in *F. communis* subsp. *communis* extract indicates a potential toxicological risk and may limit its suitability for biological activity studies. *F. elaeochytris* can be a safer candidate due to its high ferutinin content and absence of detectable ferulenol. This study represents a preliminary step prior to planned *in vitro* and *in vivo* investigations and it highlights the importance of species identification and chemical profiling before biological and pharmacological activity studies.

Key Words: *Ferula elaeochytris*, *Ferula communis*, ferutinin, ferulenol, high performance liquid chromatography

References

[1] Aydogan F, Baykan S, Soliman GA, Yusufoglu H, Bedir E. Evaluation of the potential aphrodisiac activity of sesquiterpenoids from roots of *Ferula huber-morathii* Peşmen in male rats. J Ethnopharmacol. 2020 Jul 15;257:112868. doi: 10.1016/j.jep.2020.112868. Epub 2020 Apr 13. PMID: 32298751.

[2] Louvet MS, Gault G, Lefebvre S, Popowycz F, Boulven M, Besse S, Benoit E, Lattard V, Grancher D. Comparative inhibitory effect of prenylated coumarins, ferulenol and ferprenin, contained in the 'poisonous chemotype' of *Ferula communis* on mammal liver microsomal VKORC1 activity. Phytochemistry. 2015 Oct;118:124-30. doi: 10.1016/j.phytochem.2015.08.012. Epub 2015 Aug 24. PMID: 26314757.

ORAL PRESENTATION

TRADITIONAL PREPARATION METHODS OF PSYCHOACTIVE BOTANICALS AND THEIR POTENTIAL ROLE IN EMOTIONAL NEUROPLASTICITY

Selenay Arslan, Aynur Sarı

Department of Pharmacognosy, Faculty of Pharmacy, Istanbul University, 34116, Istanbul, Türkiye.
Correspondance: selenay.arslan@hotmail.com

Traditional psychoactive botanical preparations have been employed for centuries within ritualistic and therapeutic frameworks to influence emotional regulation, cognition, and states of consciousness. This review aims to explore the potential role of traditional preparation methods in shaping the neuropsychological and pharmacodynamic outcomes of psychoactive plant use, with a particular focus on ayahuasca, a decoction prepared from *Banisteriopsis caapi* and *Psychotria viridis*. A narrative review methodology was used to synthesize ethnopharmacological literature, emerging clinical observations, and interdisciplinary research addressing psychoactive botanicals and mental health. Special attention was given to preparation techniques, contextual use, symbolic frameworks, and experiential integration practices described in traditional settings. Available evidence suggests that psychoactive botanical preparations may facilitate processes related to emotional neuroplasticity, including enhanced introspective capacity, adaptive emotional processing, and behavioral flexibility. These effects have been increasingly discussed in relation to depression, anxiety disorders, and substance use disorders. Furthermore, traditional preparation methods such as prolonged decoction, combination of plant species, and ritualized consumption contexts may influence both pharmacokinetic interactions and subjective therapeutic experiences. The findings highlight the importance of understanding psychoactive plants as dynamic biocultural systems rather than solely as sources of isolated active compounds. Integrating traditional knowledge with contemporary neuroscientific and pharmacognostic perspectives may contribute to the development of more holistic and culturally informed mental health approaches. Future research should focus on controlled interdisciplinary models that examine how preparation methods and contextual variables modulate therapeutic outcomes and long-term psychological integration.

Key Words: Ethnopharmacology, Ayahuasca, psychoactive botanicals, emotional neuroplasticity, traditional preparation, integrative mental health

Acknowledgements: The authors would like to thank the Department of Pharmacognosy, Faculty of Pharmacy, Istanbul University, for academic support.

References

[1] Dos Santos, R.G., et al., 2016. Antidepressive and anxiolytic effects of ayahuasca. *Journal of Clinical Psychopharmacology*, 36(1), 77–81.
[2] Palhano-Fontes, F., et al., 2019. Rapid antidepressant effects of ayahuasca. *Psychological Medicine*, 49(4), 655–663.
[3] Arslan, S., 2024. *Potential role of ayahuasca (Banisteriopsis caapi & Psychotria viridis) in psychiatric disorders*, MSc Thesis, Istanbul University, Faculty of Pharmacy, Istanbul, Türkiye. Thesis

ORAL PRESENTATION

ESSENTIAL OIL COMPOSITION OF *CALENDULA OFFICINALIS* L. COLLECTED FROM DIFFERENT LOCALITIES IN ESKISEHIR, TÜRKIYE

Merve Kalas[1], Betül Demirci[2] and Sevim Küçük[3]

[1] Department of Pharmaceutical Botany, Faculty of Pharmacy, Cukurova University 01130, Adana, Türkiye
[2]Department of Pharmacognosy, Faculty of Pharmacy, Anadolu University, 26470, Eskisehir, Türkiye
[3] Department of Pharmaceutical Botany, Faculty of Pharmacy, Anadolu University 26470, Eskisehir, Türkiye
Correspondance: E-mail: mrw.kalas@gmail.com

The genus of *Calendula* belongs to the Asteraceae family, which is the largest family of flowering plants, and is represented by three taxa in Flora of Türkiye: *Calendula suffruticosa* Vahl. subsp. *fulgida* (Raf.) Guadagno, *Calendula officinalis* L. and *Calendula arvensis* L. *C. officinalis*, known as "Aynısefa otu" in Türkiye and, is one of the most popular species used in the cosmetics and pharmaceutical industry. Since ancient times, it has been used for the treatment of skin inflammations, wounds, burns, bruises and cuts. The plant is administered both internally and externally in the form of infusions, tinctures, liquid extracts, cold-pressed oils, and ointments. In this study, *C. officinalis* specimens collected from four different localities around Eskişehir, Türkiye, and their essential oil compositions were investigated. Essential olis were obtained from the aerial parts of the plant by the water distillation method, yielding for different volatile oils corresponding to the collection sites. The volatile oil compounds were analyzed using GC and GC/MS techniques. The main components of the essential oils of *C. officinalis* were identified as *α*-cadinol (30.0-34.5%), *δ*-cadinene (15.2-18.8%) and *T*-muurolol (6.3-8.2%).

Key Words: Asteraceae, *Calendula officinalis*, Essential oil, GC/MS, α-cadinol

ORAL PRESENTATION

WHISPERS AND FRAGRANCES OF OAK LEAVES

Nina Djapic

[1] *University of Novi Sad, Technical Faculty "Mihajlo Pupin", Djure Djakovica bb, 23000, Zrenjanin, Serbia*
Correspondance: nina.djapic@tfzr.rs

The oak tree located in Epirus, by the lake Ioannina [1], from the rustling of leaves the oracle of Dodona was able to tell the will of Zeus [2]. It is unknown which natural phenomenon, if any, was the basis for this belief [2]. The exact classification of oak tree is unknown [2]. There are, in Eastern Mediterranean and in North-West Greece, at least eleven different oak species [2]. The sacred tree at Dodona might not have been an oak, others are satisfied to identify it with *Quercus macrolepis,* a species now extended to include *Quercus aegilops* [2]. The oak tree loses its leaves in late winter or early spring [2]. Marcescence is the phenomenon where the oak tree holds its leaves after senescence [3]. This phenomenon permitted the oracle of Dodona to listen the rustling of leaves, almost throughout the whole year. The oracle at Delphi is associated with laurel leaves [2]. It may have been that the fragrances of laurel leaves or ethylene from volcanic fumes or hallucinogenic gases emerging from a crevice in the floor of her temple influenced her prophecies. The objective of the study was to find the fragrances of white oak leaves collected at the South-Eastern Adriatic coast. The green and amber, white oak leaves were extracted by supercritical CO_2 extraction. The extracts obtained were analyzed by GC-MS. The most abundant compounds in green leaves were phytol (24.11%) and limonene (21.32%) and in amber leaves were anethole (7.99%), limonene (3.75%), β-eudesmol (3.61%), α-eudesmol (3.21%) and α-pinene (2.70%). It is hard to know the Zeus's whispering to Dodona by season and the influence of fragrances. For Thucydides, the writer of the Peloponnesian War, the only true prophecy about the Peloponnesian war was the one that it would last for "thrice nine years" [4].

Key Words: oak, leaves, supercritical CO_2 extraction, GC-MS

References

[1] Berens, E.M., 2007. Myths and Legends of Ancient Greece and Rome. Project Gutenberg, NY
[2] Parke, H.W., 1967. The Oracles of Zeus: Dodona, Olympia, Ammon. Harvard University Press, Cambridge
[3] Angst, Š., Veselá, H., Bartuška, M., Jílková, V., Frouz, J., et al. 2022. Changes in the quality of marcescent and shed senescent leaves during the dormant season. Plant Soil, 474, 373–382. DOI number: 10.1007/s11104-022-05341-4
[4] Flower, M.A., 2009. Athenian Religion and the Peloponnesian War. In: Art in Athens during the Peloponnesian War. Cambridge University Press, NY

ORAL PRESENTATION

FROM TRADITION TO COSMECEUTICALS: ETHNOBOTANICAL AND COSMETIC USES OF *CROCUS SATIVUS* L.

Diren Ergin[1,2], Irmak Alev Çetinkaya[1,2,3], Mert Baran Uçar[4,5]

[1]Department of Pharmacognosy, Faculty of Pharmacy, Altınbaş University, 34143, İstanbul, Türkiye,
[2]Altınbaş University Natural Products Research and Development Center (DÜAGEM), Altınbaş University, İstanbul 34147, Türkiye
[3]Department of Pharmacognosy and Natural Products Chemistry, Institute of Health Sciences, Bezmialem Vakif University, 34093, İstanbul, Türkiye
[4]Department of Pharmacognosy, Institute of Health Sciences, İstanbul University, 34116, İstanbul, Türkiye
[5]Department of Pharmacognosy, Faculty of Pharmacy, İstanbul Health and Technology University 34275, İstanbul/Türkiye
Correspondance: diren.ergin@altinbas.edu.tr,

Crocus sativus L., commonly known as "saffron", is a sterile triploid geophyte belongs to Iridaceae family. *Crocus* genus has more than 200 species worldwide and is widely distributed across Western Asia and Mediterranean floristic region [1]. It is represented by more than 150 taxa in Türkiye, 55 of which are endemic [2]. In addition to its historical use as spice, it has been generally used for both medicinal and cosmetic purposes in traditional medicine. In Greek, Persian and Ayurvedic medical systems, *C. sativus* has been valued for improving skin appearance and treating acne and wounds. It has also been used for mood enhancement, to treat insomnia and headaches, also to protect gastrointestinal, cardiovascular, and reproductive health. *C. sativus* is widely cultivated for its stigmas. Characteristic components such as crocrine, picrocrocin, crocetin, and safranal have been identified in the phytochemical content of these stigmas [3]. In recent years, not only the stigmas but also the floral byproducts of *C. sativus* such as the petals have gained importance as valuable sources of bioactive compounds. These byproducts contain secondary metabolites like flavonoids, anthocyanins and carotenoids [4]. These phytochemical compositions significantly contribute to various biological activities exhibited by *C. sativus*. Strong antioxidant activity of this plant helps prevent photoaging caused by UV radiations, as well as its melanogenesis-regulating effects contribute to skin brightening and protection. The cosmetic potential of *C. sativus* is mostly mediated by the inhibition of skin-aging enzymes such as collagenase, hyaluronidase, elastase and tyrosinase [5]. In conclusion, both the floral bio-residues and stigmas of *C. sativus* are a highly valuable natural ingredient for modern skin-lightening, anti-aging and sun-protective cosmetic formulations [5-7]. All these findings emphasize that *C. sativus*, whose various biological activities have been demonstrated by scientific studies, can be an important resource for cosmetic applications, beyond its traditional uses.

Key Words: Crocus *genus, Crocus sativus* L., cosmetic applications

ORAL PRESENTATION

WILD APRICOTS: MEDICINAL AND AROMATIC USE

Sezai Ercişli[1], Melekber Sülüşoğlu Durul[2], Mehmet Ramazan Bozhüyük[3]

[1]Atatürk University, Faculty of Agriculture, Department of Horticulture, 25240 Erzurum, Türkiye
[2]Kocaeli University, Faculty of Agriculture, Department of Horticulture, 41300 Kocaeli, Türkiye
[3]Iğdır University, Faculty of Agriculture, Department of Horticulture, 76100 Iğdır, Türkiye
Correspondance: sercisli@gmail.com

Apricots, which grow naturally in different regions of Türkiye, especially in rural areas, hold a valuable place in the food industry, both fresh and dried. Wild apricot (*Prunus armeniaca*) is close relatives of cultivated apricot and has edible, smaller, sour, and intensely aromatic fruits. It is found as non-grafted forms in many apricot growing countries. The fruits of wild apricots are getting more importance recently due to it is a natural food source with high antioxidant content. Valuable oil is extracted from its kernels and has high market values. Its fruits used in making jams and compotes. For centuries Zerdali fruits used in medicinal and aromatic purposes. It has a more sour, sharp, and aromatic taste compared to cultivated apricots. Besides fresh consumption, it is preferred processing into several traditional products due to high aroma. The fruits have high antioxidant properties and it protects human cells by fighting free radicals in the body. Oil obtained from wild apricot kernels is used in the cosmetics and health sectors for skin care. It is rich in vitamins A and C and supports the immune system. It is used in natural fruit juice, dried fruit, apricot kernel oil, and aromatic jams.

Key Words: Wild apricot, medicinal use, *Prunus armeniaca*, Zerdali

ORAL PRESENTATION

INVESTIGATION OF THE PROTECTIVE EFFECT OF *SMYRNIUM CONNATUM* BOISS. & KOTSCHY AGAINST LPS-INDUCED ACUTE LUNG INJURY IN RATS

Feyyaz Mihoğlugil[1], İpek Süntar[2], Mürşide Ayşe Demirel[3]
Saadet Özen Akarca Dizakar[4], Fatma Sezer Şenol Deniz[2], Kevser Taban[5]

[1]Department of Pharmacognosy, Faculty of Pharmacy, Bahçeşehir Cyprus University, Nicosia, Northern Cyprus
[2]Department of Pharmacognosy, Faculty of Pharmacy, Gazi University, Ankara, Türkiye
[3]Department of Basic Pharmaceutical Sciences, Faculty of Pharmacy, Gazi University, Ankara, Türkiye
[4]Department of Histology and Embryology, Faculty of Medicine, Bakırçay University, İzmir, Türkiye
[5]Department of Pharmacognosy, Faculty of Pharmacy, Sivas Cumhuriyet University, Sivas, Türkiye

The genus *Smyrnium* (Apiaceae) was reported to be represented by 38 species worldwide and 7 species in Türkiye. Some species of the genus *Smyrnium* have been traditionally used as food in Türkiye. It was documented that the roots of *Smyrnium connatum* Boiss. & Kotschy were consumed as food, while its fresh aerial parts were used against asthma and dyspnea as well as in the treatment of infertility and diabetes (Demirci et al., 2014; Güneş et al., 2018; Ayaz et al., 2022). In the present study, based on its ethnobotanical use in respiratory disorders, the protective effect of *S. connatum* against lung injury was investigated in a lipopolysaccharide (LPS)-induced acute lung injury model. For this purpose, an aqueous-methanolic extract of *S. connatum* was administered to experimental animals at three different doses (100, 200, and 400 mg/kg) prior to the induction of LPS-induced acute lung injury. Dexamethasone (1.5 mg/kg) was used as a reference drug. Following the experiment, rats were sacrificed, and bronchoalveolar lavage fluid and lung tissues were collected. Routine histopathological, immunohistochemical, and biochemical analyses were performed on these samples. The results demonstrated that the group treated with the 200 mg/kg extract showed the most pronounced improvement. Specifically, the lung wet-to-dry weight ratio (5.39±0.81; $p<0.001$), an indicator of edema, as well as the levels of IL-1β (52.04±6.346; $p<0.01$) and IL-6 (21.96±2.006; $p<0.001$), were significantly reduced compared to the control group, indicating a marked therapeutic effect. The mentioned group also exhibited a statistically significant reduction in the histopathological score (6.92±0.37; $p<0,05$) compared to the control group. As no previous study had investigated *Smyrnium* species for this specific purpose, this study provided the first evaluation of the ethnobotanical use of *S. connatum* in respiratory diseases and contributed to the elucidation of its possible mechanism of action. The findings obtained were considered to provide a basis for further studies.

Key Words: *Smyrnium connatum,* Apiaceae, Inflammation, Lipopolysaccharide, *in vivo*

Acknowledgement: The authors would like to thank the Gazi University Scientific Investigations Project Unit (GAZI BAP) for supporting this work under project number TGA-2024-9755.

References

Ayaz, F., Eruygur, N., Doğru, T., Bağcı, Y., & Doğu, S. (2022). Biological Activities of the Methanol Extracts of Smyrnium connatum Boiss. and Kotschy. *Tarim ve Doga Dergisi*, *25*(6), 1216.

Demirci, S., Özkan, E. E., & Demirci, S. (2014). Ethnobotanical studies of some Apiaceae plants in Kahramanmaras and a review of their phytochemical studies. *Journal of Faculty of Pharmacy of Istanbul University*, *44*(2), 241-250.

Güneş, S., Savran, A., Paksoy, M. Y., & Çakılcıoğlu, U. (2018). Survey of wild food plants for human consumption in Karaisalı (Adana-Turkey).

ORAL PRESENTATION

PROTECTIVE EFFECTS OF OLIVE LEAF ANTIOXIDANTS ON VEGETABLE OIL OXIDATION

Ferdaous Guasmi, Sihem Ben Ali, Faiza Boussora, Tebra Triki, Mbarka Ben Mohamed

Arid Land Institute of Medenine, Medenine Tunisia
Correspondance: ben_ali.sihem@yahoo.fr

Olive leaves are valued for their rich content of bioactive compounds, particularly phenolic compounds, which reveal antibacterial, antiviral, anticancer, and antioxidant properties. These attributes make them a promising natural alternative in the food industry. This study investigates the effect of antioxidant extracts from olive leaves on the stability of vegetable oil. Different doses of extracts, obtained using ethanol (70%) and acetone, as well as crushed leaf powder, were tested over various storage periods. Results indicate that 70% ethanol is the most effective extraction solvent. Analysis of oil acidity reveals that phenolic compounds reduce acidity levels similarly to BHT. Furthermore, oxidative stability measurements (K232 and K270) show that the addition of olive leaf powder reduces oil oxidation risks. Enhanced free radical-scavenging activities (DPPH, ABTS) and ferric reducing power (FRAP) were also observed.

Key words: Olive leaves, Phenolic Compounds, Antioxidant Activity, Vegetable Oil Stability, Oxidative Stability

ORAL PRESENTATION

HISTOLOGICAL SAFETY OF STRAWBERRY, ASCORBIC ACID, AND *BALANITES AEGYPTIACA* ON KIDNEY AND TESTICULAR TISSUES IN RABBITS

Fayrouz. A. Khaled[1], Hesham E. Abdolhfid Mohamed[2], Aisha O. Miqdad[3]

[1]Chemistry Department, Faculty of Science, Omar Al-Mokhtar University, El -Beida, Libya
[2]Oral Biology Department, Faculty of Dentistry, University of Omar Al-Mukhtar, Al Bayda, Libya
[3]Pathology Department, University of Helsinki, Helsinki, Finland
Correspondance: fayalzobair@yahoo.com

Natural plant-derived compounds are widely investigated for their biological activities and safety in experimental models. Strawberry, ascorbic acid (vitamin C), and *Balanites aegyptiaca* are rich sources of natural antioxidants and bioactive phytochemicals that may support tissue integrity and protect against cellular damage. This study aimed to evaluate the histopathological effects of strawberry, ascorbic acid, and *Balanites aegyptiaca* supplementation on kidney and testicular tissues in rabbits as an experimental animal model. Kidney and testicular tissues were collected from rabbits treated with strawberry, ascorbic acid, or *Balanites aegyptiaca*. Tissue samples were processed using standard histological techniques and stained with hematoxylin and eosin (H&E). Microscopic examination was performed to assess the structural integrity of renal corpuscles, glomeruli, renal tubules, and seminiferous tubules as well as the organization of spermatogenic cells. Histological examination revealed preserved kidney architecture in all treated groups, with intact glomeruli, renal tubules, and interstitial tissues. Slight widening of Bowman's space was observed in the strawberry- and ascorbic acid-treated groups, whereas the *Balanites aegyptiaca*-treated group showed normal Bowman's space with well-defined glomeruli, indicating comparatively better preservation of renal microstructure. Testicular tissues from all groups demonstrated normal histological organization with well-structured seminiferous tubules and abundant spermatogenic cells at different stages of maturation, indicating active and normal spermatogenesis without evidence of degeneration or tissue damage. The results suggest that strawberry, ascorbic acid, and *Balanites aegyptiaca* supplementation do not induce renal or testicular toxicity in rabbits under the experimental conditions. Among the treatments, *Balanites aegyptiaca* exhibited slightly superior preservation of renal histological features, highlighting its potential as a safe natural plant-derived supplement.

Key Words: *Balanites aegyptiaca*, strawberry, ascorbic acid, histopathology, kidney, testes, medicinal plants, rabbits

ORAL PRESENTATION

ETHNOBOTANICAL STUDY FOR MATERNAL HEALTHCARE IN QWAQWA, FREE STATE PROVINCE, SOUTH AFRICA

Mamokete Venolia Setshego, Sechaba Bareetseng and Motheo Koitsiwe

Indigenous Knowledge Systems (IKS) Centre, Faculty of Natural and Agricultural Sciences, North West University, Private Mail Bag X2046, Mmabatho 2790, North West Province, South Africa
Correpondance: mamokete.Setshego@nwu.ac.za

The medicinal plant use is an ancient custom practiced in most rural areas around the world as service to meet the health care requirements of patients. Conversely, the very custom was perceived by old government as witchcraft, hence there was an Act 3 of 19 of 1957 Witchcraft Suppression which forbidden the use of medicinal plants and that lead to its marginalization. The custom of medicinal plant-use is significantly practiced for diverse reproductive and maternal health related conditions such as childbearing, assuage menstruation challenges, assist recovery from after miscarriage, alleviate postpartum, haemorrhage, aid postpartum recovery and for pregnancy challenges. Maternal health refers to the health of women during pregnancy, childbirth, and the postnatal period. In African, most women use medicinal plants because of their socio-economic status and poor access to health care in their communities. However, the use of traditional medicine for maternal healthcare is banned in most African countries despite its significance because of misunderstanding and mistrust of the Indigenous knowledge systems. The mistrust is not because of the ineffectiveness, however because of the lack of knowledge. As a result, the very ethnobotanical knowledge is disappearing hence this study aimed to document the traditional use of medicinal plants used for maternal healthcare. A survey was conducted with 149 participants that includes mothers, traditional health practitioners and traditional birth attendants to collect data. Forty-five (45) plants (for example *Mimulus gracilis R.Br.*, *Eriocephalus punctulatus, Dicoma anomala* Sond) from 32 families used for maternal healthcare were recorded. The results shows that most plants recorded belong to the family of *Asteraceae*. Modes of preparation and administration were also documented. Most of information was received from the elders and this suggests that young people do not have such knowledge, hence it is important to intensify the effort to document them. To advance the study, scientific validation of the claimed efficacy of traditional medicine is warranted.

Key Words: Traditional medicine, medicinal plants, maternal healthcare, indigenous knowledge

References

[1] Setshego M.V, Aremu, A.O, Mooki,I., Mbeng, W.O., 2020. Natural resources used as folk cosmeceuticals among rural communities in Vhembe district municipality, Limpopo province,South Africa. BMC Complementary and Alternative Medicine (BCAM-D-18-01679).
[2] Setshego MV, Bhuda MT, Koitsiwe M. What is the role of indigenous participants in participatory action research? Discussion from the indigenous scholars. Book: Enabling indigenous Knowledge systems in action research and action learning
[3] Molokwa TD, Setshego MV. Traditional food systems as a tool for achieving food sovereignty in South Africa. Book: Revaluation and Preservation of Indigenous Knowledge Systems in Modern Society.
[4] Bhuda TM, Setshego MV, Molokwa DT. How is indigenous Knowledge used on Climate Change Adaptation in South Africa? Discussion by indigenous scholars. Book: Governance of Climate Change In Rural And Urban Africa: Issues, Lessons and Policy Directions (upcoming book)

ORAL PRESENTATION

COMPARATIVE MORPHOLOGY AND MICROMORPHOLOGY OF *GALIUM HUMIFUSUM* BIEB. AND *GALIUM VERUM* L. SUBSP. *VERUM* FROM TÜRKİYE

Merve Kalas[1], Ayla Kaya[2]

[1] Department of Pharmaceutical Botany, Faculty of Pharmacy, Cukurova University, 01130, Adana, Türkiye
[2]Department of Pharmaceutical Botany, Faculty of Pharmacy, Anadolu University, 26470, Eskisehir, Türkiye
Correspondance: mrw.kalas@gmail.com

In this study, two taxa, *Galium humifusum* Bieb. and *Galium verum* L. subsp. *verum*, belonging to the section *Galium* of the genus *Galium* (Rubiaceae), were comparatively investigated using morphological and micromorphological approaches. Morphological analyses included detailed taxonomic descriptions, in situ photographic documentation, and comparative evaluation with Flora of Türkiye. Morphological characters particularly the number of leaves per whorl; the presence of an erect, densely hairy stem; linear-subfiliform leaves; a densely short-hairy abaxial leaf surface; a glabrous, rotating, bright yellow petals; shorter anthers and filaments; and greenish-yellow mericarps that turn red when mature and black when dry clearly distinguished *G. verum* subsp. *verum* from *G. humifusum*. Micromorphological features —including epidermal cell patterns, stomatal characteristics, indumentum, and surface ornamentation—of the stem, leaves, and fruits were examined using scanning electron microscopy (SEM). *G. verum* subsp. *verum* exhibited dense, short to long, fine, reclinate hairs on the stem and on both adaxial and abaxial leaf surfaces, whereas *G. humifusum* was predominantly glabrous or sparsely hairy on the stem, with scattered short, conical, antrorse hairs confined to the adaxial surface, midvein, and leaf margins. The mericarp surfaces in both taxa were characterized by polygonal epidermal cells with a reticulate pattern and irregular outlines; however, these cells were transversely elongated in *G. verum* subsp. *verum*. Deep surface folds were observed in both taxa, while slit-like structures were detected exclusively in *G. verum* subsp. *verum*. Epidermal cells adjacent to the mericarp attachment region were polygonal, whereas those on the stalk surface were elongated-rectangular, and contained stomata.

Key Words: *Galium*, Rubiaceae, morphology, micromorphology, SEM, diagnostic characters

,

ORAL PRESENTATION

WILD EDIBLE FRUITS: USE IN TRADITIONAL MEDICINE

Sezai Ercişli[1], Ishak Bayyigit[2], Mehmet Ramazan Bozhüyük[3]

[1]Atatürk University, Faculty of Agriculture, Department of Horticulture, 25240 Erzurum, Türkiye
[2]Mardin Artuklu University, Kızıltepe Faculty of Agriculture Science and Technology, Department of Horticulture, 47400 Kızıltepe-Mardin, Türkiye
[3]Iğdır University, Faculty of Agriculture, Department of Horticulture, 76100 Iğdır, Türkiye
Correspondance: sercisli@gmail.com

Fruit cultivation is considered a very important industry worldwide and provides high economic income. Fruit varieties with different characteristics generally contain high water content, fiber, sugar, antioxidants, vitamins, and organic acids, and therefore serve as a fundamental source for human nutrition. There is a strong correlation between fruit consumption and healthy living. Compared to cultivated fruit varieties, wild edible fruits, being fruits that grow in their natural environment, are not exposed to pesticides and chemical fertilizers. These characteristics place them in the healthy food category. Wild edible fruits play a very important role in meeting the nutritional needs of local and tribal populations worldwide. Wild edible fruits have an important place in traditional medicine as they are reported to cure numerous ailments, including microbial infections, respiratory, dermatological, and gastrointestinal disorders. Wild edible fruits have attracted the attention of researchers in obtaining bioactive compounds with promising therapeutic potential. They are noted to be rich in phytochemicals such as flavonoids, anthocyanins, and alkaloids. For villagers and locals, wild berries are also an important source of medicine. Therefore, they have great potential in the prevention and treatment of numerous diseases.

Key Words: Wild fruits, ethnobotany, edible plants, folk medicine, secondary metabolites

ORAL PRESENTATION

HERB-DERIVED ESSENTIAL OILS AS SUSTAINABLE BIOSTIMULANTS FOR STRAWBERRY MICROPROPAGATION

Rym Chaouch[1], Sihem Soufi[1], Zayneb Kthiri[2], Taoufik Bettaieb[1]

[1]Laboratory of Horticultural Sciences, Department of Agronomy and plant Biotechnology, National Agronomic Institute of Tunisia (INAT), The University of Carthage (UCAR), 43 Av. Charles Nicolle, 1082 Tunis, Tunisia
[2]Laboratory of Genetics and Cereal Breeding, The National Agronomic Institute of Tunisia (INAT), The University of Carthage (UCAR), 43 Av. Charles Nicolle, 1082 Tunis, Tunisia
Correspondance: rym_chaouch@yahoo.com

This study aimed to develop an efficient *in vitro* rooting system for strawberry using essential oils (EOs) as natural alternatives to synthetic growth regulators in Murashige and Skoog (MS) medium. Essential oils from *Thymus capitatus* and *Salvia rosmarinus* Spenn. were evaluated at different concentrations to determine their effectiveness in inducing root formation. Micro shoots were cultured on auxin-free MS medium supplemented with thyme (TEO) or rosemary (REO) essential oils and compared with indole-3-butyric acid (IBA) treatments. All treatments successfully induced rooting, indicating that IBA is not essential for root induction in strawberry micropropagation. The best rooting responses were obtained with REO at 100 ppm and TEO at 10 ppm after 30 days. Plantlets treated with REO (100 ppm) also showed the highest growth rate during acclimatization. These findings highlight the potential of essential oils as eco-friendly biostimulants and sustainable alternatives to synthetic hormones for improving the rooting and establishment of micropropagated strawberry plants.

Key Words: *Fragaria×ananassa* Duch, *in vitro* rooting, MS auxin-free medium, *Salvia rosmarinus* Spenn. *Thymus capitatus* L., biostimulants

ORAL PRESENTATION

TOXICOLOGICAL COMPARISON OF ESSENTIAL OILS DERIVED FROM *MELALEUCA ALTERNIFOLIA* AND *LAURUS NOBILIS* AND THEIR MAJOR BIOACTIVE COMPOUNDS ON KEY AGRICULTURAL PEST SPECIES

Salih Chibani, **Meriem Boukabache**

Laboratoire de biochimie appliquée. Université Constantine 1 frères Mentouri. Algeria
Correspondance: schibani.bot@gmail.com

Modern agricultural methods often harm ecosystems, despite the availability of more sustainable and eco-friendly alternatives. This study compares the toxicological properties and biosurveillance potential of two essential oils *Melaleuca alternifolia* and *Laurus nobilis* and their major compounds against three key agricultural pests: *Myzus persicae*, *Rhopalosiphum maidis*, and *Aphis fabae*. *Melaleuca alternifolia* essential oil and its main constituents, α-Terpinene and p-Cymene, demonstrated strong contact and fumigant toxicity. Contact bioassays showed the highest susceptibility in *M. persicae* (LC_{50} = 0.008 µL/adult), followed by *R. maidis* (LC_{50} = 0.026 µL/adult) and *A. fabae* (LC_{50} = 0.039 µL/adult). Fumigant tests resulted in 100% mortality of *A. fabae* within 12 hours, while *M. persicae* and *R. maidis* reached 100% mortality after 48 hours at 0.06 µL/cm^3. Among the major compounds, p-Cymene exhibited greater toxicity than α-Terpinene, with LC_{50} values between 0.072 and 0.091 µL/adult (contact) and between 0.071 and 0.15 µL/cm^3 (fumigant). In comparison, *Laurus nobilis* essential oil and its main components, methyleugenol and 1,8-cineole, also demonstrated significant insecticidal activity. However, higher concentrations and longer exposure times were required. 100% mortality was achieved only after 72 hours at 0.06 µL/cm^3 for *A. fabae*, and at 0.09 µL/cm^3 for both *M. persicae* and *R. maidis*. Furthermore, the essential oil was consistently more effective than its individual major compounds in all bioassays. Comparative analysis based on LC_{50} values indicated that *Melaleuca alternifolia* was more potent than *Laurus nobilis*, showing lower LC_{50} values and faster mortality rates across all tested insects. While synthetic insecticides remain more effective, both essential oils particularly *Melaleuca alternifolia* present promising eco-friendly alternatives for integrated pest management, offering viable strategies for reducing the environmental impact of chemical pesticides.

Key Words: *Melaleuca alternifolia, Laurus nobilis,* contact, fumigant, agricultural pests

ORAL PRESENTATION

EFFECT OF CLOPIDOGREL, BERBERINE, AND THEIR COMBINATION ON HORMONAL PROFILES IN MALE RABBITS

Fayrouz. A. Khaled[1], Marwah. Z Abdulali[2]

[1]Chemistry Department, Faculty of Science, Omar Al-Mokhtar University, El -Beida, Libya
[2]Libyan Academy for Postgraduate Studies, Biomedicine Department
Jabal Al-Akhdar Branch, El -Beida, Libya
Correspondance: fayalzobair@yahoo.com

Clopidogrel, an antiplatelet drug, and berberine, a bioactive alkaloid from medicinal plants, have been investigated for their cardiovascular and metabolic effects. However, their influence on endocrine function, particularly hormonal regulation in male rabbits, remains underexplored. This study aimed to evaluate the effects of Clopidogrel (CLOP), berberine (BBR), and their combination (CLOP+BBR) on key hormonal parameters, including follicle-stimulating hormone (FSH), luteinizing hormone (LH), triiodothyronine (T_3), thyroxine (T_4), and testosterone in male rabbits. Twenty male rabbits were randomly assigned to four groups (n = 5 each): control, CLOP, BBR, and CLOP+BBR. Treatments were administered chronically, and serum samples were collected weekly. Hormonal concentrations were measured using standard immunoassays, and statistical analysis was performed to determine significant differences among groups ($p < 0.05$). FSH, LH, and T_3 levels remained statistically unchanged across all groups. In contrast, T_4 concentrations were significantly elevated in the CLOP and BBR groups compared with the control and CLOP+BBR groups. Testosterone levels showed a significant increase in the CLOP+BBR group relative to CLOP alone, while control and BBR groups exhibited intermediate values. These findings suggest that Clopidogrel and berberine selectively modulate thyroid and gonadal hormones without affecting pituitary gonadotropins in male rabbits. Clopidogrel, berberine, and their combination influence specific hormonal pathways, with combined treatment notably enhancing testosterone levels. These results highlight the potential endocrine effects of berberine and its interaction with conventional drugs, emphasizing the importance of hormonal monitoring in pharmacological and nutraceutical studies.

Key Words: Clopidogrel, berberine, male rabbits, hormonal profile, endocrine function

ORAL PRESENTATION

EFFECT OF *ZIZIPHUS SPINA-CHRISTI* EXTRACT ON HEMATOLOGICAL PARAMETERS IN MALE RABBITS

Fayrouz. A. Khaled[1] , Asma .I. Ahmed[2]

[1]Chemistry Department, Faculty of Science, Omar Al-Mokhtar University, El -Beida-Libya
[2]Libyan Academy for Postgraduate Studies, Biomedicine department
Jabal Al-Akhdar Branch, El -Beida-Libya
Correspondance: fayalzobair@yahoo.com

Ziziphus spina-christi, a medicinal plant widely used in traditional medicine, is recognized for its bioactive compounds with antioxidant, anti-inflammatory, and hematopoietic properties. However, its impact on blood parameters in experimental animals remains underexplored. This study aimed to evaluate the effects of *Z. spina-christi* extract on hematological parameters in male rabbits, focusing on red and white blood cells, platelets, and erythrocyte indices. Male rabbits were divided into control and treatment groups (n = 5 per group). The treatment group received *Z. spina-christi* extract chronically, and blood samples were collected to assess complete blood counts, including red blood cells (RBCs), white blood cells (WBCs), platelets (PLT), hemoglobin (Hb), hematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC). Data were analyzed statistically to identify significant differences ($p < 0.05$). Treatment with *Z. spina-christi* extract significantly increased RBC counts ($p = 0.001$) while reducing WBC and platelet counts ($p = 0.011$ and 0.002, respectively). Hemoglobin and hematocrit levels were not significantly altered. Significant decreases in MCV and MCH were observed ($p < 0.001$), whereas MCHC remained unchanged. These findings indicate a selective modulation of erythrocyte indices and leukocyte and platelet profiles without inducing anemia. *Z. spina-christi* extract exhibits a modulatory effect on hematological parameters in male rabbits, enhancing erythrocyte numbers while reducing leukocytes and platelets. These results suggest potential applications of this plant in supporting hematopoietic health and regulating blood cell profiles in experimental models.

Key Words: *Ziziphus spina-christi*, hematology, male rabbits, medicinal plants

ORAL PRESENTATION

SUSTAINABLE VALORIZATION OF MEDICINAL AND AROMATIC PLANTS FROM THE MOROCCAN CENTRAL RIF: BRIDGING BIODIVERSITY, ECO-FRIENDLY INNOVATION AND SMART DIGITAL MARKETING

Alami Khaoula[1], Harrak Hasnaâ[2]

[1]Research Unit for Resilient Agricultural Systems Development in the Central Rif, Al Hoceima, Regional Centre for Agricultural Research of Tangier, National Institute for Agricultural Research (INRA), Avenue Ennasr, PO Box 514, Rabat, Morocco
[2]Laboratory of Agri-Food Technology and Quality, Regional Centre for Agricultural Research of Marrakesh, National Institute for Agricultural Research (INRA), Avenue Ennasr, PO Box 514, Rabat, Morocco, E-mail: Correspondance: khaoula.alami@inra.ma

Central Rif in Northern Morocco hosts a diverse array of medicinal and aromatic plants (MAPs) with therapeutic, cosmetic, culinary, and industrial values. Species such as thyme, lavender, and rosemary play a crucial role in the region economic development and underpin the distinctiveness of local or *terroir* products, including honey. This review examines the potential of these resources and how they can be sustainably exploited to support circular economy. A scoping review methodology is employed to map relevant literature on recent advances in eco-friendly practices. Data are categorized according to the most widespread species in Central Rif, the applied valorisation processes, quality enhancement measures and standards, as well as recent technological and scientific advances in the world. By integrating traditional knowledge developed by indigenous population with green innovation, Central Rif's MAPs can provide a model for sustainable resource management, biodiversity conservation, promotion and community-based economic empowerment. The findings demonstrate that organic cultivation, green extraction technologies, and circular economy applications utilizing plant by-products contribute to development of innovative and eco-friendly formulations. Phytochemical studies show high levels of bioactive compounds such as phenolic compounds, flavonoids, and essential oils, enabling applications in pharmaceuticals, functional foods, and cosmetics. However, challenges, including quality standardization, overexploitation, and habitat preservation, need to be addressed. The increasing demand for natural and organic products presents an incentive for cooperatives, predominantly feminines, to develop innovative green formulations that meet consumer needs. By leveraging online platforms, social media, and e-commerce tools, cooperatives can reach large clientele, and communicate the distinctive qualities of local species. Furthermore, digital strategies facilitate traceability, labelling, and storytelling, which enhance the perceived value of MAPs based products and support the development of niche markets. Indeed, alliances aimed at creating capacity-building programs focused on sustainable valorisation and digital marketing are crucial for MAPs promotion and local economy growth.

Key Words: Moroccan Central Rif, medicinal and aromatic plants, eco-friendly innovation, sustainable practices, digital strategies, cooperatives

ORAL PRESENTATION

BUCKWHEAT (FAGOPYRUM ESCULENTUM MOENCH) AS A FUNCTIONAL MEDICINAL-ASSOCIATED CROP: AGRONOMIC EVALUATION OF GENOTYPES FOR MEDITERRANEAN AGROECOSYSTEMS

Rea Tako, Najada Kadiasi, Esmeralda Alushi, Alban Ibraliu

Department of Agronomic Sciences, Faculty of Agriculture and Environment, Agricultural University of Tirana, Tirana,1001, Albania
Correspondance: rtako@ubt.edu.al

Buckwheat (*Fagopyrum esculentum* Moench) is increasingly recognized as a multifunctional crop with significant potential in sustainable agriculture, functional food systems, and medicinal plant-associated production. Beyond its role as a pseudo-cereal, buckwheat is known for its richness in bioactive compounds such as flavonoids (e.g., rutin), which are widely utilized in herbal, pharmaceutical, and nutraceutical applications. This study aimed to evaluate the agronomic performance and adaptability of four buckwheat genotypes (Panda, Korona, Smuga, and Borovci) under Mediterranean conditions in Valias, Albania. A field experiment was conducted in 2025 using a randomized complete block design with three replications under low-input conditions, without fertilization, irrigation, or chemical plant protection. Biometric and agronomic parameters, including plant height, branching, phenological stages, biomass, grain yield, and thousand kernel weight, were assessed.S ignificant differences among genotypes were observed. Korona exhibited earlier maturity, while Panda and Borovci showed higher biomass and yield potential, while Smuga demonstrated intermediate performance. In addition to agronomic traits, the extended flowering period and high nectar production highlight buckwheat's value as a pollinator-supporting species, linking it to honeybee products and agroecological services. The results indicate that buckwheat can be successfully integrated into Mediterranean agroecosystems as a functional crop, contributing to diversification, sustainable production, and potential applications within medicinal and aromatic plant systems.

Key Words: Buckwheat, functional crop, medicinal plants, Mediterranean agriculture, bioactive compounds, pollinators

ORAL PRESENTATION

EFFECTS OF DIFFERENT PLANT DENSITIES AND HUMIC ACID DOSES ON SOME AGRONOMIC TRAITS OF *DRACOCEPHALUM MOLDAVICA* L.

Nilüfer Koçak Şahin, Ehsan Khadem Arabbaghi, Dilek Başalma

Department of Field Crops, Faculty of Agriculture, Ankara University, Ankara, Türkiye
Correspondance: dlkbasalma@gmail.com

This study was conducted during the 2014 and 2015 growing seasons at the experimental fields of the Faculty of Agriculture, Ankara University, to determine the adaptation of *Dracocephalum moldavica* L. under Ankara ecological conditions and to evaluate the effects of different plant densities and humic acid doses on yield and quality parameters. The experiment was arranged in a split-plot design based on a randomized complete block design with four replications. Plant density treatments were assigned to main plots, while humic acid doses were allocated to subplots. Plant densities consisted of 40 × 20 cm, 30 × 20 cm, 40 × 30 cm, and 30 × 30 cm spacings, whereas humic acid doses were applied at 0, 2, 4, and 6 L da^{-1}. Approximately one week after transplanting, humic acid was applied to the soil between rows. The humic acid fertilizer used in the study was a liquid form extracted from leonhardite containing 17% humic acid. Plants were harvested at the full flowering stage in both years, and measurements were taken for plant height, number of branches, fresh herbage yield, dry herbage yield, fresh leaf yield, dry leaf yield, and leaf ratio. The data obtained in both years were analyzed according to the split-plot design using the MSTAT-C statistical software, including mean comparisons and dependency analyses. The results indicated that plant density had no significant effect on plant height, number of branches, and leaf ratio, whereas it significantly affected fresh herbage yield, dry herbage yield, fresh leaf yield, and dry leaf yield. On the other hand, humic acid doses did not have a significant effect on the examined traits. It is suggested that higher yields can be achieved with increased plant density. Although humic acid application did not show a short-term effect on yield, it is expected to contribute positively to yield and quality in the long term.

Key Words: *Dracocephalum moldavica* L., plant density, humic acid, dry herbage yield

ORAL PRESENTATION

USE OF SPONTANEOUS PLANTS AS SOURCES OF TRADITIONAL MEDICINES IN SOUTH ALGERIA

Diab Nacima, Boucif Asma[2], Abbas Saliha[1], Ouamane Abdelmoneim Tarek[1]

[1]Scientific and Technical Research Center on Arid Regions, PoBox 1682 Rp 07000, Biskra, Algeria
[2]Biological Sciences Department, Mohamed Khider University, PoBox 145 Rp 07000, Biskra, Algeria
Correspondance: diab_nassima@yahoo.fr

Poisonous spontaneous plants in South Algeria have long been used traditionally as medicinal remedies. This study examined the use of poisonous wild plants as traditional medicines in Biskra, highlighting their ecological diversity and environmental adaptations. Using a questionnaire survey containing 300 items was developed and distributed in the region. The survey shows that the majority of respondents (65%) are between 30 and 60 years old, with women (59%) being more involved than men (41%). Most live in the outskirts of Biskra (62%), university graduates (36%) are the most knowledgeable. *Citrullus colocynthis*, *Ruta chalepensis*, and *Thapsia garganica* were among the most commonly used plants in the region used to treat digestive (20%) and dermatological (20%) disorders. Leaves are most used (38%) administered orally (54%) with common preparations decoctions (33%) and powders (29%). Measured by handful (55%) by spoonful (25%) and by a pinch (20%). Digestive toxicity is most common (30%), followed by skin, nerve, and kidney effects (15%). Medicinal plants contain both beneficial and toxic compounds, making extracts promising yet risky. Proper identification, characterization, and quantification are essential for safe and effective use.

Key Words: ethnobotanical, inventory, safe use, traditional medicine, toxic plants

ORAL PRESENTATION

PHYTOCHEMICAL ANALYSIS AND EVALUATION OF ANTIOXIDANT ACTIVITY OF ALGERIAN CLUSIUS'S ROCK ROSE (*CISTUS CLUSII*)

Bouhenni Hasna[1], Doukani Koula[1,2], Mouaz Salima[1]
Benbrahim Louiza[1]Amira[1], Khelifa Khadidja[1]

[1]Department of Biology, Faculty of Nature and Life Sciences, University of Ibn Khaldoun 14000, Tiaret, Algeria
[2]Laboratory of Laboratory of Sciences and Technics of Animal Production, University of Abdelhamid Ibn Badis, 27000, Mostaganem, Algeria
Correspondance: k_doukani@univ-tiaret.dz

Many plants are recognized for their use in traditional medicine to treat a variety of conditions, including inflammatory diseases. *Cistus clusii* is a therapeutic herbaceous species in the *Cistaceae* family. The main aim of this study was to evaluate the antioxidant activity and analyze the phytochemical properties of ethanolic and aqueous extracts derived from the leaves of this plant. Results showed that both ethanolic and aqueous extracts contained high concentrations of phenolic compounds, including total polyphenols, flavonoids, condensed and hydrolysable tannins. Phytochemical analysis revealed varying concentrations of bioactive compounds. The 70% ethanolic extract is characterized by a higher content of total polyphenols, with a value of 20.66 ± 0.76 mg EAG/g. Flavonoids are also more abundant in this 70% ethanolic extract, with a concentration of 115.13 ± 0.92 mg EQ/g. Condensed tannins and hydrolysable tannins are also more abundant in the ethanolic extracts, with particularly high values for the 70% extract, namely 56.61 ± 0.83 mg CT/g and 11.20 ± 0.40 mg HT/g respectively. Phytochemical screening revealed the presence of several important compounds, including anthocyanins, flavonoids, polyphenols, terpenoids, gall tannins, total tannins and saponosides. Antioxidant activity, measured by the DPPH method, proved powerful, with IC50 values of 1.7mg/ml for 70% ethanolic extracts.

Key Words: *Cistus clusii*, extracts, phytochemical, antioxidant activity, DPPH

ORAL PRESENTATION

IMPACT OF MULCHING ON BIOMASS AND ESSENTIAL OIL PROFILE OF *THYMBRA SPICATA* L. VAR. SPICATA GROWN AS AN INTERCROP IN AN OLIVE ORCHARD

Hakan Çetinkaya[1], Hatice Gözel[1], Nazım Şekeroğlu[2],

[1]Department of Horticulture, Faculty of Agriculture, Kilis 7 Aralık University,79000, Kilis, Türkiye,
[2]Department of Biology, Faculty of Science and Literature, Gaziantep University, 27300, Gaziantep, Türkiye
Correspondence: hcetinkaya@kilis.edu.tr

This study evaluated the effects of black polyethylene mulching on the vegetative growth and essential oil profile of *Thymbra spicata* L. var. spicata, grown as an intercrop in an olive orchard. Essential oils from the aerial parts were extracted via hydrodistillation and analyzed by GC-MS. The results showed that mulching significantly increased canopy diameter, spike length, and fresh and dry biomass compared to unmulched conditions. Additionally, the essential oil yield was higher with mulching (1.95%) than without (1.67%). GC-MS identified 20 major compounds in the oils. Both cultivation conditions featured γ-Terpinene and 4-Hydroxy-3-methylacetophenone as the dominant components. Mulching increased the p-Cymene/o-Cymene ratio, while unmulched cultivation yielded higher proportions of Caryophyllene and Thymol. In conclusion, black polyethylene mulching is an effective agronomic practice to enhance both the biomass and essential oil yield of *T. spicata*.

Key Words: *Thymbra spicata* L. var. *spicata*, mulching, essential oil composition, intercropping system, GC–MS analysis

ORAL PRESENTATION

SUPERFOOD CHARACTERISTICS OF SEEDS FROM DIFFERENT OKRA (*ABELMOSCHUS ESCULENTUS* L.) GENOTYPES GROWN IN TÜRKIYE

Semiye Burcin Karakoc[1], Hasene Keskin Cavdar[2], Nazım Sekeroglu[3]

[1]Kilis 7 Aralik University, Faculty of Agriculture, Department of Horticulture, 79000, Kilis, Türkiye
[2]Gaziantep University, Faculty of Engineering, Department of Food Science, 27310, Gaziantep, Türkiye
[3]Gaziantep University, Faculty of Art and Sciences, Department of Biology, 27310, Gaziantep, Türkiye
**Correspondance: nsekeroglu@gmail.com; nazimsekeroglu@gantep.edu.tr*

Okra (*Abelmoschus esculentus* L.) seeds are gaining attention as a potential superfood due to their high nutritional and bioactive compound content. Besides the fresh and dried pods, the seeds have been used for food, feed and medicinal purposes during the long human history. Having high content of the fatty oil (20-40%) and distinctive protein composition (up to 37%) having high content of lysine and tryptophan amino acid, the okra seeds are assumed as a superfood. The seeds have also good amount of dietary fiber, phenolic compounds, along with essential minerals, as well. This study aimed to evaluate the superfood characteristics of the seeds obtained from different okra genotypes (two commercial variety as Bornova-2003 and Marmara-1, and five local genotypes as Mugla, Amasya, Samsun, Adıyaman and Mersin) grown under field conditions in Gaziantep and Samsun cities of Türkiye in 2025 growing season. The results demonstrate that okra seeds from selected Turkish genotypes possess enhanced nutritional and bioactive profiles, supporting their classification as a *superfood* and their potential utilization in nutraceutical and food industry applications. Further exploration of genotype × environment interactions and processing effects on bioactivity is recommended to optimize the functional value of okra seed products.

Keywords: *Abelmoschus esculentus*, okra seed, superfood, bioactive compounds, antioxidant activity, genotype, Türkiye

POSTER PRESENTATION

Poster Presentations

POSTER PRESENTATION

FROM GOLD STANDARD QUALITY TO PHARMACOKINETIC INSIGHT: A COMBINED ISO 3632 AND ADMET STUDY OF MOROCCAN TALIOUINE SAFFRON

Maroua Ait Tastift, Fatima Zohra Taleb, Chemseddoha Gadhi

Laboratory of Excellence in Agrobiotechnology and Bioengineering, AgroBiotech Centre, Research Unit Accredited by CNRST (URL05-CNRST), Plant Resources Protection and Valorization Team. Faculty of Sciences Semlalia, Cadi Ayyad University Marrakech, 40 000, Morocco
Correspondance: dgadhi@uca.ac.ma

Saffron (*Crocus sativus* L.) is a high-value natural product widely recognized for its culinary, economic, and pharmacological importance. Its quality and bioactivity are mainly attributed to apocarotenoids responsible for color, taste, and aroma. The present study aimed to evaluate the chemical quality of saffron from the Taliouine region (Morocco) following ISO 3632 guidelines and to predict the pharmacokinetic and toxicological (ADMET) properties of its principal bioactive compounds. Chemical characterization was conducted using UV–Visible spectrophotometry according to ISO 3632 standards, which assess specific absorbance values associated with coloring strength (crocin), bitterness (picrocrocin), and aroma (safranal). The analytical results classified Taliouine saffron in the first quality category, indicating high coloring power and a rich content of characteristic metabolites. In addition, an in silico ADMET analysis was carried out using the pkCSM web server for crocin, picrocrocin, and safranal. The predictions indicated distinct pharmacokinetic profiles among the compounds. Overall, the in silico toxicological assessment did not reveal major safety concerns within the evaluated thresholds. In conclusion, the combined application of ISO 3632 quality assessment and in silico ADMET prediction provides a comprehensive strategy to authenticate saffron quality and preliminarily estimate the pharmacological potential of its main constituents. These findings highlight the scientific and therapeutic value of Moroccan saffron and support further biological and clinical investigations.

Keywords: Moroccan saffron, ISO 3632, crocin, picrocrocin, safranal, ADMET, pkCSM

Acknowledgment: This work was supported by the 4th edition of the Program for the Valorization of Medicinal and Aromatic Plants (VPMA4-2022/12), co-financed by the National Center for Scientific and Technical Research (CNRST) of the Kingdom of Morocco, the National Agency for Medicinal and Aromatic Plants (ANPMA), and Cadi Ayyad University (UCA) of Marrakech. (2022-2025).

POSTER PRESENTATION

SELECTIVE ACTIVITY OF NOVEL OLEANOLIC ACID DERIVATIVES IN A375 MELANOMA CELLS

Diana Ungureanu (Similie)[1,2,3], Bora Larisa[1,3], Diana Haj Ali[2,4,5], Māris Turks[6] Cristina Adriana Dehelean[4,5], and Corina Danciu[1,3]

[1] Department of Pharmacognosy, Faculty of Pharmacy, "Victor Babeş" University of Medicine and Pharmacy, 300041, Timişoara, Romania
[2] Doctoral School, "Victor Babeş" University of Medicine and Pharmacy, 300041, Timişoara, Romania.
[3] Research and Processing Center of Medicinal and Aromatic Plants, "Victor Babeş" University of Medicine and Pharmacy Timişoara, 300041 Timişoara, Romania
[4] Department of Toxicology, Drug Industry, Management and Legislation, Faculty of Pharmacy, "Victor Babeş" University of Medicine and Pharmacy, 300041, Timişoara, Romania
[5] Research Centre for Pharmaco-Toxicological Evaluation, "Victor Babeş" University of Medicine and Pharmacy Timişoara, 300041 Timişoara, Romania
[6] Institute of Chemistry and Chemical Technology, Faculty of Natural Sciences and Technology, Riga Technical University, LV-1048, Riga, Latvia
Correspondance: diana.similie@umft.ro

Approximately 80% of new anti-cancer drugs currently used in clinical practice are derived from or originate from natural sources [1]. Melanoma is the most aggressive type of skin cancer. Its treatment represents a significant challenge on a global scale. Oleanolic acid (OA), a pentacyclic triterpenoid, exhibits considerable anti-cancer potential; however, its poor solubility and bioavailability limit its clinical use. In this regard, Lugiņina *et al.* [2] synthesized oleanonic acid (OoA) - the 3-oxo analog of OA, along with three novel phosphonate derivatives of OA and OoA: OPm, OP, and OoPm. This study investigated the *in vitro* anti-melanoma potential of OA, OPm, OP, OoA, and OoPm, along with their selectivity towards cancer cells. The antiproliferative activity was evaluated on A375 melanoma cells and HaCaT keratinocytes (72 h of incubation; 1, 10, 25, 50, and 75 µM) using the MTT method. The cytotoxicity against the A375 cell line was determined by the LDH method (72 h of incubation; 1 - 75 µM). The exploration of intracellular oxidative stress induced by OoA was performed using the ROS assay (A375 cells; 72 h of exposure; 1 - 75 µM). The MTT assay revealed that all the tested compounds decreased the A375 cell viability in a dose-dependent manner. OoPm determined a significant reduction in the viability of both A375 and HaCaT cells. In contrast, OoA exhibited great potency and selectivity towards melanoma cells, with IC_{50} values of 1.073 µM for A375 cells and 109.6 µM for HaCaT cells. The LDH assay showed that OA and its derivatives exhibited modest cytotoxicity against A375 cells, while OoPm determined significant cytotoxicity (~50% of LDH release). Within the ROS assay, OoA demonstrated increased ROS production in melanoma cells at concentrations ranging from 1 to 25 µM. In conclusion, these findings emphasize the potential of the tested compounds as anti-melanoma agents.

Key Words: pentacyclic triterpenoids, phosphonate derivatives, melanoma

Acknowledgements: Doctoral School of "Victor Babeş" University of Medicine and Pharmacy Timişoara.

References

[1] Markov, A.V., Zenkova, M.A., and Logashenko, E.B., 2017. Modulation of tumor-related signaling pathway by natural pentacyclic triterpenoids and their semisynthetic derivatives. Current Topics in Medicinal Chemistry, 24, 1277-1320. https://doi.org/10.2174/0929867324666170112115313.

[2] Lugiņina, J., Kroškins, V., Lācis, R., Fedorovska, E., Demir, Ö., Dubnika, et al. 2024. Synthesis and Preliminary Cytotoxicity Evaluation of Water-Soluble Pentacyclic Triterpenoid Phosphonates. Scientific Reports, 14 (1), 1–15. https://doi.org/10.1038/s41598-024-76816-w.

POSTER PRESENTATION

ANTI-UREASE ACTIVITIES OF THE NATURAL COUMARINS FROM APIACEAE PLANTS

Turgut Taşkın[1], Fatma Tosun[2], Feyyaz Mıhoğlugil[3]
Demet Akalgan Aklar[4], Mahmut Miski[5]

[1] Department of Pharmacognosy, Faculty of Pharmacy, Marmara University,34854, İstanbul, Türkiye
[2] Department of Pharmacognosy, School of Pharmacy, İstanbul Medipol University,34810, İstanbul, Türkiye
[3] Faculty of Pharmacy, Bahçeşehir Cyprus University, Nicosia, Northern Cyprus
[4] Department of Pharmacy Business Administration, Faculty of Pharmacy, İstanbul University-Cerrahpaşa,34320, İstanbul, Türkiye
[5] Department of Pharmacognosy, Faculty of Pharmacy, İstanbul University,34116, İstanbul, Türkiye
Correspondance: feyyazmihoglugil@gmail.com

Helicobacter pylori are known to cause chronic inflammation and is closely associated with peptic ulcers, gastric adenocarcinoma, and MALT (mucosal-associated lymphoid tissue) lymphoma [1]. *H. pylori* convert urea into carbon dioxide and ammonia through the urease enzymes it produces. Urease is well-known in pathologies caused by *Helicobacter pylori*; it helps bacteria survive in the acidic environment of the stomach and plays an important role in the pathogenesis of gastric and peptic ulcers, as well as cancer [2]. Coumarins are isolated from many plant species, especially of the family Apiaceae [3]. Coumarins derivatives have several biological and therapeutic properties such as anti-*H. pylori* activity [4]. Twenty natural coumarin derivatives; badrakemin (1), colladonin (2), 14'-acetoxybadrakemin (3), anatolicin (4), 14'-hydroxycolladonin (5), badrakemone (6), karatavicinol (7), 14'-acetoxybadrakemone (8), 14'-acetoxycolladonin (9), colladonin acetate (10), 14'-hydroxybadrakemin (11); deltoin (12), smyrnioridin (13), isoimperatorin (14), oxypeucedanin (15), bergapten (16), osthol (17), 4'-senecioyloxyostol (18), neopapillarine (19), and scoparone (20) were tested for their inhibitor activity against urease enzyme. Deltoin (12), isoimperatorin (14), osthol (17), scoparone (20), 14'-acetoxybadrakemone (8), and smyrnioridin (13) have shown significant urease inhibition activity with IC_{50} values of 13.1, 19.6, 20.0, 24.7, 25.5, and 29.0 μM, respectively compared to the reference thiourea (IC_{50} 182 μM).

Key Words: Coumarin, anti-urease, Apiaceae

References

[1] Ullah, O., Rahman, H., Ijaz, S. 2025. *Helicobacter pylori*-associated infection: A comprehensive histopathological analysis of gastric biopsies from patients of Pakistan. Microbiology Research, 16(232). https://doi.org/10.3390/microbiolres16110232
[2] Asghar, H., Asghar, H., Asghar. T. 2021. A review on anti-urease potential of coumarins. Current Drug Targets, 22(17), 1926-1943. https://doi.org/10.2174/1389450122666210222091412
[3] Reddy, D.S., Kongot, M., Kumar, A. 2021. Coumarin hybrid derivatives as promising leads to treat tuberculosis: Recent developments and critical aspects of structural design to exhibit anti-tubercular activity. Tuberculosis, 127, 102050. https://doi.org/10.1016/j.tube.2020.102050
[4] Jadhav, S.G., Meshram, R.J., Gond, D.S., Gacche, R.N. 2013. Inhibition of growth of *Helicobacter pylori* and its urease by coumarin derivatives: Molecular docking analysis. Journal of Pharmacy Research, 7(8), 705-711. https://doi.org/10.1016/j.jopr.2013.09.002

POSTER PRESENTATION

BIOACTIVITY-GUIDED ISOLATION OF CHRYSIN FROM SCUTELLARIA GALERICULATA L. WITH ANTI-INFLAMMATORY AND ANTIOXIDANT POTENTIAL

Gülsüm Metkin[1], İpek Süntar[2], Çiğdem Kahraman[3]
Fatma Sezer Şenol Deniz[2], Osman Tugay[4]

[1]Department of Pharmacognosy, Faculty of Pharmacy, Selcuk University, Konya, Türkiye
[2]Department of Pharmacognosy, Faculty of Pharmacy, Gazi University, Ankara, Türkiye
[3]Department of Pharmacognosy, Faculty of Pharmacy, Hacettepe University, Ankara, Türkiye
[4]Department of Pharmaceutical Botany, Faculty of Pharmacy, Selcuk University, Konya, Türkiye

Species of the genus *Scutellaria* have been traditionally used in herbal medicine and are reported in the literature to possess significant anti-inflammatory, antioxidant, and antimicrobial activities. In the present study, the in vitro antioxidant and anti-inflammatory activities of extracts obtained from five *Scutellaria* species naturally distributed in the flora of Türkiye, *Scutellaria albida* L. subsp. *albida*, *Scutellaria altissima* L., *Scutellaria diffusa* Benth., *Scutellaria galericulata* L., and *Scutellaria pontica* K. Koch, were evaluated. Methanolic extracts were prepared from both the roots and aerial parts of the selected species due to the high extraction efficiency of methanol for a wide range of bioactive phytochemicals. A total of ten methanolic extracts were subjected to in vitro activity-guided assays targeting cyclooxygenase-2 (COX-2) and 5-lipoxygenase (5-LOX) inhibition. Among the tested samples, the methanolic extract of the aerial parts of *S. galericulata* exhibited the most pronounced activity, with COX-2 and 5-LOX inhibition values of 90.80 ± 0.16% and 82.70 ± 2.20%, respectively. This extract was therefore selected for further activity-guided fractionation. Liquid–liquid partitioning yielded five sub-extracts, among which the dichloromethane (DCM) fraction demonstrated the strongest inhibitory activity (COX-2: 86.62 ± 1.26%; 5-LOX: 93.92 ± 1.90%). Subsequent chromatographic separation of the DCM fraction using Sephadex LH-20 produced 42 fractions, which were combined into five main fractions based on similarity. Activity-guided evaluation identified Fraction E as the most potent (COX-2 IC_{50} = 1.27 ± 0.01). Further purification using advanced chromatographic techniques led to the isolation of the major active compound, identified as chrysin. Chrysin was also detected in Fraction F and subsequently isolated using chromatographic methods. These findings indicate that *S. galericulata* is a promising natural source of bioactive compounds with significant anti-inflammatory potential. The isolated flavonoid chrysin may contribute to the observed biological activity and could represent a potential lead compound for the development of therapeutic agents targeting inflammatory pathways.

Key Words: *Scutellaria galericulata, Lamiaceae, bioactivity, anti-inflammatory, flavonoid, chrysin*

Acknowledgement: The authors would like to thank the Turkish Institutes of Health (TUSEB) for supporting this work under project number 33729

POSTER PRESENTATION

EVALUATION OF THE EFFECT OF *FUCUS SPIRALIS* EXTRACT AND PGPR ON *OCIMUM BASILICUM* GROWTH AND DEVELOPMENT UNDER WATER STRESS

Lamia Laadani[1,2], Meriem Rafya[1,2], Aouatif Aboudia[1], Cherki Ghoulam[1], Mimoun El Kaoua[1], Fatiha Benkhalti[2], Naïma Zehhar[1]

[1] Cadi Ayyad University, UCA, Faculty of Sciences and Techniques, Center for Agrobiotechnology and Bioengineering, CNRST Labeled Research Unit., Bd Abdelkrim Khattabi, BP 549, 40000 Marrakesh, Morocco
[2] Cadi Ayyad University, UCA, Faculty of Sciences and Techniques, Sustainable Development and Health Research Laboratory, Bd Abdelkrim Khattabi, BP 549, 40000 Marrakesh, Morocco
Correspondance : n.zehhar@uca.ac.ma

Basil (*Ocimum basilicum*) is an aromatic and medicinal plant widely cultivated and used worldwide, particularly in culinary and pharmaceutical applications. However, exposure to drought conditions induces several physiological and morphological changes that can adversely affect plant growth, yield and biochemical composition. In this context, this study aims to evaluate the effects of a consortium of Plant Growth-Promoting Rhizobacteria (PGPR), namely *Bacillus subtilis* and *Bacillus cereus*, as well as a liquid extract of the seaweed *Fucus spiralis*, on the growth and biochemical composition of basil under water stress conditions. To this end, a greenhouse trial was conducted where plants were treated either with a PGPR consortium or a seaweed extract (SE), under both well-watered and water-stressed conditions. Various biochemical and growth parameters were measured. The results showed that water stress significantly reduced the fresh weight of basil by 63.7%. Among the treatments, the application of SE resulted in the highest growth performance, increasing biomass by a factor of 3.25 compared to untreated plants. Under water deficit conditions, PGPR treatment increased protein content to 21.86 ± 0.68 mg/g. In contrast, SE treatment raised sugar concentrations under both well-watered (0.46 ± 0.01 mg/g) and water-stressed conditions (0.58 ± 0.07 mg/g). PGPRs also improved mineral content, regardless of water availability. Chlorophyll fluorescence was not significantly affected by either water stress or the applied treatment. However, glycine betaine levels decreased by 33.3% under stress conditions in PGPR-treated plant. In addition, peroxidase activity increased under water deficit conditions, with PGPRs further enhancing this activity, reaching 32.82 ± 1.33 mg/g in stressed plants. These findings indicate that water stress markedly reduces basil growth, while both seaweed extract (SE) and PGPR treatments help mitigate its adverse effects through complementary mechanisms. SE primarily promotes sugar accumulation, whereas PGPR enhances protein content, mineral uptake, and antioxidant activity. Together, these treatments represent promising and sustainable strategies for improving basil tolerance to drought conditions.

Key Words: Basil, biochemical composition, growth parameters, PGPR, seaweed extract, water stress

POSTER PRESENTATION

TETRACLINIS ARTICULATA FROM ESSAOUIRA, MOROCCO, AND ITS BIOLOGICAL ACTIVITIES OF PHENOLIC EXTRACTS

Assia Issoughaine[1,2], Hafida Bouamama[1], Ahmed Qaddoury[2]

[1]Cadi Ayyad University of Marrakech, Faculty of Sciences and Techniques, Laboratory of Research on Sustainable Development and Health, 40000, Morocco
[2] Cadi Ayyad University of Marrakech, Faculty of Sciences and Techniques, Laboratory of Agro Biotechnology and Bioengineering, 40000, Morocco
Correspondance: h.bouamama@uca.ac.ma

Tetraclinis articulata, or Berberian thuja, is a resinous conifer belonging to the Cupressaceae family and the only species of the genus *Tetraclinis*. Its components are used in folk medicine to treat respiratory and intestinal infections, childhood fevers, stomach pain, high blood pressure, and diabetes. In this study, a hydroethanolic extract from *Tetraclinis articulata* was screened for in vitro antioxidant, antibacterial, and antifungal properties, as well as for its polyphenol and flavonoid contents. DPPH, FRAP, $ABTS^{+}$, and TAC methods were used for antioxidant activity analysis, while microdilution and disk diffusion methods were designed for antibacterial and antifungal activities, respectively. Tested microorganisms were *Escherichia coli, Pseudomonas aeruginosa, Enterococcus faecalis, Staphylococcus aureus*, and *Fusarium sp*. The result suggests that the leaves of *T. articulata* are richer in total polyphenols (49± 23 mg/g) and flavonoid content (1.9± 0.1mg/g), these compounds have low antioxidant activity (2.89 ± 0.1 mg/mL for antiradical activity (DPPH)), moderate antifungal activity (50% of radial growth inhibition (PRGI) in a concentration of 5 mg/mL), and a remarkable antibacterial propriety (0.08 mg/mL against *Staphylococcus aureus*). These results confirm the traditional uses of *T. articulata* and open up possibilities for its exploitation in the pharmaceutical, cosmetic, and agri-food sectors.

Keywords: *Tetraclinis articulata,* antioxidant activity, antimicrobial activity.

POSTER PRESENTATION

OVERVIEW OF OREGANO PRODUCTION AND NEW APPROACHES

Mükremin Temel[1], A. Bircan Tinmaz[1], Arzu Şen[1], Mustafa Öztürk[1]

Atatürk Horticultural Central Research Institute, Türkiye
Correspondance: mukremintemel@gmail.com

This study aims to provide detailed information on the changes in production, foreign trade (including essential oils) and emerging approaches related to oregano from the early 2000s to the present. The research is based on both primary and secondary data. Production and foreign trade data were obtained from primary sources through screening, filtering, and classification methods and analyzed using descriptive statistics. Emerging approaches were discussed with support from both primary and secondary data. According to the findings, oregano production has increased by approximately 250% since 2002, reaching 24,000 tons over an area of 185,000 decares. This increase in production is largely attributed to oregano exports. Within the total exports of medicinal and aromatic plants, oregano ranks first with a share of 25%. Oregano exports have increased by approximately 450% compared to previous years, reaching 71 million USD, with nearly half of this amount realized through the Aegean Free Zone. It is also observed that oregano essential oil ranks second in total essential oil exports after rose oil. Domestic use is also considered to have a considerable trade volume. The role of exporting companies as the driving force behind growth to date is supported at the producer level by production costs and product purity. While the proportional profit per kilogram was around 2 in favor of producers in the early years, recent trends indicate a decline toward 1, which may pose a potential threat. Product purity is threatened by herbicide-resistant weeds and improper postharvest practices by producers. These two structural factors are particularly important as they determine competitiveness in foreign trade. Despite the increasing trend in both production and foreign trade, it is currently debated whether oregano has reached its peak in terms of production and trade. This situation has led to the emergence of new approaches and strategies. Some stakeholders in the sector believe that growth has not yet been completed; however, they emphasize that further progress cannot be sustained through conventional tools alone, highlighting the necessity of adopting innovative approaches. Moreover, this necessity is considered even more critical in ensuring the sustainability and continuity of the achieved success.

Key Words: oregano, production, foreign trade, emerging approaches

POSTER PRESENTATION

BIOACTIVE COMPOUNDS, LIPID PROFILE, AND ORAL TOXICITY ASSESSMENT OF OPUNTIA FICUS-INDICA SEED OIL: AN IN VIVO SAFETY REPORT

Fatima Ettalibi[1,2,3], Abderraouf El Antari[1], Rachida Makbal[2], Maroua Ait Tastift[2] Houda Elyacoubi[3], Hasnaâ Harrak[1], Chemseddoha Gadhi[2]

[1]Laboratory of Food Technology and Quality, Plant Breeding and Quality Research Unit, Regional Agricultural Research Center of Marrakech, National Institute of Agricultural Research (INRA), Rabat 10090, Morocco
[2]Laboratory of Excellence in Agrobiotechnology and Bioengineering, AgroBiotech Centre, Research Unit Accredited by CNRST (URL05-CNRST), Plant Resources Protection and Valorization Team. Faculty of Sciences Semlalia, Cadi Ayyad University, Marrakech, 40 000, Morocco
[3]Laboratory of Natural Resources and Sustainable Development, Faculty of Sciences, Ibn Tofaïl University, Kenitra, Morocco
Correspondence: dgadhi@uca.ac.ma

Prickly pear seed oil (PPSO) is highly valued for its cosmetic and nutraceutical properties. This study investigated its bioactive compounds, lipid profile, and in vivo safety. The oil color pigment, fatty acid, and triglyceride contents were determined. Acute toxicity was evaluated in mice following a single oral dose of 4 g/kg, monitored over 14 days for behavioral changes, body weight, and food intake. Sub-chronic toxicity was assessed in Wistar rats via daily oral administration (125 and 250 mg/kg) for 28 days. Evaluated parameters included clinical signs, biochemical and hematological constants, and relative organ weights. Results showed that PPSO is rich in bioactives. Alpha-pheophytin and carotenoid levels were higher than chlorophyll. Unsaturated fatty acids dominate the lipid profile (82.9%), primarily linoleic acid (63.5%), followed by oleic acid (18.9%). The main triglycerides were trilinolein (LLL: 25.5%) and oleoyl-dilinoleoyl-glycerol (OLL: 20.9%). Toxicological tests revealed no mortality or behavioral changes in the acute study, indicating a value of LD50 > 4 g/kg. Similarly, sub-chronic administration showed no significant differences in body weight, biochemical constants, or hematological parameters compared to controls. These findings confirm the in vivo safety of PPSO at the tested doses. While its apparent low toxicity supports its use in cosmetic and nutraceutical applications, further specific toxicological studies are encouraged to establish comprehensive safety standards.

Key Words: *Opuntia ficus-indica*, prickly pear seed oil, lipid profile, bioactive compounds, acute and subchronic toxicity, in vivo safety.

Acknowledgments: This work was supported by the 4th edition of the Program for the Valorization of Medicinal and Aromatic Plants (VPMA4-2022/12), co-financed by the National Center for Scientific and Technical Research (CNRST) of the Kingdom of Morocco, the National Agency for Medicinal and Aromatic Plants (ANPMA), and Cadi Ayyad University (UCA) of Marrakech. (2022-2025), and by the Megaproject: "Preservation and development of the cactus sector" - Research axis: "Cactus valorisation for human uses" - of the National Institute of Agricultural Research Medium Term Research Program (INRA of the Kingdom of Morocco, PRMT 2020-2024).

POSTER PRESENTATION

TETRACLINIS ARTICULATA VS *MENTHA SUAVEOLENS* EHRH. SUBSP. *TIMIJA:* BIOLOGICAL ACTIVITIES OF ESSENTIAL OILS

Assia Issoughaine[1,2], Siham Houssayni[1,2], Myriem Youssfi[1,2]
Ahmed Qaddoury[2] Hafida Bouamama[1]

[1]Cadi Ayyad University of Marrakech, Faculty of Sciences and Techniques, Laboratory of Research on Sustainable Development and Health, 40000, Morocco
[2] Cadi Ayyad University of Marrakech, Faculty of Sciences and Techniques, Laboratory of Agro Biotechnology and Bioengineering, 40000, Morocco
Correspondance : h.bouamama@uca.ac.ma

Aromatic and medicinal plants (MAP) have always attracted growing interest due to their potential therapeutic, cosmetic, and culinary properties. Regarding socio-economic importance, Morocco is the world's 12th-largest exporter of these plants. Thanks to their ability to produce a variety of secondary metabolites, MAPs have long been known for their wide therapeutic use against various diseases. To compare MAP, this work aims to investigate the antioxidant and antibacterial properties of *Tetraclinis articulata* and *Mentha suaveolens* Ehrh. subsp. Timija essential oils. To this end, DPPH, FRAP, TAC, and the microdilution method against *Escherichia coli*, *Pseudomonas aeruginosa*, *Enterococcus faecalis*, and *Staphylococcus aureus* were used. The results show that *Tetraclinis articulata* essential oil has the highest yield (0.5 %) compared to *Mentha suaveolens* (0.179 %); it also has the lowest Minimum Inhibitory Concentration (MIC) against Enterococcus faecalis. Tetraclinis articulata exhibits the highest antiradical activity (DPPH) and the greatest reducing capacity (FRAP) in comparison to *Mentha suaveolens*. On the other hand, Mentha suaveolens Ehrh. subsp. Timija essential oil is more interesting for its total antioxidant capacity (TAC) of 0,064 ± 0 mg/mL and its antimicrobial activity against *Escherichia coli*, *Pseudomonas aeruginosa*, and *Staphylococcus aureus*. As a result, the comparison between the two spices depends on the intended use.

Keywords: *Tetraclinis articulata, Mentha suaveolens*, biological activity

POSTER PRESENTATION

UNLOCKING SYNERGY IN MOROCCAN ESSENTIAL OILS: A PROMISING SOURCE OF NATURAL ANTIOXIDANT AND ANTIFUNGAL AGENTS

Bouchra Chebli[1,2], Safaa Bounimi[1], Khadija Basaid[1], Asmaa Mziouid[1], Soukaina Kaoui[1] Safaa Zaidouni[1], Mohamed Berrabah[3], El Hassan Mayad[4]

[1] Laboratory of Mechanic Process Energy and Environment, Environmental engineering and biotechnology team, National School of Applied Sciences, Ibn Zohr University, Agadir, Morocco
[2]Department of Preclinical Sciences, Faculty of Medicine and Pharmacy, Ibn Zohr University, Agadir, Morocco
[3] Laboratory of Solid Mineral and Analytical Chemistry, Department of Chemistry, Faculty of Sciences, Mohammed Premier University, Oujda, Morocco
[4] Laboratory of Biotechnology and Valorization of Natural Resources, Faculty of Sciences of Agadir, Department of Biology, Ibn Zohr University, BP 8106, 80000 Agadir, Morocco
Correspondance: b.chebli@uiz.ac.ma

Among plant extracts, essential oils have been able to attract a lot of interest as a potential source of bioactive natural molecules. The present investigation aimed to evaluate antioxidant and antifungal efficacy of essential oils of four Moroccan wild plants (*Origanum compactum*, *Thymus leptobotrys*, *Kleinia anteuphorbium* and *Warionia saharae*) in combination, along with chemical characterization evaluation. Hydro-distilled essential oils were analyzed by gas chromatography-mass spectrometry (GC/MS). The antioxidant activity was investigated by the free radical capture using DPPH test, and the evaluation of antifungal activity against wild strains of *Penicillium digitatum*, *Penicillium italicum* and *Botrytis cinerea* was made by the poisoned food method. GC-MS analysis identified n-Non-1-one (37.17%) and α-selinene (13.45%) as main constituents of *K. anteuphorbium* oil, and β-Eudesmol (41.56%), p-linalool (20.33%) and trans-nerolidol (13.29%) as the main compounds of *W. saharae* oil. A strong anti-free radical activity was observed for the essential oil of *O. compactum* followed by *T. leptobotrys*. Among the possible combinations tested, *K. anteuphorbium /O. compactum* and *K. anteuphorbium/T. leptobotrys* oil combinations showed the highest synergistic antioxidant potentials. Moreover, the highest antifungal activity against the three phytopathogens was exhibited by essential oils of *O. compactum* and *T. leptobotrys*. Their combination produced a higher inhibitory effect than single EO treatments against *P. digitatum* and *P. italicum*. The synergistic effects observed could be exploited in designing safe and effective novel natural antifungal and antioxidant blend in the food and pharmaceutical industries.

Key Words: Essential oil, antifungal, antioxidant, synergistic

FULL PAPER

Fulltext Papers

FULL PAPER

ANCIENT USES OF MEDICINAL PLANTS IN THE MEDITERRANEAN: AN EXAMINATION OF *MELISSA OFFICINALIS*

Maria Christodoulou Mlis

Clinical Herbalist and Independent Researcher, 11635 Athens, Greece
Correspondance: maria@thegreekherbalist.com

Abstract: Surviving medical texts written by ancient physicians from the Mediterranean region offer valuable insight into how medicinal plants were applied for healing. Many of these ancient uses have not been closely examined to determine continuity of use and potential applications for modern needs. Medicinal plants endemic to the Mediterranean region are especially important for their strong therapeutic value and as markers of cultural heritage. *Melissa officinalis* (Lemon balm), a medicinal and culinary herb native to the Mediterranean region and parts of Africa and Asia, is an important example of continuity of therapeutic applications since antiquity. The plant was written about by Pedanius Dioscorides (1st century CE) in his influential text, *De Materia Medica*, in which he described uses for the respiratory, digestive, and muscular systems, and topical applications. The plant continues to be recommended to support the recovery and healing of these systems in addition to ailments not mentioned or known in antiquity, including for anxiety, viral infections, and fever. From the perspective of a clinical herbalist, these ancient and modern applications will be cross-referenced to determine to what extent ancient medicines compare to modern uses and how ancient uses can inform modern applications for home healthcare and pharmaceutical development. The examination of *Melissa officinalis* can demonstrate the importance of ancient medical knowledge, provide broader understanding of the plant's therapeutic benefits, and suggest additional research for modern therapies. It can also demonstrate the possibilities of uncovering new information on other medicinal plants native to the Mediterranean region written about by ancient physicians.

Key Words: *Melissa officinalis*, Dioscorides, ancient medicine, herbal medicine, Mediterranean region

1. Introduction

Surviving medical texts written by ancient physicians from the Mediterranean region offer valuable insight into how medicinal plants were applied for healing. Most notably, the influential five-volume medical text, *De Materia Medica* (*About Medical Material*), by the Greek physician Pedanius Dioscorides (1st century CE) was referenced by physicians throughout Roman, Byzantine, Classical, Arabic, and early modern European history (Beck, 2020). Many ancient uses of medicinal plants that Dioscorides described have not been closely examined to determine continuity of use and potential applications for modern needs. His plants were primarily endemic to the Mediterranean region, many of which have been recognized for their strong therapeutic value. Studies have shown that herbs grown in the hot and dry conditions of the Mediterranean environment contain a strong profile of therapeutic constituents that contribute to the antioxidant and anti-inflammatory character of the Mediterranean diet (Trajkovska-Broach & Petkoska, 2023). These plants also serve as important markers of cultural heritage, including ancient myths and traditional uses from villages. Examining ancient medical texts can help determine to what extent ancient remedies compare to modern Western uses,

FULL PAPER

identify forgotten ancient uses that may be useful today, and direct new scientific research for potential modern therapies.
For this study, *Melissa officinalis* (Lemon balm) was chosen due to its continuity of therapeutic use since antiquity, its familiarity across many countries, and its cultural significance. The Latin botanical name *Melissa* is the Greek word for honeybee, *mélissa* (μέλισσα), and o*fficinalis* refers to its place in official pharmacopeias. "Balm" is related to the Greek word *bálsamon* (βάλσαμον), meaning "balsam," an aromatic or resinous substance, or a substance that heals and soothes. The plant's name in ancient Greek was *melissóphyllon* (μελισσόφυλλον), meaning "honey-leaf," and similarly in modern Greek, *melissóchorto* (μελισσόχορτο). The plant was known to attract bees. In ancient Greek mythology, a group of nymphs called *melissai* were credited to having discovered honey.

Lemon balm is a well-known medicinal and culinary herb native to the Mediterranean region and parts of Africa and Asia. There are only four accepted *Melissa* species, three of which are native to Asia. *Melissa officinalis* and *M. officinalis* subsp. *officinalis* (syn. *M. officinalis* subsp. *altissima* (Sm.) Arcang.) have been identified in Greece (Hellenic Botanical Society, 2024). Like other Lamiaceae plants, lemon balm has been naturalized in many parts of the world, including the United States where it is common garden herb and popular herbal remedy. Lemon balm is a bushy herbaceous perennial known for its aromatic lemony scent and sour taste with sweet and bitter undertones. Small, two-lipped, white-pink flowers blossom throughout the summer. Like other mint species, it spreads aggressively by rhizomes. Entire stems can be harvested throughout the growing season, but is recommended before or during flowering when essential oils are most concentrated. The plant contains volatile compounds (geranial, neral, citronellal and geraniol), triterpenes (ursolic acid, oleanolic acid), phenolic acids (rosmarinic acid, caffeic acid, chlorogenic acid), flavonoids (quercetin, rhamnocitrin, luteolin), and essential oils (Shakeri et al., 2016).

Lemon balm is used fresh in foods, as a tea infusion, in capsule, distilled as an essential oil, infused in vinegar, made into an oxymel, applied as a poultice, and used in creams, salves, baths, and tinctures. The dried form is most commonly infused as a tea and easily found in herb shops and online retailers. Trained herbalists apply lemon balm for a variety of acute and chronic conditions, primarily for the nervous, respiratory, and digestive systems, typically in combination with other herbs in crafted formulas to meet the personal needs of the individual client.

2. Material and Methods

Ancient and modern sources of the medicinal uses of lemon balm were cross-referenced to determine the similarities and differences in uses from antiquity to today.

2.1. Ancient Resources

The entries for *Melissa* were examined in modern English translations of *De Materia Medica* by Pedanius Dioscorides and in *Naturalis Historia* by Pliny the Elder. Both writers lived in the first century CE and described the medicinal and therapeutic uses for the plant. The writers did not know each other, however. Dioscorides was a Greek physician born in modern-day Turkey who traveled the Mediterranean extensively as a traveling physician, which was common practice at

FULL PAPER

the time. Pliny the Elder was a Roman naturalist, scientist, and commander of the Roman Empire based primarily in modern-day Italy. Their entries exhibit some overlap, suggesting a common understanding of the plant across the region. According to these ancient texts, lemon balm was used for the respiratory and digestive systems, and for topical skin treatments.

2.2. Traditional and Modern Herbal Resources

Modern descriptions of lemon balm indicate a medicinal plant celebrated for its therapeutic properties. It was described in herbal texts from the Middle Ages as an herb that "contains within it the virtues of a dozen other plants" and as an "elixir of life" (The Herb Society of America, 2007). In Greece, many traditional uses of medicinal plants have disappeared with an aging population in villages where medicinal plants are commonly relied upon for home healthcare. Records from the *vikoyiatroi*, traditional physicians in the northern region of Zagori, indicate that a decoction of dried stems was used to treat hysteria, insomnia, heart arrhythmia, bronchitis, epilepsy, and skin infections (Malamas & Marselos, 1992). In Pelion, a region in central Greece, a decoction was similarly consumed as a heart and nerve tonic. Known for its attraction to bees, lemon balm was used to lure bees to certain villages to promote the production of honey.

In the United States, there are many herbal resources describing the benefits of lemon balm and the various ways to use it. It is generally known as the gladdening herb that helps to revitalize the spirit and is primarily applied as a remedy for agitated conditions of the nervous and digestive systems.

3. Results and Discussion

The examination of lemon balm in ancient medical texts and modern herbal texts reveals the evolving needs of humans since antiquity.

3.1. Ancient Uses of Lemon Balm

According to Dioscorides and Pliny, lemon balm was primarily recommended for the respiratory and digestive systems. It was crafted into syrup and lozenges to relieve difficult breathing and applied as an enema for dysentery. A decoction was used as a mouth rinse for toothache and added to the bath to stimulate menstruation. As a poultice, the leaves lessened arthritic pain, and with salt, cleaned wounds and dissolved goiters. Topically, lemon balm infused in wine relieved the bites of scorpions, spiders, and dogs. Pliny described many of the same medicinal applications, although also mentioned a remedy with potassium nitrate for a "wandering womb," a misunderstood condition of the female body, and the hysterical suffocations that followed (Pliny the Elder, 1st century/1855).

3.2. Challenges with Ancient Medical Texts and Remedies

Ancient medical texts did not often provide the preparation method, dosage, and frequency of use of the medicinal plant. These texts were written for trained physicians who would already have an understanding of how to craft remedies. This makes it challenging to recreate these remedies today for an intended effect. Trained herbalists can make educated decisions based on knowledge and first-hand experience with herbal medicines. There are also genetic and environmental

changes over thousands of years to consider. It is unknown how plants 2,000 years ago differed in terms of phytoconstituent level, growing conditions, soil conditions, air quality, and other factors. It is impossible to recreate the same environmental conditions and understand how these conditions affected the therapeutic strength of plants during that time. It is highly likely that plants today have decreased in strength due to pollution, destruction to habitat, and intense climatic conditions caused by human-induced climate change. If this is the case, the dosage in antiquity would have been less than what is required today to obtain the same therapeutic effect.

3.3. Modern Uses of Lemon Balm

Our modern understanding of lemon balm provides more options for therapeutic applications than what was applied or known in antiquity. Like in antiquity, lemon balm supports the respiratory and digestive systems, and is applied topically for the relief of bites and stings. Lemon balm contains aromatic bitters that relieve congestion in the lungs and digestive tract. It settles nervous indigestion, nausea, vomiting, and cramps in the smooth muscles of the digestive tract and uterus. Unlike in antiquity, lemon balm is primarily used today for its nervine properties to help relieve agitated states, such as anxiety, nervousness, insomnia, mild depression, and panic attacks. Herbalists recommend it for individuals who are constantly running on adrenaline and have difficultly turning off the mind. Lemon balm acts as a gentle herbal tranquilizer to settle an overactive mind and improve concentration, focus, and memory. Its relaxing qualities help relieve insomnia and improve sleep. Lemon balm supports those with hyperthyroidism, which can cause anxiety, palpitations, and headaches. It is used to lower fever and speed up healing from colds and flu. Due to its antiviral properties, lemon balm is used in protocols against herpes and shingles. In the United States where Lyme disease is prevalent, it is included in antiviral formulas for the treatment of symptoms, such as nerve pain.

Lemon balm contains the following properties: antibacterial, antidepressive, antifungal, anti-inflammatory, antioxidant, antispasmodic, antiviral, astringent, carminative, diaphoretic, hypotensive, immune-stimulating, sedative, vulnerary (Shakeri et al., 2016). Studies have confirmed lemon balm's strong antioxidant activity for use in preventing and treating oxidative stress-related diseases (Miraj et al., 2016). The plant is considered safe with no known toxicity. It is especially helpful for children and teenagers with ADHD and for the treatment of Alzheimer's disease in the elderly to improve cognitive function. There are possible contraindications with pharmaceutical sedatives, and thyroid and HIV medications. Due to its potential effect on the uterus, only a low dosage is recommended during pregnancy, or none at all.

3.4. Notable Differences of Use Between Antiquity and Today

Lemon balm has been known as the gladdening herb for centuries in Western herbal traditions due to its therapeutic effects on the nervous system. However, there is no mention of anxiety, insomnia, and depression in the entries of lemon balm in the ancient medical texts of Dioscorides and Pliny. It is unclear if ancient populations did not suffer from these ailments as we do today or if ancient physicians did not recognize lemon balm's benefits for the nervous system. Cross-examination of other medicinal plants with nervine properties have come to similar conclusions; perhaps ancient populations were happier and less stressed than we are today (Christodoulou, forthcoming 2027). Additionally, lemon balm's modern uses to support the cardiovascular system

FULL PAPER

and as an antiviral are also absent in antiquity. These health issues may also be modern-day problems unknown to ancient physicians.

3.5. Other Questions to Consider

Dioscorides documented that a decoction of lemon balm added to the bath stimulated menstruation. He did not include instructions for preparation, including if the plant material was fresh or dried, the quantity of plant material, the quantity of water, and for how long to soak in the bath for the intended effect. It is also unclear if this remedy was for inducing late menstruation to regulate the cycle or as a form of birth control. This ancient use is important to consider for modern safety concerns during pregnancy, for which low doses or none at all are recommended.

3.6. Additional Research to Consider

The examination of lemon balm in ancient medical texts demonstrates the importance of cross-referencing ancient and modern uses for other medicinal plants. The author has achieved this for fifty plants native to the Mediterranean in a forthcoming book, "Herbs of Greece: Four Seasons of Ancient Plants for Modern Health" (Timber Press, 2027).

Table. Comparison of ancient and modern uses of *Melissa* by organ system.

Organ System	Ancient Use	Modern Use
Skin / Muscular	stings/bites (scorpion, spider, dogs), toothaches, swollen glands, sores, joint pain	stings, burns, blisters, rashes, joint pain
Respiratory / Immune	shortness of breath / difficulty breathing	colds, coughs, fevers
Digestive	colic, griping, dysentery, mushroom poisoning	indigestion, flatulence, spasms, heartburn, cramps
Cardiovascular	-	palpitations, high blood pressure, arrhythmia
Reproductive	induce menstruation	menstrual cramps
Nervous	-	anxiety, insomnia, panic attacks, depression, cognitive function, headaches, epilepsy, antiviral

4. Conclusion

Ancient and modern applications of lemon balm were cross-referenced from the perspective of a clinical herbalist, revealing the similarities and differences in therapeutic uses. Ancient medical knowledge can provide a broader understanding of the plant's therapeutic benefits and areas for additional research for modern needs.

FULL PAPER

Conflict of Interest

No conflict of interest.

References

[1] Beck, Lily Y. (2020). *Pedanius Dioscorides of Anazarbus, De Materia Medica*. Fourth edition. Olms-Weidmann.

[2] Trajkovska-Broach, A., & Trajkovska, A. P. (2023). Nutritional values and therapeutical effects of Mediterranean herbs, spices, and medicinal plants. In E. Ivanišová (Ed.), *Herbs and spices - New advances* (1-35). IntechOpen. https://doi.org/10.5772/intechopen.108838

[3] Hellenic Botanical Society. (2024). *Melissa Officinalis L.* Flora of Greece Web. https://portal.cybertaxonomy.org/flora-greece/cdm_dataportal/taxon/2988fc71-52e5-474b-9f3c-7f7b52591316

[4] Shakeri, A., Sahebkar, A., & Javadi, B. (2016). *Melissa officinalis* L. – A Review of its traditional uses, phytochemistry and pharmacology. *Journal of Ethnopharmacology 188*, 204-228. https://doi.org/10.1016/j.jep.2016.05.010

[5] The Herb Society of America. (2007). *Lemon balm: An herb society of America guide*. The Herb Society of America. https://www.herbsociety.org/file_download/inline/d7d790e9-c19e-4a40-93b0-8f4b45a644f1

[6] Malamas, M. & Marselos, M. (1992). The tradition of medicinal plants in Zagori, Epirus (northwestern Greece). *Journal of Ethnopharmacology,* 37(3): 197-203. doi:10.1016/0378-8741(92)90034-o

[7] Pliny the Elder. 1855. *The Natural History*. (J. Bostock and H. T. Riley, Trans.). Taylor and Francis. (Original work published 1st century CE). https://topostext.org/work/148

[8] Miraj, S., Rafieian-Kopaei, M., & Kiani, S. (2016). *Melissa officinalis* L: A review study with an antioxidant prospective. *Journal of Evidence-Based Complementary & Alternative Medicine 22*(3): 385-394. https://doi:10.1177/2156587216663433

[9] Christodulou, M. (forthcoming 2027). *Herbs of Greece: Four Seasons of Ancient Plants for Modern Health*. Tim

FULL PAPER

IMPACT OF MULCHING ON BIOMASS AND ESSENTIAL OIL PROFILE OF *THYMBRA SPICATA* L. VAR. SPICATA GROWN AS AN INTERCROP IN AN OLIVE ORCHARD

Hakan Çetinkaya[1], Hatice Gözel[1], Nazım Şekeroğlu[2]

[1]Department of Horticulture, Faculty of Agriculture, Kilis 7 Aralık University,79000, Kilis, Türkiye,
[2]Department of Biology, Faculty of Science and Literature, Gaziantep University, 27300, Gaziantep, Türkiye
Correspondence: hcetinkaya@kilis.edu.tr

Abstract

This study evaluated the effects of black polyethylene mulching on the vegetative growth and essential oil profile of *Thymbra spicata* L. var. spicata, grown as an intercrop in an olive orchard. Essential oils from the aerial parts were extracted via hydrodistillation and analyzed by GC-MS. The results showed that mulching significantly increased canopy diameter, spike length, and fresh and dry biomass compared to unmulched conditions. Additionally, the essential oil yield was higher with mulching (1.95%) than without (1.67%). GC-MS identified 20 major compounds in the oils. Both cultivation conditions featured γ-Terpinene and 4-Hydroxy-3-methylacetophenone as the dominant components. Mulching increased the p-Cymene / o-Cymene ratio, while unmulched cultivation yielded higher proportions of Caryophyllene and Thymol. In conclusion, black polyethylene mulching is an effective agronomic practice to enhance both the biomass and essential oil yield of *T. Spicata*.

Key Words: *Thymbra spicata* L. var. *spicata*, mulching, essential oil composition, intercropping system, GC–MS analysis

1. Introduction

Medicinal and aromatic plants play a significant role in pharmaceutical, cosmetic, and food industries due to their bioactive compounds and essential oils. Among these, *Thymbra spicata* L. var. spicata (commonly known as zahter) is a perennial shrub belonging to the Lamiaceae family, widely distributed in the Mediterranean region. It is valued for its strong aroma, antimicrobial properties, and traditional uses in herbal medicine and culinary applications [1, 2]. The essential oil composition of *T. spicata* is known to vary depending on environmental conditions, cultivation practices, and genetic factors. Major constituents such as γ-terpinene, thymol, and p-cymene are primarily responsible for its biological activities, including antioxidant and antimicrobial effects [3]. Therefore, optimizing agronomic practices to improve both biomass and essential oil yield, as well as composition, is of great importance.

Mulching is a widely used agricultural practice that modifies soil temperature, conserves moisture, suppresses weeds, and enhances plant growth. In particular, black polyethylene mulch has been reported to improve vegetative development and yield in various medicinal and aromatic plants by creating a favorable microclimate around the root zone [4]. Additionally, mulching can influence secondary metabolite production by altering plant stress responses and nutrient availability [5]. Intercropping systems, especially in perennial orchards such as olive groves, offer an efficient approach to maximize land use and increase economic returns while

FULL PAPER

maintaining ecological sustainability. Integrating aromatic plants like *T. spicata* into olive orchards may provide added value through essential oil production without compromising the primary crop [6].

Despite the known benefits of mulching and intercropping, limited information is available regarding their combined effects on *T. spicata*, particularly in terms of essential oil composition. Therefore, this study aimed to evaluate the impact of black polyethylene mulching on vegetative growth parameters and essential oil profile of *T. spicata* cultivated as an intercrop in an olive orchard. Understanding these effects could contribute to the development of improved cultivation strategies for higher yield and quality of essential oils.

2. Material and Methods

2.1. Experimental Site and Plant Material

The research was carried out in a pre-existing olive orchard located at the Agriculture Faculty of Kilis 7 Aralık University, utilizing *Thymbra spicata* L. var. *spicata* as an intercrop. The experimental design compared two specific growing environments: a treatment using black polyethylene as an inorganic mulch and a control group without any mulch. Throughout the cultivation period, researchers measured various morphological traits, including plant height, canopy diameter, shoot and spike lengths, as well as both fresh and dry biomass. To prevent discrepancies caused by environmental changes or plant developmental stages, all botanical samples were collected simultaneously during the flowering phase, which is widely recognized as the ideal time to maximize essential oil yields in *Thymbra* species [7, 8].

2.2. Isolation of Essential Oils

The essential oils were isolated from the above-ground portions of the collected plants through a hydro distillation technique utilizing an alembic setup. In this procedure, the botanical material was combined with water and brought to a boil under regulated conditions, allowing the generated steam to transport the volatile compounds through the system. Following condensation, the mixture naturally separated into distinct oil and water layers. After a predetermined distillation duration, the collected essential oils were dehydrated using anhydrous sodium sulfate to eliminate any remaining moisture. Finally, to prevent chemical alteration and oxidative breakdown before testing, the dried oils were carefully preserved in sealed amber glass vials and refrigerated at +4 °C [1].

2.3. GC–MS Evaluation

The chemical profile of the extracted oils was analyzed utilizing an Agilent gas chromatography–mass spectrometry (GC–MS) device. The volatile components were successfully separated via capillary gas chromatography and subsequently detected through mass spectrometry. To accurately identify individual compounds, their mass spectra were cross-referenced with established commercial databases, such as Wiley and NIST, and their retention indices were validated against existing scientific literature [8]. Through this rigorous process, 20 primary constituents were successfully recognized, making up the bulk of the total essential oil content. The relative amount of each compound was quantified as a percentage of the total peak area derived from the GC–MS chromatograms, which provided the basis for comparing the chemical profiles of plants from the mulched and unmulched systems.

FULL PAPER

3. Results and Discussion

3.1. Vegetative Growth and Yield

The effects of black polyethylene mulching on vegetative growth parameters and essential oil yield of Thymbra spicata L. var. spicata are presented in Table 3.1. As shown in Table 3.1, mulching significantly increased several growth parameters compared to the unmulched control. Spike length was markedly higher in mulched plants (6.52 cm) than in unmulched plants (3.25 cm). Similarly, canopy diameter showed a slight but significant increase under mulched conditions (39.37 cm) compared to non-mulched plants (38.22 cm). Fresh and dry biomass were also significantly enhanced by mulching, reaching 770 g and 382.5 g, respectively, whereas unmulched plants produced 578.4 g fresh biomass and 290 g dry biomass. In addition, essential oil yield (%) was significantly higher in mulched plants (1.95%) compared to unmulched plants (1.67%), as indicated in Table 3.1. In contrast, shoot length and plant height did not show statistically significant differences between treatments, suggesting that mulching primarily affected biomass accumulation rather than vertical growth.

3.2. Essential Oil Profile

The chemical composition of essential oils obtained from mulched and unmulched plants is summarized in Table 3.2. According to Table 3.2, a total of 20 major compounds were identified by GC–MS analysis under both cultivation conditions. The dominant components in both treatments were γ-terpinene and 4-hydroxy-3-methylacetophenone, and their proportions did not differ significantly between mulched and unmulched plants. However, significant variations were observed in several other compounds. As shown in Table 3.2, the p-cymene/o-cymene ratio was significantly higher in mulched plants (21.73%) compared to unmulched plants (17.07%).

On the other hand, unmulched plants exhibited significantly higher concentrations of certain compounds, including caryophyllene (6.08%), thymol (3.27%), bis(2-ethylhexyl) phthalate (4.46%), phenol, 2,3,5,6-tetramethyl- (3.58%), and p-tert-butylcatechol (1.19%), as presented in Table 3.2. Overall, while mulching enhanced essential oil yield, it also resulted in selective changes in the relative abundance of specific compounds within the essential oil profile.

Table 3.1. Effect of black polyethylene mulching on vegetative growth parameters and essential oil yield of *Thymbra spicata* L. var. spicata under intercropping conditions in an olive orchard

	2023		2024		Year		Application	
	Mulched	Non-Mulched	Mulched	Non-Mulched	2023	2024	Mulched	Non-Mulched
Spike length	9,40^{a}	2,90^{b}	3,63^{b}	3,60^{b}	6,15^{a}	3,61^{b}	6,52^{a}	3,25^{b}
Shoot length	7,30^{d}	10,89^{c}	24,17^{a}	21,17^{b}	9,09^{b}	22,67^{a}	15,73	16,03
Plant height	30,90^{ab}	29,47^{ab}	28,13^{b}	32,20^{a}	30,18	30,17	29,52	30,83
Canopy diameter	38,70^{ab}	37,57^{b}	40,03^{a}	38,87^{ab}	38,13^{b}	39,45^{a}	39,37^{a}	38,22^{b}
Fresh biomass	1084^{a}	657^{b}	456^{b}	500^{b}	870^{a}	478^{b}	770^{a}	578,4^{b}
Dry biomass	505^{a}	335^{b}	260^{c}	245^{c}	420^{a}	252,5^{b}	382,5^{a}	290^{b}
Yield (%)	1,63^{b}	1,01^{c}	2,27^{a}	2,34^{a}	1,32^{b}	2,31^{a}	1,95^{a}	1,67^{b}

Nutrient contents of leaves samples with different lowercase letters (a-d) in the same row are statistically significant ($p<0.05$)

FULL PAPER

The findings of the present study clearly demonstrate that black polyethylene mulching significantly improves vegetative growth parameters and essential oil yield in *Thymbra spicata* L. var. *spicata*. The observed increases in canopy diameter, spike length, fresh biomass, and dry biomass under mulched conditions are consistent with previous studies reporting that mulching enhances plant growth by improving soil moisture retention, regulating soil temperature, and reducing weed competition [4, 5]. These favorable microenvironmental changes likely contributed to the enhanced vegetative performance observed in this study.

The increase in essential oil yield (1.95% in mulched plants vs. 1.67% in unmulched plants) aligns with findings in other aromatic and medicinal plants, where improved water availability and reduced abiotic stress under mulching conditions positively influence secondary metabolite production [5]. In this context, the higher biomass production in mulched plants may also have contributed indirectly to increased oil yield, as essential oil accumulation is often correlated with vegetative growth and glandular trichome density.

Interestingly, while mulching significantly enhanced yield and biomass, it did not markedly alter the dominant components of the essential oil. In both treatments, γ-terpinene and 4-hydroxy-3-methylacetophenone remained the major constituents. This finding is in agreement with previous reports indicating that the core chemotype of *T. spicata* is relatively stable and largely determined by genetic factors rather than cultivation practices [1, 2]. However, the relative proportions of some minor and intermediate compounds were affected by mulching.

Table 3.2. Effect of black polyethylene mulching on the essential oil composition (%) of *Thymbra spicata* L. var. *spicata* as determined by GC–MS analysis

	2023		2024		Year		Application	
	Mulched	Non-Mulched	Mulched	Non-Mulched	2023	2024	Mulched	Non-Mulched
γ-Terpinene	20,10^{b}	22,23^{ab}	25,07^{a}	21,39^{ab}	21,17	23,23	22,58	21,81
p-Cymene / o-Cymene	26,71^{a}	19,30^{b}	16,74^{b}	14,84^{b}	23,01^{a}	15,79^{b}	21,73^{a}	17,07^{b}
4-Hydroxy-3-methylacetophenone	18,66^{b}	23,57^{ab}	25,94^{a}	22,63^{ab}	21,12^{b}	24,29^{a}	22,30	23,10
Caryophyllene	5,32	5,72	4,91	6,43	5,52	5,67	5,12^{b}	6,08^{a}
Thymol	2,44^{b}	1,68^{b}	0,93^{b}	4,85^{a}	2,06	2,89	1,68^{b}	3,27^{a}
Bis(2-ethylhexyl) phthalate	0,00^{c}	8,91^{a}	7,44^{b}	0,00^{c}	4,46^{a}	3,72^{b}	3,72^{b}	4,46^{a}
Sabinene (Bicyclo[3.1.0]hex-2-ene)	3,66^{ab}	4,12^{a}	2,85^{b}	2,75^{b}	3,89^{a}	2,80^{b}	3,26	3,44
Phenol, 2,3,5,6-tetramethyl-	3,57^{a}	3,15^{a}	0,00^{b}	4,00^{a}	3,36^{a}	2,00^{b}	1,79^{b}	3,58^{a}
β-Myrcene	3,06	3,36	2,76	3,25	3,21	3,01	2,91	3,31
(+)-4-Carene / (+)-2-Carene	0,17**c**	2,53^{b}	4,26^{a}	2,45^{b}	1,35^{b}	3,36^{a}	2,22	2,49
Terpinen-4-ol	1,28	0,91	1,08	1,01	1,10	1,05	1,18	0,96
α-Pinene	1,42^{a}	1,32^{a}	0,99^{ab}	0,81^{b}	1,37^{a}	0,90^{b}	1,21	1,07
p-tert-Butylcatechol	0,00**c**	1,40**a**	0,59**b**	0,97^{ab}	0,70	0,78	0,30^{b}	1,19^{a}
Caryophyllene oxide	0,64	0,44	0,58	0,55	0,54	0,57	0,61	0,50
3-Methyl-4-isopropylphenol	0,72^{bc}	1,19^{a}	0,93^{ab}	0,47^{c}	0,96^{a}	0,70^{b}	0,83	0,83
1-Octen-3-ol	0,79	0,72	0,54	0,57	0,75	0,56	0,66	0,65
D-Limonene	0,66	0,71	0,51	0,59	0,69	0,55	0,59	0,65
α-Phellandrene	0,37^{ab}	0,25^{b}	0,43^{ab}	0,52^{a}	0,31^{b}	0,48^{a}	0,40	0,39
β-Pinene	0,45	0,29	0,33	0,39	0,37	0,36	0,39	0,34
Camphene	0,22	0,13	0,15	0,20	0,18	0,18	0,19	0,17

Nutrient contents of leaves samples with different lowercase letters (a-d) in the same row are statistically significant ($p<0.05$)

FULL PAPER

The increase in the p-cymene/o-cymene ratio under mulched conditions suggests that mulching may influence specific pathways within monoterpene biosynthesis. p-Cymene is a key precursor in the biosynthetic pathway leading to phenolic compounds such as thymol and carvacrol. The higher p-cymene levels observed in mulched plants may indicate a shift toward precursor accumulation rather than conversion to downstream phenolic compounds. This interpretation is supported by the lower thymol content observed under mulched conditions, as thymol biosynthesis depends on further enzymatic transformations of p-cymene [3].

Conversely, the higher concentrations of caryophyllene and thymol in unmulched plants may be attributed to increased environmental stress conditions. It is well established that abiotic stress factors such as water limitation and higher soil temperature fluctuations can stimulate the synthesis of phenolic compounds and sesquiterpenes as part of plant defence mechanisms [5]. Therefore, the unmulched treatment, which likely exposed plants to greater stress, may have promoted the accumulation of these compounds.

Another notable observation is the presence and variation of compounds such as bis(2-ethylhexyl) phthalate and phenolic derivatives. While some of these compounds may originate from environmental contamination or analytical artifacts, their higher proportion in unmulched conditions could also be associated with increased exposure to external environmental factors. This aspect should be interpreted cautiously and may require further investigation.

Overall, the results indicate that mulching primarily enhances quantitative traits such as biomass and essential oil yield, while its influence on qualitative composition is more selective and compound specific. These findings are in line with previous studies on aromatic plants, where agronomic practices tend to modify essential oil composition without drastically altering the dominant chemotype [1].

From an agronomic perspective, the integration of black polyethylene mulching in intercropping systems within olive orchards appears to be a highly effective strategy. It not only improves plant growth and oil yield but also maintains the core chemical profile of *T. spicata*, which is important for its commercial and medicinal value. Moreover, the slight shifts in secondary metabolite composition may offer opportunities to tailor essential oil profiles depending on desired end-use applications.

4. Conclusion

The results of this study demonstrate that black polyethylene mulching is an effective agronomic practice for improving the growth performance and essential oil yield of *Thymbra spicata* L. var. *spicata* when cultivated as an intercrop in an olive orchard. Mulching significantly enhanced key vegetative parameters, including canopy diameter, spike length, and biomass accumulation, which collectively contributed to a higher essential oil yield compared to unmulched conditions. Although the dominant components of the essential oil, namely γ-terpinene and 4-hydroxy-3-methylacetophenone, remained stable across treatments, mulching influenced the relative proportions of several secondary metabolites. In particular, the increase in the p-cymene/o-cymene ratio under mulched conditions and the higher levels of thymol and caryophyllene in unmulched plants indicate that cultivation practices can modulate essential oil composition in a compound-specific manner without altering the core chemotype.

FULL PAPER

From a practical perspective, the use of black polyethylene mulch in intercropping systems offers a promising strategy to enhance productivity and maintain essential oil quality in *T. spicata* cultivation. These findings are particularly relevant for sustainable agricultural systems in Mediterranean environments, where efficient resource use and crop diversification are critical. However, further studies are recommended to evaluate long-term effects of mulching, its economic feasibility, and its interaction with environmental stress factors on secondary metabolite pathways. Such investigations would contribute to optimizing cultivation techniques for both yield and quality in medicinal and aromatic plants.

Acknowledgements: This study was conducted at the experimental fields of Kilis 7 Aralık University Faculty of Agriculture, and we would like to thank the staff who provided technical support.

Conflict of Interest

The authors declare that they have no conflict of interest.

References

[1] Baser, K. H. C., & Buchbauer, G. (2015). Handbook of Essential Oils: Science, Technology, and Applications (2nd ed.). CRC Press.
[2] Tepe, B., Daferera, D., Sokmen, A., Sokmen, M., & Polissiou, M. (2004). Antimicrobial and antioxidant activities of the essential oil and various extracts of Thymbra spicata L. Food Chemistry, 90(3), 333–340. https://doi.org/10.1016/j.foodchem.2004.03.032
[3] Soković, M., Glamočlija, J., Marin, P. D., Brkić, D., & van Griensven, L. J. L. D. (2010). Antibacterial effects of the essential oils of commonly consumed medicinal herbs using an in vitro model. Molecules, 15(11), 7532–7546. https://doi.org/10.3390/molecules15117532
[4] Kader, M. A., Senge, M., Mojid, M. A., & Ito, K. (2017). Recent advances in mulching materials and methods for modifying the soil environment. Soil and Tillage Research, 168, 155–166. https://doi.org/10.1016/j.still.2017.01.001
[5] Lithourgidis, A. S., Dordas, C. A., Damalas, C. A., & Vlachostergios, D. (2011). Annual intercrops: An alternative pathway for sustainable agriculture. Australian Journal of Crop Science, 5(4), 396–410.
[6] Kokkini, S., Karousou, R., & Lanaras, T. (1997). Essential oils of Greek aromatic plants: Taxonomic and phytochemical relationships. Biochemical Systematics and Ecology, 25(4), 353–364. https://doi.org/10.1016/S0305-1978(96)00120-3
[7] Başer, K. H. C. (2008). Biological and pharmacological activities of carvacrol and carvacrol bearing essential oils. Current Pharmaceutical Design, 14(29), 3106–3119. https://doi.org/10.2174/138161208786404227
[8] Adams, R. P. (2007). Identification of essential oil components by gas chromatography/mass spectrometry (4th ed.). Allured Publishing Corporation.
[9] Kasirajan, S., & Ngouajio, M. (2012). Polyethylene and biodegradable mulches for agricultural applications: A review. Agronomy for Sustainable Development, 32(2), 501–529. https://doi.org/10.1007/s13593-011-0068-3

FULL PAPER

EFFECTS OF DIFFERENT PLANT DENSITIES AND HUMIC ACID DOSES ON SOME AGRONOMIC TRAITS OF *DRACOCEPHALUM MOLDAVICA* L.

Nilüfer Koçak Şahin[1], Ehsan Khadem Arabbaghi[1], Dilek Başalma[1]

[1] Department of Field Crops, Faculty of Agriculture, University Ankara, 06110, Ankara, Türkiye, correspondence: basalma@ankara.edu.tr, nkocak@ankara.edu.tr

Abstract

This study was conducted at the experimental fields of the Faculty of Agriculture, Ankara University, to determine the adaptation of *Dracocephalum moldavica* L. under Ankara ecological conditions and to evaluate the effects of different plant densities and humic acid doses on yield and quality parameters. The experiment was arranged in a split-plot design based on a randomized complete block design with four replications. Plant density treatments were assigned to main plots, while humic acid doses were allocated to subplots. Plant densities consisted of 40 × 20 cm, 30 × 20 cm, 40 × 30 cm and 30 × 30 cm spacings, whereas humic acid doses were applied at 0, 2, 4 and 6 L da^{-1}. Approximately one week after transplanting, humic acid was applied to the soil between rows. The humic acid fertilizer used in the study was a liquid form extracted from leonardite containing 17% humic acid. Plants were harvested at the full flowering stage in both years, and measurements were taken for plant height, number of branches, fresh herbage yield and dry herbage yield. The data obtained in both years were analyzed according to the split-plot design using the MSTAT-C statistical software, including mean comparisons and dependency analyses. The results indicated that plant density had no significant effect on plant height, number of branches, whereas it significantly affected fresh herbage yield, dry herbage yield. On the other hand, humic acid doses did not have a significant effect on the examined traits. It is suggested that higher yields can be achieved with increased plant density. Although humic acid application did not show a short-term effect on yield, it is expected to contribute positively to yield and quality in the long term.

Key Words: *Dracocephalum moldavica* L., plant density, humic acid, dry herbage yield

1. Introduction

Dracocephalum moldavica L. is an annual aromatic plant belonging to the Lamiaceae family, originating from Central Asia. It naturally grows in Egypt, China, Mongolia, and the Himalayas at altitudes ranging from 2700 to 3100 m. The genus *Dracocephalum* comprises approximately 40 species (Holm et al., 1988). Known as "Moldavian balm" in English, this species originates from Southern Siberia and the Himalayan Mountains and is also distributed in Central and Eastern Europe.

In Iran, the plant is mainly found in the northern regions, particularly in the Alborz Mountains, where it is locally called "badreşbu" in Persian. It is consumed as a herbal tea due to its relaxing effects and is also used as a food additive. In traditional medicine, it is used for the treatment of stomach and liver disorders as well as headaches (Dastmalchi, 2008). In addition, it is utilized in the food and beverage industry as well as in cosmetics and hygiene products (Rezaei et al., 2013).

FULL PAPER

Although several *Dracocephalum* species (e.g., *D. austriacum, D. ruyschiana, D. multicaule*) commonly known as "dragonhead" exist in the flora of Turkey, *D. moldavica* is not naturally distributed in the country (Anonymous, 2022). Therefore, studies on the cultivation of this species in Turkey are very limited.The trichomes on the flowers, stems, and leaves emit a lemon-like fragrance similar to lemon balm (*Melissa officinalis* L.), which is highly attractive to bees. The honey production potential of the plant has been estimated to range between 129 and 650 kg per hectare (Dmitruk et al., 2018). It is also used in the perfume and soap industry, as well as for flavoring jams, alcoholic beverages, syrups, and canned fish products. When consumed as herbal tea, it exhibits stomach-soothing, anti-stress, and antiemetic effects, particularly useful for pregnant women (Ştefania et al., 2018). Furthermore, its extracts have been reported to possess high biological activity, including antioxidant and antitumor properties (Chachoyan and Oganesyan, 1996; Povilaityté et al., 2001; Dastmalchi et al., 2007).

One of the main objectives in agriculture is to maximize the efficient use of environmental resources to achieve high yield. Plant density is one of the key factors affecting the utilization of environmental resources such as soil water, nutrient availability, and sunlight (Perrott et al., 2018). Optimum plant density is defined as the level at which maximum light interception, highest leaf area index, and consequently maximum yield are achieved (Basiri and Nadjafi, 2019). If plant density exceeds or falls below the optimum level, environmental resources cannot be efficiently utilized.

Abdossi et al. (2015) reported that under Iranian conditions, the highest fresh and dry herbage yield of *D. moldavica* was obtained at a planting density of 30 × 10 cm, while the highest essential oil content was achieved at 30 × 30 cm spacing. However, studies on optimal planting density for yield and quality components of *D. moldavica* are still limited.

Plant density is an important agronomic factor that should ensure optimal utilization of sunlight, water, and nutrients in the field. It varies depending on plant characteristics and environmental conditions and must be properly adjusted to obtain high yield and quality.

Due to the low organic matter content of soils, the use of chemical fertilizers has increased rapidly. However, plants cannot fully utilize applied fertilizers efficiently. Intensive chemical fertilization leads to soil degradation, increased salinity, reduced microbial activity, groundwater contamination, nutrient leaching, and yield and quality reduction. In contrast, the use of organic matter improves soil properties and enhances nutrient availability (Özkan, 2007).

The beneficial effects of soil organic matter on physical, chemical, and biological soil properties have long been recognized (Stepherd et al., 2002). Soils in Turkey are generally poor in organic matter (Şenol and Bayramin, 2013), and it is insufficient in terms of organic matter content, which limits agricultural productivity (Akyüz et al., 2021).

Humic acids are natural organic compounds that promote plant growth by supplying nutrients, vitamins, and mineral elements to both soil and plants. They can be applied via irrigation water or foliar application and may also be used in combination with organic or chemical fertilizers (NPK). Humic substances derived from leonardite are widely accepted in organic agriculture and are increasingly used due to restrictions on chemical fertilizers and pesticides and rising demand for organic products (Güneş, 2007).In Turkey, four *Dracocephalum* species are naturally

FULL PAPER

distributed and known as dragonhead; however, *D. moldavica* does not occur naturally and is not cultivated. Although this species is economically important in Iran, especially in traditional medicine, its cultivation potential under Turkish environmental conditions has not been sufficiently studied.

Therefore, this study was conducted to determine the effects of different plant densities and humic acid doses on the yield characteristics of *Dracocephalum moldavica L.* under Ankara ecological conditions, and to evaluate its adaptability and potential for cultivation in Turkey.

2. Material and Methods

This experiment was conducted in the experimental fields of Ankara University, Faculty of Agriculture, during the 2014 and 2015 growing seasons. Soil analysis results indicated that the experimental site had a sandy loam texture. Based on electrical conductivity (EC) values, no salinity problem was detected; however, the soil was found to have a high lime content and a high pH value. In addition, the soil was determined to be poor in organic matter.

Total annual precipitation was recorded as 245.5 mm in 2014 and 204 mm in 2015. When compared with the long-term average, precipitation levels were higher during the experimental years. The highest monthly precipitation was 100.9 mm in June 2015, while the lowest was 2.7 mm in July 2015. Regarding temperature, the highest values were recorded in August in both years, exceeding the long-term average. Relative humidity data indicated that the experimental area has a generally low-humidity climate.

In the study, seeds were first sown and seedlings were raised under greenhouse conditions. Plastic trays (plug trays) were filled with peat substrate, and 2–3 seeds were sown per cell to obtain seedlings. Irrigation and maintenance practices were carried out regularly. In 2014, fungicide applications were performed due to fungal disease incidence. However, in 2015, no fungal diseases were observed because the trays were sterilized using 5% bleach solution and sterilized peat was used; therefore, no fungicide application was required. Seedlings were transplanted to the field when they reached a height of 10–15 cm.

The experiment was established in 2014 and 2015 using a randomized complete block design in a split-plot arrangement with four replications. The study included two factors: plant density as the main plot factor and humic acid doses as the subplot factor. Subplot size was 5.76 m^2 (2.4 m × 2.4 m), while main plots were 2.4 m wide and 9.6 m long. The total experimental area was 23.04 m^2 per block and 368.64 m^2 in total.

Four plant spacings were used: 40 × 20 cm, 30 × 20 cm, 40 × 30 cm, and 30 × 30 cm. Humic acid was applied at four doses: 0, 2, 4, and 6 L da^{-1}. In plots with 40 cm row spacing, 6 rows were established per subplot, while in plots with 30 cm row spacing, 8 rows were established. Accordingly, the number of plants per subplot was 72 (40 × 20 cm), 96 (30 × 20 cm), 48 (40 × 30 cm), and 64 (30 × 30 cm).

FULL PAPER

Seeds were sown in the first week of April, and seedlings were transplanted to the field in the first week of May. Humic acid application was performed approximately one week after transplanting by applying it between rows. Liquid humic acid derived from leonardite (17% humic acid content) was mixed with water and uniformly applied to the plots.

Border effects were eliminated by excluding one row at the beginning of each main plot and one plant at the beginning of each row from the measurements. Harvesting was carried out once each year at full flowering stage, and the following measurements and analyses were performed:

Plant height (cm): Ten randomly selected plants from each subplot were measured from soil surface to the highest point of the plant.

Number of branches (units): The number of branches was counted on 10 randomly selected plants per subplot before harvest.

Fresh herbage yield (kg da^{-1}): Plants were cut approximately 5–6 cm above soil level in each subplot, weighed, and converted to decare basis.

Dry (drug) herbage yield (kg da^{-1}): A 500 g fresh sample from each subplot was dried in an oven at 35°C for 3 days. Dry matter ratio was calculated and multiplied by fresh herbage yield to determine dry herbage yield.

3. Results and Discussion

3.1 Plant Height

According to the two-year analysis of variance results for plant height of Moldavian balm (*Dracocephalum moldavica* L.) under different plant densities and humic acid doses, the effects of plant density, humic acid doses, and their interaction were found to be statistically non-significant on plant height (Table 1). However, the Year × Plant Density × Humic Acid interaction had a significant effect on plant height at the 5% significance level ($P < 0.05$).

Table 1. Duncan Multiple Range Test Results for Plant Height Means in Different Years

Treatments		1.Year	2.Year	Mean
1. Density (30×20 cm)	**0 L da^{-1}**	58.025 a-g	55.175d-k	56.60
	2 L da^{-1}	58.375a-g	56.675b-i	57.525
	4 L da^{-1}	59.300a-f	54.050f-k	56.675
	6 L da^{-1}	59.850a-e	56.600b-i	58.225
2. Density (40×20 cm)	**0 L da^{-1}**	60.375a-d	55.750c-j	58.063
	2 L da^{-1}	59.275a-f	53.700g-k	56.448
	4 L da^{-1}	56.775b-i	54.650e-k	55.712
	6 L da^{-1}	62.300a	51.675i-k	56.987
3. Density (30×30 cm)	**0 L da^{-1}**	60.700a-c	50.125k	55.412
	2 L da^{-1}	61.475ab	53.350g-k	57.413
	4 L da^{-1}	57.775a-g	50.975jk	54.375

FULL PAPER

	6 L da^{-1}	53.125g-k	52.025h-k	52.575
4. Density (40×30 cm)	**0 L da^{-1}**	54.725e-k	51.500i-k	53.112
	2 L da^{-1}	57.425a-h	54.450e-k	55.938
	4 L da^{-1}	57.575a-g	53.375g-k	55.475
	6 L da^{-1}	58.150a-g	53.025g-k	55.588
General Means		**58.452**	**53.569**	**56.008**
1. Density (30×20 cm)		58.887	55.625	57.256
2. Density (40×20 cm)		59.681	53.944	56.813
3. Density (30×30 cm)		58.269	51.619	54.944
4. Density (40×30 cm)		56.969	53.088	55.028
0 L da^{-1}		58.456	53.138	55.797
2 L da^{-1}		59.138	54.544	56.841
4 L da^{-1}		57.856	53.263	55.559
6 L da^{-1}		58.356	53.331	55.844

*: Means followed by different letters are significantly different at the 5% significance level
Year × Plant Density × Humic Acid Doses. LSD (0.05): 4.484

In 2014, plant height ranged between 53.12 cm and 62.300 cm. The highest plant height was obtained from the second plant density (40 × 20 cm) combined with 6 L da^{-1} humic acid application, while the lowest value was recorded in the third plant density (30 × 30 cm) with 6 L da^{-1} humic acid application. In 2015, plant height values ranged between 50.125 cm and 56.675 cm. The highest plant height was recorded in the 30 × 20 cm plant density combined with 2 L da^{-1} humic acid application, whereas the lowest value was obtained from the 30 × 30 cm plant density with no humic acid application (0 L da^{-1}). When the two-year averages were considered, the effect of different plant densities on plant height was found to be statistically non-significant. The highest mean plant height was observed in the first plant density (57.256 cm). Similarly, the effect of humic acid doses on plant height was also not significant, although the highest mean plant height (56.841 cm) was obtained from the 2 L da^{-1} application.

Considering overall means, average plant height was 58.452 cm in 2014 and 53.569 cm in 2015, indicating a decrease in the second year. This reduction may be attributed to higher precipitation levels in the first year. Previous studies reported plant height values in *Dracocephalum moldavica* populations ranging between 54.76 cm and 74.76 cm (Borghei et al., 2015). Rahbarian and Afsharmanesh (2011) reported plant heights between 24.50 cm and 52.10 cm, while Hashemian Ahmadi et al. (2011) found values ranging from 44.81 cm to 51.83 cm. Janmohammadi et al. (2014) reported an average plant height of 75.71 cm in the control treatment. In the present study, two-year mean plant height values ranged between 50.125 cm and 62.300 cm. These values are lower or higher compared to previous studies. However, the wide variation reported in the literature indicates that plant height in *D. moldavica* is highly influenced by ecological and genetic factors and may vary considerably.

The obtained results are consistent with findings reported by Ekren et al. (2009), Cecilia et al. (2011), and Abdossi et al. (2015). Increasing plant density may reduce plant height due to limited access to environmental resources; however, reduced auxin degradation under shaded conditions in dense plantings may also promote stem elongation. In the present study, the balance between

FULL PAPER

these opposing factors or their limited influence may explain the non-significant effect of plant density on plant height.

3.2 Branch Number

According to the two-year analysis of variance results for the number of branches of Moldavian balm (*Dracocephalum moldavica* L.) under different plant densities and humic acid doses, the effects of plant density and humic acid doses on branch number were found to be statistically non-significant (Table 2). In addition, the interaction between plant density and humic acid doses also had no significant effect on branch number.

In 2014, the number of branches ranged between 9.825 and 10.900. The highest number of branches was recorded in the third plant density (30 × 30 cm) combined with 2 L da^{-1} humic acid application, while the lowest value was observed in the first plant density (30 × 20 cm) with 4 L da^{-1} humic acid application. In 2015, the number of branches varied between 10.250 and 11.600. The highest value was obtained from the first plant density (30 × 20 cm) with 4 L da^{-1} humic acid application, whereas the lowest value was recorded in the fourth plant density (40 × 30 cm) with 4 L da^{-1} humic acid application. When two-year averages were considered, the highest number of branches (10.975) was obtained from the second plant density (40 × 20 cm) with 4 L da^{-1} humic acid application, while the lowest value (9.988) was recorded in the third plant density (30 × 30 cm) with 6 L da^{-1} humic acid application

Table 2. Mean Values of Branch Number for Different Years (number)

Treatments		1.Year	2.Year	Mean
1. Density (30×20 cm)	**0 L da^{-1}**	10.075	10.525	10.300
	2 L da^{-1}	10.025	11.375	10.700
	4 L da^{-1}	9.825	11.600	10.713
	6 L da^{-1}	10.150	11.325	10.738
2. Density (40×20 cm)	**0 L da^{-1}**	10.100	11.575	10.838
	2 L da^{-1}	10.700	11.025	10.862
	4 L da^{-1}	10.475	11.475	10.975
	6 L da^{-1}	10.600	10.900	10.750
3. Density (30×30 cm)	**0 L da^{-1}**	10.200	10.425	10.312
	2 L da^{-1}	10.900	10.475	10.688
	4 L da^{-1}	10.100	10.975	10.538
	6 L da^{-1}	9.275	10.700	9.988
4. Density (40×30 cm)	**0 L da^{-1}**	9.900	11.175	10.538
	2 L da^{-1}	9.900	11.025	10.462
	4 L da^{-1}	10.175	10.250	10.213
	6 L da^{-1}	9.850	11.225	10.537
General Means		**10.141**	**11.003**	**10.572**
1. Density (30×20 cm)		10.019	11.206	10.613
2. Density (40×20 cm)		10.469	11.244	10.856
3. Density (30×30 cm)		10.119	10.644	10.381

FULL PAPER

4. Density (40×30 cm)	9.956	10.919	10.437
0 L da^{-1}	10.069	10.925	10.497
2 L da^{-1}	10.381	10.975	10.678
4 L da^{-1}	10.144	11.075	10.609
6 L da^{-1}	9.969	11.038	10.503

*: Means followed by different letters are significantly different at the 5% significance level

In 2014, the number of branches ranged between 9.825 and 10.900. The highest number of branches was recorded in the third plant density (30 × 30 cm) combined with 2 L da^{-1} humic acid application, while the lowest value was observed in the first plant density (30 × 20 cm) with 4 L da^{-1} humic acid application. In 2015, the number of branches varied between 10.250 and 11.600. The highest value was obtained from the first plant density (30 × 20 cm) with 4 L da^{-1} humic acid application, whereas the lowest value was recorded in the fourth plant density (40 × 30 cm) with 4 L da^{-1} humic acid application. When two-year averages were considered, the highest number of branches (10.975) was obtained from the second plant density (40 × 20 cm) with 4 L da^{-1} humic acid application, while the lowest value (9.988) was recorded in the third plant density (30 × 30 cm) with 6 L da^{-1} humic acid application.

The effect of plant density on branch number was found to be statistically non-significant; however, in both years and in the overall mean, the highest branch number was observed in the second plant density (40 × 20 cm). Similarly, humic acid doses had no statistically significant effect on branch number. The highest values were obtained at 2 L da^{-1} in 2014 (10.381), at 4 L da^{-1} in 2015 (11.075), and at 2 L da^{-1} in the two-year average (10.678).

Overall means indicated that the number of branches was 10.141 in 2014 and 11.003 in 2015, showing an increase in the second year compared to the first year.

Previous studies reported branch numbers in *Dracocephalum moldavica* populations ranging between 7.86 and 11.66 (Borghei et al., 2015). Gholizadeh et al. (2010) reported values between 10 and 13, Hashemian Ahmadi et al. (2017) between 11.47 and 11.88, and Alaei et al. (2013) between 8.00 and 16.42. The results obtained in the present study are close to the mid-range of previous findings and are consistent with those reported by Hashemian Ahmadi et al. (2011).

3.3 Green Herbage Yield

The analysis of variance results for green herbage yield of *Dracocephalum moldavica* under different plant densities and humic acid doses indicated that plant density had a highly significant effect on green herbage yield at the 1% significance level, whereas the effect of humic acid doses was not statistically significant. In addition, the interaction between plant density and humic acid doses had no significant effect on green herbage yield.

Table 3. Mean Green Herbage Yield Values for Different Years (kg da^{-1})

Treatments		1.Year	2.Year	Mean
1.Density (30×20 cm)	**0 L da^{-1}**	1003.281	899.688	951.484
	2 L da^{-1}	982.188	1039.063	1010.625
	4 L da^{-1}	991.094	1052.656	1021.875

FULL PAPER

	6 L da^{-1}	1052.696	1102.344	1077.656
2. Density (40×20 cm)	**0 L da^{-1}**	1153.125	870.313	1011.719
	2 L da^{-1}	877.734	774.063	825.898
	4 L da^{-1}	814.609	781.094	797.852
	6 L da^{-1}	958.359	745.313	851.836
3. Density (30×30 cm)	**0 L da^{-1}**	897.031	508.906	702.969
	2 L da^{-1}	989.063	804.063	896.563
	4 L da^{-1}	671.719	657.344	664.531
	6 L da^{-1}	698.594	650.625	674.609
4. Density (40×30 cm)	**0 L da^{-1}**	636.719	539.063	587.891
	2 L da^{-1}	634.375	660.156	647.266
	4 L da^{-1}	639.531	581.563	610.547
	6 L da^{-1}	705.469	586.875	646.172
General Means		**856.616**	**765.820**	**811.218**
1. Density (30×20 cm)		1007.383	1023.438	1015.410**a**
2. Density (40×20 cm)		950.957	792.695	871.826**b**
3. Density (30×30 cm)		814.102	655.234	734.668**c**
4. Density (40×30 cm)		654.023	591.914	622.969**c**
0 L da^{-1}		922.539	704.492	813.516
2 L da^{-1}		870.840	819.336	845.088
4 L da^{-1}		779.238	768.164	773.701
6 L da^{-1}		853.848	771.289	812.568

*: Means followed by different letters are significantly different at the 5% significance level

The interaction effects of plant density and humic acid doses, as well as their main effects and mean values for green herbage yield, are presented in Table 3In the first year, green herbage yield ranged between 634.375 and 1153.125 kg da^{-1}. The highest yield was obtained from the second plant density (40 × 20 cm) with 0 L da^{-1} humic acid application, while the lowest yield was recorded in the fourth plant density (40 × 30 cm) with 2 L da^{-1} humic acid application.

In the second year, green herbage yield varied between 508.906 and 1102.344 kg da^{-1}. The highest value was obtained from the first plant density (30 × 20 cm) with 6 L da^{-1} humic acid application, whereas the lowest yield was observed in the third plant density (30 × 30 cm) with no humic acid application.

Considering the two-year averages, the highest green herbage yield (1011.719 kg da^{-1}) was recorded in the second plant density (40 × 20 cm) with 0 L da^{-1} humic acid, while the lowest yield (587.891 kg da^{-1}) was obtained from the fourth plant density (40 × 30 cm) with 0 L da^{-1} humic acid.

Table 3. Mean Green Herbage Yield Values for Different Years (kg da^{-1})

Treatments		1.Year	2.Year	Mean
1. Density (30×20 cm)	**0 L da^{-1}**	1003.281	899.688	951.484
	2 L da^{-1}	982.188	1039.063	1010.625
	4 L da^{-1}	991.094	1052.656	1021.875
	6 L da^{-1}	1052.696	1102.344	1077.656

FULL PAPER

2. Density (40×20 cm)	**0 L da^{-1}**	1153.125	870.313	1011.719
	2 L da^{-1}	877.734	774.063	825.898
	4 L da^{-1}	814.609	781.094	797.852
	6 L da^{-1}	958.359	745.313	851.836
3. Density (30×30 cm)	**0 L da^{-1}**	897.031	508.906	702.969
	2 L da^{-1}	989.063	804.063	896.563
	4 L da^{-1}	671.719	657.344	664.531
	6 L da^{-1}	698.594	650.625	674.609
4. Density (40×30 cm)	**0 L da^{-1}**	636.719	539.063	587.891
	2 L da^{-1}	634.375	660.156	647.266
	4 L da^{-1}	639.531	581.563	610.547
	6 L da^{-1}	705.469	586.875	646.172
General Means		**856.616**	**765.820**	**811.218**
1. Density (30×20 cm)		1007.383	1023.438	1015.410**a**
2. Density (40×20 cm)		950.957	792.695	871.826**b**
3. Density (30×30 cm)		814.102	655.234	734.668**c**
4. Density (40×30 cm)		654.023	591.914	622.969**c**
0 L da^{-1}		922.539	704.492	813.516
2 L da^{-1}		870.840	819.336	845.088
4 L da^{-1}		779.238	768.164	773.701
6 L da^{-1}		853.848	771.289	812.568

*: Means followed by different letters are significantly different at the 5% significance level

The effect of plant density on green herbage yield was found to be statistically significant at the 1% level. According to Duncan's test, mean values were grouped into three different categories. The highest mean value (1015.410 kg da^{-1}) was obtained from the first plant density and differed significantly from the other groups. In general, green herbage yield increased with increasing plant density; however, no statistically significant difference was observed between the third and fourth plant densities, and therefore they were placed in the same group.

The effect of humic acid application on green herbage yield was found to be statistically non-significant. The highest yield was obtained in the first year with 0 L da^{-1}, in the second year with 2 L da^{-1}, and in the two-year average also with 2 L da^{-1} humic acid application.

Overall means indicated that green herbage yield was 856.616 kg da^{-1} in 2014 and 765.820 kg da^{-1} in 2015. The higher yield observed in the first year may be attributed to more favorable climatic conditions and higher precipitation. Rahbarian and Afsharmanesh (2011) reported green herbage yields ranging between 3080.6 and 3620 kg ha^{-1}, while Aghaee Okhchular et al. (2012) reported values between 2967.4 and 3892.3 kg ha^{-1}. Davazdahemami et al. (2008) found significant differences between spring and summer sowing dates in *Dracocephalum moldavica*, with higher green herbage yield obtained from spring sowing. Gholizadeh et al. (2010) and Aghaee Okhchular et al. (2012) also reported that drought stress, sowing time, and sowing method significantly affect green herbage yield. The results of the present study are in agreement with previous research findings.

FULL PAPER

3.4 Dry Herbage Yield

According to the two-year analysis of variance results for dry herbage yield of *Dracocephalum moldavica* under different plant densities and humic acid doses, the effect of plant density on dry herbage yield was found to be statistically significant at the 1% level, whereas the effect of humic acid doses was not statistically significant. In addition, the interaction between plant density and humic acid doses had no significant effect on dry herbage yield (Table 4).

Table 4. Mean Dry Herbage Yield Values for Different Years (kg da^{-1})

Treatments		1.Year	2.Year	Mean
1. Density (30×20 cm)	**0 L da^{-1}**	243.415	232.104	237.759
	2 L da^{-1}	236.314	266.107	251.211
	4 L da^{-1}	249.844	283.490	266.667
	6 L da^{-1}	260.853	284.625	272.739
2. Density (40×20 cm)	**0 L da^{-1}**	291.400	217.576	254.488
	2 L da^{-1}	222.419	204.110	213.264
	4 L da^{-1}	206.989	207.375	207.182
	6 L da^{-1}	231.433	193.490	212.462
3. Density (30×30 cm)	**0 L da^{-1}**	218.858	129.366	174.112
	2 L da^{-1}	232.206	197.703	214.955
	4 L da^{-1}	166.57	169.495	168.032
	6 L da^{-1}	170.865	165.631	168.248
4. Density (40×30 cm)	**0 L da^{-1}**	155.641	145.025	150.333
	2 L da^{-1}	156.392	174.448	165.420
	4 L da^{-1}	159.991	151.918	155.955
	6 L da^{-1}	172.277	163.497	167.887
General Means		**210.967**	**199.122**	**205.045**
1. Density (30×20 cm)		247.607	266.581	257.094**a**
2. Density (40×20 cm)		238.060	205.638	221.849**b**
3. Density (30×30 cm)		197.125	165.549	181.337**c**
4. Density (40×30 cm)		161.075	158.722	159.899**c**
0 L da-1		227.328	181.018	204.173
2 L da-1		211.833	210.592	211.212
4 L da-1		195.849	203.070	199.459
6 L da-1		208.857	201.811	205.334

*: Means followed by different letters are significantly different at the 5% significance level

In the first year, dry herbage yield ranged between 155.641 and 291.400 kg da^{-1}. The highest dry herbage yield was obtained from the second plant density (40 × 20 cm) with 0 L da^{-1} humic acid application, while the lowest yield was recorded in the fourth plant density (40 × 30 cm) with 0 L da^{-1} humic acid application.

In the second year, dry herbage yield ranged between 129.366 and 266.107 kg da^{-1}. The highest value was observed in the first plant density (30 × 20 cm) combined with 2 L da^{-1} humic acid

FULL PAPER

application, whereas the lowest yield was obtained from the third plant density (30 × 30 cm) with 0 L da^{-1} humic acid application.

Considering the two-year averages, the highest dry herbage yield was obtained from the first plant density (30 × 20 cm) with 6 L da^{-1} humic acid application, while the lowest yield was recorded in the fourth plant density (40 × 30 cm) with 0 L da^{-1} humic acid application.

The effect of plant density on dry herbage yield was found to be statistically significant at the 1% level. According to Duncan's test ($P < 0.05$), mean values were grouped into three different categories. The highest mean value (257.094 kg da^{-1}) was obtained from the first plant density, which differed significantly from the other groups. Dry herbage yield increased with increasing plant density; however, no significant difference was found between the third and fourth plant densities, and therefore they were grouped together. The lowest dry herbage yield (159.899 kg da^{-1}) was recorded in the fourth plant density.

The effect of humic acid application on dry herbage yield was found to be statistically non-significant. The highest yield was obtained in the first year with 0 L da^{-1}, in the second year with 2 L da^{-1}, and in the two-year average with 2 L da^{-1} humic acid application.

Overall means indicated that dry herbage yield was 210.967 kg da^{-1} in 2014 and 199.122 kg da^{-1} in 2015. Although dry herbage yield was higher in 2014 than in 2015, this difference was not statistically significant.

Previous studies reported that dry herbage yield varies considerably depending on environmental conditions, sowing time, and agronomic practices. Davazdahemami et al. (2008) reported significant differences between spring and summer sowing dates in *Dracocephalum moldavica*, with higher yields obtained from spring sowing. Hashemian Ahmadi et al. (2011) found that sowing time and plant density had no significant effect on dry matter yield. Rahbarian and Afsharmanesh (2011) reported that drought stress and fertilization significantly affected dry herbage yield, with drought reducing yield and fertilization increasing it. Rahimzadeh et al. (2011) also reported significant effects of chemical and organic fertilizers on dry herbage yield.

4. Conclusion

Medicinal and aromatic plants are of great importance for human health and are increasingly expected to be compatible with organic farming systems. However, *Dracocephalum moldavica* L. cultivated in regions such as Urmia, Iran, is often exposed to excessive chemical fertilization, particularly nitrogen fertilizers, due to improper agricultural practices.

Humic acid fertilizers can be considered an alternative due to their ability to improve soil physical properties and enhance nutrient uptake. Based on the two-year results, the highest green herbage yield (1011.719 kg da^{-1}) was obtained from the second plant density (40 × 20 cm) with 0 L da^{-1} humic acid application, while the lowest yield (587.891 kg da^{-1}) was recorded in the fourth plant density (40 × 30 cm) with 0 L da^{-1} humic acid application. Similarly, the highest dry herbage yield was obtained from the second plant density with 0 L da^{-1} humic acid, and the lowest from the fourth plant density with 0 L da^{-1} humic acid.

FULL PAPER

The increase in green and dry herbage yield with increasing plant density is an expected result and has also been reported in similar studies. If seed production is not the main objective, dense planting can be recommended to increase herbage yield. Although humic acid application had no significant effect in this study, more promising results may be obtained in long-term studies.

Overall, *Dracocephalum moldavica* L. showed partial adaptation to Ankara climatic and soil conditions and can be cultivated under these conditions.

Conflict of Interest

The authors declare that there is no conflict of interest among them.

References

[1] Abdossi, V., Mohammadi, H., Hossein, S., Ahmadi, H., & Hadipanah, A. (2015). The response of dragonhead (*Dracocephalum moldavica* L.) plant to sowing date and planting density. *Biological Forum – An International Journal*, 7(2), 36–42.

[2] Alaei, S., & Mahna, N. (2013). Comparison of essential oil composition in *Dracocephalum moldavica* in greenhouse and field. *Journal of Essential Oil Bearing Plants*, 16(3), 346–351.

[3] Anonymous. (2022). *Dracocephalum moldavica L.* Retrieved April 06, 2022, from https://www.bizimbitkiler.org.tr/v2/hiyerarsi.php?c=Dracocephalum

[4] Basiri, M. H., & Nadjafi, F. (2019). Effect of plant density on growth, yield and essential oil characteristics of Iranian tarragon (*Artemisia dracunculus* L.) landraces. *Scientia Horticulturae*, 257, 108655.

[5] Baydar, H. (2016). *Tıbbi ve Aromatik Bitkiler Bilimi ve Teknolojisi*. Isparta: Süleyman Demirel Üniversitesi Yayınları.

[6] Borghei, S. F., Azizi, A., Hadian, J., & Abdosi, V. (2015). Broad variation in herbage yield and essential oil content among Iranian landraces of *Dracocephalum moldavica*. *(Journal details missing)*

[7] Cakirli Akyüz, N., & Theuvsen, L. (2021). Organic agriculture in Turkey: Status, achievements, and shortcomings. *Organic Agriculture*, 11(4), 501–517.

[8] Chachoyan, A. A., & Oganesyan, G. B. (1996). Antitumor activity of some species of the family Lamiaceae. *Rastitel'nye Resursy*, 32(4), 59–64.

[9] Dastmalchi, K., Dorman, H. D., Laakso, I., & Hiltunen, R. (2007). Chemical composition and antioxidative activity of Moldavian balm (*Dracocephalum moldavica* L.) extracts. *LWT – Food Science and Technology*, 40(9), 1655–1663.

[10] Davazdahemami, S., Sefidkon, F., Jahansooz, M. R., & Mazaheri, D. (2008). Comparison of biological yield, essential oil content and phenological stages of Moldavian balm (*Dracocephalum moldavica* L.) in three planting dates. *(Journal details incomplete)*

[11] Dmitruk, M., Weryszko-Chmielewska, E., & Sulborska, A. (2018). Flowering and nectar secretion in two forms of Moldavian dragonhead (*Dracocephalum moldavica* L.). *Journal of Apicultural Science*, 62(1), 97–110.

[12] Ekren, S., Sönmez, Ç., Sancaktaroğlu, S., & Bayram, E. (2009). Farklı dikim sıklıklarının fesleğen (*Ocimum basilicum* L.) bitkisinin verim ve kalite özellikleri üzerine etkisi. *Ege Üniversitesi Ziraat Fakültesi Dergisi*, 46(3), 165–173.

[13] Gholizadeh, A., Amin, M. S. M., Anuar, A. R., & Saberioon, M. M. (2010). Water stress and natural zeolite impacts on physiomorphological characteristics of Moldavian balm (*Dracocephalum moldavica* L.). *(Journal details missing)*

[14] Güneş, A. (2007). *Gübreler ve Gübreleme Teknikleri*. Ankara: Ankara Üniversitesi Yayınları.

[15] Hashemian, M., et al. (2017). Curcumin-loaded chitosan-alginate-STPP nanoparticles ameliorate memory deficits and reduce glial activation. *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, 79, 462–471.

FULL PAPER

[16] Holm, Y., Galambosi, B., & Hiltunen, R. (1988). Variation of the main terpenes in dragonhead (*Dracocephalum moldavica* L.) during growth. *Flavour and Fragrance Journal*, 3(3), 113–115.
[17] Janmohammadi, M., Sufi-Mahmoudi, Z., Ahadnezhad, A., Yousefzadeh, S., & Sabaghnia, N. (2014). Influence of chemical and organic fertilizer on growth, yield and essential oil of dragonhead (*Dracocephalum moldavica* L.). *Acta Agriculturae Slovenica*, 103(1), 73–81.
[18] Perrott, L. A., Strydhorst, S. M., Hall, L. M., Yang, R. C., Pauly, D., Gill, K. S., & Bowness, R. (2018). Advanced agronomic practices to maximize feed barley yield, quality, and standability in Alberta, Canada. I. Responses to plant density, a plant growth regulator, and foliar fungicides. *Agronomy Journal*, 110(4), 1447–1457.
[19] Povilaityté, V., Cuvelier, M. E., & Berset, C. (2001). Antioxidant properties of Moldavian dragonhead (*Dracocephalum moldavica* L.). *Journal of Food Lipids*, 8(1), 45–64.
[20] Rahbarian, P., Afsharmanesh, G., & Behzadi, N. (2011). Effect of drought stress as water deficit and plant density on yield of roselle (*Hibiscus sabdariffa*). *New Findings in Agriculture*, 5(3), 249–257.
[21] Rahimzadeh, S., Sohrabi, Y., Heidary, G. R., & Pirzad, A. R. (2011a). Effect of biofertilizers on morphological traits and yield of dragonhead (*Dracocephalum moldavica* L.). *Journal of Horticultural Science*, 25(3), 335–343.
[22] Senol, S., & Bayramin, I. (2013). Soil resources of Turkey. In *Soil Resources of Mediterranean and Caucasus Countries* (pp. 225–237). Luxembourg: Office for Official Publications of the European Communities.
[23] Shepherd, M. A., Harrison, R., & Webb, J. J. S. U. (2002). Managing soil organic matter – implications for soil structure on organic farms. *Soil Use and Management*, 18, 284–292.
[24] Ştefania, S., Duda, M., Ghete, A., Mureşan, C., & Crîşan, L. (2018). The importance and use of the species *Dracocephalum moldavica*. *Hop and Medicinal Plants*, 26(1–2), 39–43.

FULL PAPER

WILD EDIBLE FRUITS: USE IN TRADITIONAL MEDICINE

Sezai Ercişli[1], Ishak Bayyigit[2], Mehmet Ramazan Bozhüyük[3]

[1]Atatürk University, Faculty of Agriculture, Department of Horticulture, 25240 Erzurum, Türkiye
[2]Mardin Artuklu University, Kızıltepe Faculty of Agriculture Science and Technology, Department of Horticulture, 47400 Kızıltepe-Mardin, Türkiye
[3]Iğdır University, Faculty of Agriculture, Department of Horticulture, 76100 Iğdır, Türkiye
correspondence: sercisli@atauni.edu.tr

Abstract

Fruit cultivation is considered a very important industry worldwide and provides high economic income. Fruit varieties with different characteristics generally contain high water content, fiber, sugar, antioxidants, vitamins, and organic acids, and therefore serve as a fundamental source for human nutrition. There is a strong correlation between fruit consumption and healthy living. Compared to cultivated fruit varieties, wild edible fruits, being fruits that grow in their natural environment, are not exposed to pesticides and chemical fertilizers. These characteristics place them in the healthy food category. Wild edible fruits play a very important role in meeting the nutritional needs of local and tribal populations worldwide. Wild edible fruits have an important place in traditional medicine as they are reported to cure numerous ailments, including microbial infections, respiratory, dermatological, and gastrointestinal disorders. Wild edible fruits have attracted the attention of researchers in obtaining bioactive compounds with promising therapeutic potential. They are noted to be rich in phytochemicals such as flavonoids, anthocyanins, and alkaloids. For villagers and locals, wild edible fruits are also an important source of traditional medicine. Therefore, they have great potential in the prevention and treatment of numerous diseases.

Keywords: Wild fruits, traditional use, diversity, distribution

Introduction

The Anatolian lands, which have hosted many great civilizations in the past (Hittites, Seljuks, Ottomans), have been of great importance to humanity since the earliest periods of history for traditional medicine practices based on large plants. The knowledge gained from the use of plants in traditional medicine has been passed down from generation to generation in Anatolia. We learn that they knew, collected, and used as medicine of many medicinal wild edible fruits, especially those growing wild, such as grapes, olives, almonds, apricots, hawthorn, cranberries, chestnuts, carob, etc. (Altintas, 2022).

Wild edible fruit species, found on different continents and generally endemic to those continents, offer great diversity to the ecosystem. In recent years, especially in the context of climate change, these species, which are of great importance for future food security and possess resistance to abiotic and biotic stressors, include examples such as sea buckthorn, hawthorn, rosehip, wild strawberry, wild raspberry and blackberry, wild blueberry species, rowan, etc. (Popovic-Djordjevic et al., 2022; UI Abidin et al., 2023; Negrean et al., 2023; Ercisli, 2026).

FULL PAPER

The general characteristics of these fruit species are their ability to produce crops under minimal maintenance conditions and their significant contribution to the livelihood of people living in rural areas. Their deep root structures also contribute to their ability to prevent erosion (Li et al., 2022; González-Zamorano et al., 2025). These species, which are quite rich in nutrients, are generally found in forests, field borders, and meadows. These fruits are packed with vitamins (A, C), polyphenols, and unique flavors, making them valuable for jams, syrups, and fresh consumption (Vega et al., 2023).

Due to its diverse topographical and climatic structures, Türkiye is home to numerous wild edible fruit species. Wild edible fruit species hold a significant place in Turkish culture and are considered one of the most important elements of cultural heritage (Sagdic et al., 2022). The Turkish people possess extensive knowledge and culture surrounding wild edible fruits, and this knowledge is passed down from generation to generation (Yilmaz et al., 2015).

In recent years, the increased media coverage of these fruits and the implementation of numerous regional social responsibility projects have further increased interest in them (Yalcin et al., 2022). As in the rest of the world, a large audience has developed in Türkiye interested in wild fruit species, and the number of scientific studies on this topic is rapidly increasing. In many regions of Türkiye, efforts are being made to protect these plants and highlight their importance for food security for future generations (Ilhan et al., 2021; Yalcin et al., 2022).

In Türkiye, not only the fruits but also other plant parts (leaves, roots) of wild edible fruit species are widely used in traditional medicine by the public. Furthermore, some species, such as carob (*Ceratonia siliqua* L.) are heavily used in forested areas in Mediterranean region of Türkiye because they are not damaged by forest fires (Gadoum et al., 2026). Carob fruits (beans) are also preferred in cultivation due to their high economic return. Numerous products used extensively in traditional medicine are obtained from their fruits (Ikram et al., 2023).

Main wild edible fruits used in traditional medicine in Türkiye

Fragaria vesca (wild strawberry), *Rubus* spp (wild raspberry and wild blackberry), *Sambucus nigra,* (elderberry), *Malus* spp (wild apple), *Pyrus* spp. (wild pear), *Prunus* spp. (wild plum), *Rosa* spp. (Rose hip), *Crateagus* spp. (Hawthorn), *Vaccinium myrtillus* (Bilberry), *Hippophae* spp. (Sea buckthorn), *Morus* spp. (Mulberry), *Eleagnus angustifolia* (Russian olive), *Mespilus germanica* (Medlar), *Berberis* spp (Barberry), *Cornus mas* (Cornelian cherry), *Prunus cerasus* (wild sour cherry), *Prunus avium* (wild sweet cherry), *Prunus laurocerasus* (Cherry laurel), *Prunus armeniaca* (wild apricots), *Arbutus* spp. (Strawberry tree), *Sorbus domestics* (Service tree), *Prunus* spp. (wild almond), *Ceratonia siliqua* (Carob), *Punica granatum,* (wild pomegranate), *Olea oleaster* (wild olive), *Ficus carica* (wild fig) and *Myrtus communis* (Myrtle) are the main wild edible fruits used in traditional medicine in Türkiye (Table 1).

Among them *Sambucus nigra*, *Crateagus* spp., *Hippophae* spp. *Morus* spp., *Punica granatum* and *Myrtus communis* are used more and are of greater importance in traditional medicine.

As indicated in Table 1, wild edible fruit species in general have anti-inflammatory, antimicrobial, antioxidant and antidiabetic effects. They help prevent the development of diabetes, digestive disorders, anemia, liver and kidney diseases. They lower cholesterol levels. Some of the prevent

FULL PAPER

urinary tract infections, reduce the risk of chronic diseases such as diabetes, liver and kidney disease, support digestive health, fight free radicals, lower cholesterol levels and protect heart health. Most of them strengthen immunity.

Studies on wild edible fruit species grown in different parts of the world have revealed that these species have many environmental benefits as well as significant functions in terms of human health (Li et al., 2016; Bobinaitė et al., 2020). These studies have shown that the fruits of these species generally possess high biological activity, are superfoods with high antioxidant, vitamin C, and fiber content, strengthening immunity, preventing urinary tract infections, supporting heart health, and having anti-inflammatory effects (Li et al., 2014; Baby et al., 2018; Yang and Kortesniemi, 2018; Bobinaitė et al., 2020; Sarv et al., 2020; Telichowska et al., 2020; Arvinte et al., 2023).

It has also been shown that these species help balance blood sugar, regulate digestion, and are beneficial for anemia, and that consuming them fresh or as unsweetened juice protects vascular health. It is also revealed that wild edible fruits are potent, nutrient-dense foods rich in minerals, and polyphenols (like anthocyanins) that enhance human health. They offer significant therapeutic benefits, including antioxidant, anti-inflammatory, and antimicrobial activities, contributing to the prevention of chronic diseases like diabetes, cardiovascular, gastrointestinal and neurological disorders. Many wild fruits, contain high levels of phenolic compounds that combat free radicals, reducing oxidative stress (Saha et al., 2017; Bhatia et al., 2018; Popovic-Djordjevic et al., 2022; Yalcin et al., 2022; Vega et al., 2023; UI Abidin et al., 2024; Seansouk et al., 2025) (Figure 1).

Table 1. Main wild edible fruits used as medicinal plant in Türkiye

Species	Distribution	Medicinal use	Area of use
Fragaria vesca, wild strawberry	+++	+	Chronic diseases, neurodegenerative
Rubus spp., wild raspberry and wild blackberry	+++	+	Boost immune system
Sambucus nigra, elderberry	++	+++*	Boost immune system
Malus spp., wild apple	+++	+	High cholesterol, toxins removal
Pyrus spp., wild pear	+++	++	High cholesterol, toxins removal
Prunus spp., wild plum	+++	++	Antioxidant, cholesterol removal
Rosa spp., Rose hip	+++	+++	Boost immune system
Crateagus spp., Hawthorn	+++	+++*	Cardiovascular protection, boost immune system, anti-inflammatory, antidiabetic
Vaccinium myrtillus, Bilberry,	+++	++	Boost immune system, digestion
Hippophae spp., Sea buckthorn	++	+++*	Boost immune system, antioxidant, antimicrobial, skin health, cardiovascular protection
Morus spp., Mulberry	++	+++*	Anemia, antimicrobial, antioxidant, increase sperm cell
Eleagnus angustifolia,	++	++	Anti-inflammatory, analgesic

FULL PAPER

Russian olive			
Mespilus germanica, Medlar	++	++	Antioxidant, digestion
Berberis spp, Barberry	++	++	Boost immune system. Antimicrobial, antioxidant
Cornus mas, Cornelian cherry	++	++	Anti-inflammatory, antidiabetic
Prunus cerasus, wild sour cherry	+++	+	Boost immune system, antimicrobial, antioxidant
Prunus avium, wild sweet cherry	+++	+	Heart health
Prunus laurocerasus, cherry laurel	++	++	Boost immune system, antimicrobial, antioxidant
Prunus armeniaca, wild apricots	+++	++	Boost immune system, antimicrobial, antioxidant, digestion
Arbutus spp., Strawberry tree,	+	++	Boost immune system, antimicrobial, antioxidant
Sorbus domestics, Service tree	+	++	Boost immune system, antimicrobial, antioxidant, digestion
Prunus spp., wild Almond	+++	++	Cardivascular protection
Ceratonia siliqua, Carob	+++	++	Boost immune system, antimicrobial, antioxidant, digestion
Punica granatum, wild pomegranate	++	+++*	Boost immune system, antimicrobial, antioxidant, digestion, increase blood cell
Olea oleaster, wild olive	++	++	Anti-inflammatory, antidiabetic
Ficus carica, wild fig	++	++	Boost immune system, cell regeneration
Myrtus communis, Myrtle	+	+++*	Boost immune system, antimicrobial, antioxidant, digestion

+++*: Extremely High; +++: High; ++: Medium; +: Low

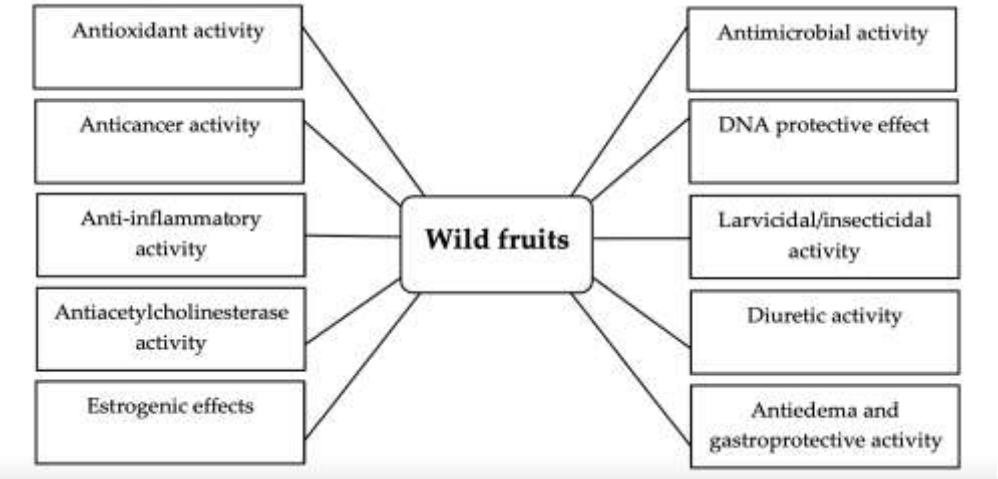


Figure 1. Bioactivity and human health effect of wild edible fruits

References

FULL PAPER

[1] Altintas, A. (2022). Anadolu Tıbbı Dergisi, 1:1-10.
[2] Arvinte, O.M., Senila, L., Becze, A., Amariei, S. (2023). Rowanberry-a source of bioactive compounds and their biopharmaceutical properties. Plants, 12:3225. https://doi.org/10.3390/plants12183225.
[3] Baby, B., Antony, P., Vijayan, R. (2018). Antioxidant and anticancer properties of berries. Critical Reviews in Food Science and Nutrition, 58(15):2491-2507. https://doi.org/10.1080/10408398.2017.1329198.
[4] Bhatia, H., Sharma, Y.P., Manhas, R.K., Kumar, K. (2018). Traditionally used wild edible plants of District Udhampur, J&K, Indian Journal Ethnobiology and Ethnomedicine, 14:73. https://doi.org/10.1186/s13002-018-0272-1.
[5] Bobinaitė, R., Grootaert, C., Van Camp, J., Šarkinas, A., Liaudanskas, M., Žvikas, V., Viškelis, P., Venskutonis, P.R. (2020). Chemical composition, antioxidant, antimicrobial and antiproliferative activities of the extracts isolated from the pomace of rowanberry (*Sorbus aucuparia* L.). Food Research International, 136:109310. https://doi.org/10.1016/j.foodres.2020.109310
[6] Ercisli, S. (2026). Wild apricots (Zerdali): High morphological, biochemical and antioxidant diversity. Acta Horticulturae. 1450: 303-308.https://doi.org/10.17660/ ActaHortic.2026.1450.40.
[7] Gadoum, A., Difallah, A., Adda, A., Merah, O. (2026). Carob tree: A review of traditional uses, medicinal properties, and future perspectives in sustainable forestry. *Life*, 16(3):448. https://doi.org/10.3390/life16030448.
[8] González-Zamorano, L., Cámara, R.M., Morales, P., Cámara, M. (2025). Harnessing edible wild fruits: Sustainability and health aspects. *Nutrients.* 17(3):412. https://doi.org/10.3390/nu17030412.
[9] Ikram, A., Khalid, W., Wajeeha Zafar, K.U., Ali, A., Afzal, M.F., Aziz, A., Faiz Ul Rasool, I., Al-Farga, A., Aqlan, F., Koraqi, H. (2023). Nutritional, biochemical, and clinical applications of carob: A review. Food Science & Nutrition, 11(7):3641-3654. https://doi.org/10.1002/fsn3.3367.
[10] Ilhan, G., Gundogdu, M., Karlovic, K., Zidovec, V., Vokurka, A., Ercisli, S. (2021). Main agro-morphological and biochemical berry characteristics of wild-grown sea buckthorn (*Hippophae rhamnoides* L. ssp. *caucasica* Rousi) genotypes in Turkey. Sustainability, 13 (3), 1198. https://doi.org/10.3390/su13031198.
[11] Li, Y., Zhang, J.J., Xu, D.P., Zhou, T., Zhou, Y., Li, S., Li, H.B. (2016). Bioactivities and health benefits of wild fruits. International Journal of Molecular Sciences 17(8):1258. https://doi.org/10.3390/ijms17081258.
[12] Li, A.N., Li, S., Li, H.B., Xu, D.P., Xu, X.R., Chen, F. (2014). Total phenolic contents and antioxidant capacities of 51 edible and wild flowers. Journal of Functional Foods, 6, 319-330. https://doi.org/10.1016/j.jff.2013.10.022.
[13] Li, H., Fang, W., Wang, Z., Chen, Y. (2022). Physicochemical, biological properties, and flavour profile of *Rosa roxburghii* Tratt, *Pyracantha fortuneana*, and *Rosa laevigata* Michx fruits: A comprehensive review. Food Chemistry, 366:130509. https://doi.org/10.1016/j.foodchem.2021.130509.
[14] Negrean, O-R., Farcas, A.C., Pop, O.L., Socaci, S.A. (2023). Blackthorn-A valuable source of phenolic antioxidants with potential health benefits. *Molecules*. 28(8): 3456.
[15] Popovic-Djordjevic, J.B., Fotiric-Akšic, M., Katanic-Stankovic, J.S., Pantelic, N.Đ., Mihailovic, V. (2022). Wild-growing species in the service of medicine: Environmental challenges and sustainable production. In Environmental Challenges and Medicinal Plants, Environmental Challenges and Solutions, 1st ed.; Aftab, T., Ed.; Springer Nature: Cham, Switzerland, pp. 49-104.
[16] Saha, S.K., Lee, S.B., Won, J., Choi, H.Y., Kim, K., Yang, G.M., Dayem, A.A., Cho, S.G. (2017). Correlation between oxidative stress, nutrition, and cancer initiation. International Journal of Molecular Sciences, 18(7):1544. https://doi.org/10.3390/ijms18071544.
[17] Sagdic, O., Polat, B., Yetim, H. (2022). Bioactivities of some wild fruits grown in Turkey. Erwerbs-Obstbau 64:299-305. https://doi.org/10.1007/s10341-021-00631-0.
[18] Sarv, V., Venskutonis, P.R., Bhat, R. (2020). The *Sorbus* spp.-underutilised plants for foods and nutraceuticals: review on polyphenolic phytochemicals and antioxidant potential. Antioxidants, 9:813. https://doi.org/10.3390/antiox9090813.

FULL PAPER

[19] Saensouk, P., Saensouk, S., Boonma, T., Junsongduang, A., Naing, M.K., Jitpromma, T. (2025). Ethnomedicinal properties of wild edible fruit plants and their horticultural potential among indigenous is an communities in Roi et province, northeastern Thailand. *Horticulturae*, 11(8):885. https://doi.org/10.3390/ horticulturae11080885.
[20] Stabnikova, O., Stabnikov, V., Paredes-López, O. (2024). Fruits of wild-grown shrubs for health nutrition. Plant Foods for Human Nutrition, 79:20-37. https://doi.org/10.1007/s11130-024-01144-3.
[21] Telichowska, A., Kobus-Cisowska, J., Szulc, P. (2020). Phytopharmacological possibilities of bird cherry *Prunus padus* L. and *Prunus serotina* L. species and their bioactive phytochemicals. Nutrients 12:1966. https://doi.org/10.3390/nu12071966.
[22] Ul Abidin, S.Z., Khan, R., Ahmad, M., Cuerrier, A., Zafar, M., Ullah, A., Khan, J., Saeed, A., Al-Qahtani, W.H., Kazi, M. (2024). Wild edible fruits as a source of food and medicine: A study among tribal communities of southern Khyber Pakhtunkhwa. Plants, 13:39. https://doi.org/10.3390/plants13010039.
[23] Vega, E.N., García-Herrera, P., Ciudad-Mulero, M., Dias, M.I., Matallana-González, M.C., Cámara, M., Tardío, J., Molina, M., Pinela, J., Pires, T.C.S.P., Barros, L., Fernandez-Ruiz, V., Morales, P. (2023). Wild sweet cherry, strawberry and bilberry as underestimated sources of natural colorants and bioactive compounds with functional properties. Food Chemistry, 414:135669. https://doi.org/10.1016/ j.foodchem.2023.135669.
[24] Yalcin, O., Bassil, N.V., Kafkas, N.E. (2022). Wild edible small fruits in Turkey and their fruit characteristics. Proceedings of the Latvian Academy of Sciences. Section B, 76 (4): 417-423. https://doi.org/10.2478/prolas-2022-0065.
[25] Yang, B., Kortesniemi, M. (2015). Clinical evidence on potential health benefits of berries. Current Opinion in Food Science, 2:36-42. https://doi.org/10.1016/j.cofs. 2015.01.002.
[26] Yilmaz, K.U., Ercisli, S., Cam, M., Uzun, A., Yilmaztekin, M., Kafkas, E., Pinar, H. (2015). Fruit weight, total phenolics, acidity and sugar content of edible wild pear (*Pyrus elaeagnifolia* Pall.) fruits. Erwerbs Obstbau 57(4):179-184. https://doi.org/10.1007/s10341-015-0246-6.

FULL PAPER

WILD APRICOT FRUITS: MEDICINAL AND AROMATIC USE

Sezai Ercişli[1], Melekber Sülüşoğlu Durul[2], Mehmet Ramazan Bozhüyük[3]

[1]Atatürk University, Faculty of Agriculture, Department of Horticulture, 25240 Erzurum, Türkiye
[2]Kocaeli University, Faculty of Agriculture, Department of Horticulture, 41300 Kocaeli, Türkiye
[3]Iğdır University, Faculty of Agriculture, Department of Horticulture, 76100 Iğdır, Türkiye
correspondance: sercisli@atauni.edu.tr

Abstract
Apricots, which grow naturally in different regions of Türkiye, especially in rural areas, hold a valuable place in the food industry, both fresh and dried. Wild apricot (*Prunus armeniaca*), Zerdali, is close relatives of cultivated apricot and has edible and smaller fruits. It is found as non-grafted forms in many apricot growing countries. The fruits of wild apricots are getting more importance recently due to it is a natural food source with high antioxidant content. High antioxidant properties protect human cells by fighting free radicals in the body. Its fruits used in making jams and compotes. For centuries, Zerdali fruits used in medicinal and aromatic purposes. It has a more sour, sharp, and intensely aromatic taste compared to cultivated apricot fruits. Besides fresh consumption, it is preferred processing into several traditional products due to high aroma and better sugar/acid ratio. It is rich in vitamin A, vitamin C, zinc, selenium, and potassium. All these vitamins and minerals are essential nutrients that the body needs and supports the immune system. Valuable oil obtained from wild apricot kernels is used in the cosmetics and health sectors for skin care and has high market values.

Keywords: Wild apricots, composition, diversity, medicinal use

Introduction

Wild apricot supports sustainable agriculture by promoting biodiverse cultivation practices. Growing wild apricot requires fewer chemical inputs and promotes soil health, which aligns well with eco-friendly farming principles. Wild apricot can also boost local economies by providing farmers with a high-value crop that can be sold fresh or processed into various products. This helps in generating revenue while adhering to sustainable farming practices (Gecer et al., 2020; Ercisli, 2026).

The deep root system of wild apricot helps in soil stabilization, reducing soil erosion and protecting the integrity of the landscape. Its cultivation can play a vital role in maintaining healthy ecosystems by preventing land degradation. Wild apricot often grows well in diverse plant communities, encouraging a balanced ecosystem. By intercropping wild apricot with other plants, farmers can create a more resilient and productive agricultural system. There is a growing market demand for wild apricot due to its unique flavor and nutritional benefits. This creates a lucrative opportunity for farmers engaged in its cultivation and helps diversify their income streams.

Beyond fresh consumption, wild apricot can be processed into a variety of value-added products such as jams, chutneys, and dietary supplements. These products not only provide additional revenue streams but also cater to niche markets interested in health and gourmet foods (Celik, 1996; Ercisli, 2009).

FULL PAPER

Wild apricot fruits are smaller than cultivated ones. Their taste is sourer compared to cultivated ones. Apricots are specially cultivated. Wild apricots, however, grow spontaneously along roadsides and in field borders. While pesticides and chemical fertilizers are used in apricot cultivation, these types of pesticides and chemical fertilizers are absolutely not used in wild apricot trees (Ilhan et al., 2020; Karatas, 2022).

Wild apricot (Zerdali) fruits
Use in traditional medicine

Wild apricot fruits have been used as a popular home remedy in China and among the mountainous inhabitants of Himalayas for centuries. The folk describes apricot as analgesic, anthelmintic, antiasthmatic, antipyretic, antiseptic, antispasmodic, demulcent, emetic, emollient, expectorant, laxative, ophthalmic, pectoral, sedative, tonic and vulnerary. Apricot fruit in Chinese medicine is thought to be useful in regenerating body fluids, detoxifying and quenching thirst, while kernels for toning respiratory system and alleviating cough (Fatima et al., 2018). (Figure 1).

The wild relative of the apricot (*Prunus armeniaca* L.), considered within the same species, has smaller fruits and a tart taste. It is a scientific fact that apricot varieties are obtained through selection among wild apricots. Wild apricots exhibit greater diversity than cultivated apricots, particularly in fruit shape, color, tree habit, and ripening (early or late). Wild apricot fruits are more advantageous for the processing industry, especially due to their more aromatic and tart nature (better sugar/acid ratio) (Ercisli, 2026). In countries where wild apricots grow, particularly Central Asia and the Near East, wild apricot fruits are traditionally used for skin beauty, diabetes, heart health, detoxification, digestive regulation, infection prevention, bone strengthening, eye health, vitality, and anemia.

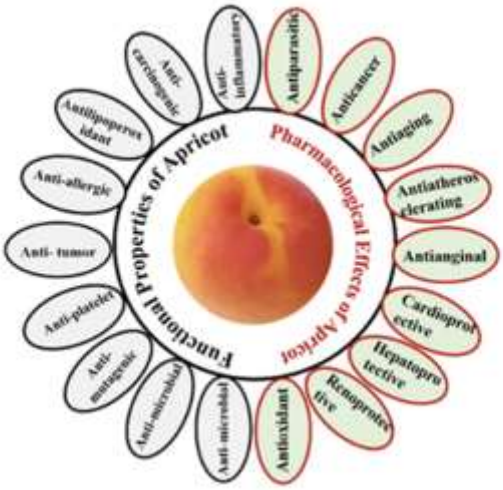


Figure 1. Functional and pharmacological properties of apricot fruits (Gupta et al., 2018; Jaafar et al., 2021)

Rich in vitamins and antioxidants
Wild apricot is rich with essential vitamins such as vitamin C, which boosts the immune system, and vitamin A, which is vital for good vision and skin health. The fruits also a treasure trove of

FULL PAPER

antioxidants, helping to neutralize harmful free radicals and potentially reducing the risk of chronic diseases. The fruit also rich for zinc, selenium, and potassium. All of these vitamins and minerals are essential nutrients that the body needs (Erdogan-Orhan and Kartal, 2011).

Promotes gut health

The high fiber content in wild apricot aids in digestion and promotes a healthy gut. Consuming wild apricot fruits can help improve digestive health and prevent constipation, ensuring a more efficient nutrient absorption process (Fatima et al., 2018). Wild apricot fruits rich for both soluble and insoluble fibers. Wild apricot fruits supply water-soluble fibers that comprise of pectin, gums and polysaccharides and soluble fibers that remain insoluble in water containing cellulose, hemicellulose and lignin. Incorporating fiber in human diet is important as fiber retains water and improves the beneficial gut bacteria by delaying the movement of food through digestive tract and relieves constipation. It lowers the risk of obesity and helps with weight loss as it helps reduce hunger. Intake of soluble fibers are useful in maintaining cholesterol levels (Sushma et al., 2025).

Health benefits of wild apricot fruit

High antioxidant content: Compared to cultivated apricots, wild apricot fruits are particularly rich in polyphenols, flavonoids such as rutin and quercetin, anthocyanins, and carotenoids (such as beta-carotene) because they grow under abiotic and biotic stress conditions and those conditions promote accumulation of more secondary metabolites in its fruits. These bioactive substances found in wild apricot fruits help neutralize free radicals that threaten healthy cells in the human body and reduce oxidative stress, and are also effective antioxidants that prevent oxidative damage to critical biomolecules such as DNA, lipids, and proteins (Ayour et al., 2022; 2026).

Anti-inflammatory effect

Thanks to its anti-inflammatory properties, wild apricot fruits prevents inflammation in the body. If human suffer from diseases caused by infection, it is recommend including more wild apricot fruits in diet. Wild apricot consumes fresh in the summer months and as dried fruit in the winter months. The pigments found in wild apricots have crucial health functions in the human body, particularly exerting significant anti-inflammatory effects by regulating the expression of pro-inflammatory mediators and signaling pathways. These effects can vary considerably among genotypes grown from seed, exhibiting significant variation. Furthermore, flavonoids commonly found in wild apricots, such as quercetin and kaempferol, inhibit the synthesis of pro-inflammatory cytokines, including tumor necrosis factor-alpha (TNF-α) and interleukin-6 (IL-6). These compounds also reduce the activity of COX and LOX enzymes involved in the biosynthesis of pro-inflammatory eicosanoids (Al-Khayri et al., 2022). Wild apricot fruits contain a high number of antioxidants. This also helps to remove toxins from the body. In addition, since wild apricots do not contain any chemicals or pesticides, they do not create an extra toxic load in the body.

Improved skin health: The high vitamin A and beta-carotene content helps prevent night blindness and macular degeneration. Vitamins C and E protect skin cells from UV damage and aid in collagen production. High in antioxidants, wild apricots are a skin-friendly fruit. They make the skin look more vibrant and radiant. A mask made with wild apricots gives the skin softness and vitality. Regular consumption of wild apricots increases the skin's elasticity. It eliminates early

FULL PAPER

signs of aging on the skin. It is also quite effective in removing skin blemishes. Apricots are also known to be good for eczema (Stahl and Sies, 2012).

Improved eye health: Among fruit species, apricots are very rich in carotenoids, which are responsible for their color ranging from yellow to orange. Some wild apricot genotypes have fruits even higher carotenoid content than cultivated apricot fruits. Among the carotenoids found in apricot fruits, beta-carotene and lutein are prominent, and they are precursors of vitamin A. They are extremely important substances for human vision. Both substances eliminate factors that cause eye diseases and also relieve eye pain. In addition to genotypic characteristics, environmental factors (lighting, altitude, etc.) also have a very important effect on the biosynthesis of carotenoids. Carotenoids not only give apricots their color, but also exhibit antioxidant and anti-inflammatory properties. These properties are extremely important in the fight against diseases. Beta-carotene and lutein, which are among the most important carotenoids, are precursors of vitamin A and support eye health (Choo et al., 2022; Sushma et al., 2025).

Digestive support: They are a good source of fiber, which helps regulate blood sugar, lowers cholesterol, and maintains a healthy gut microbiome. Wild apricots are rich in fiber. This makes them very effective in preventing constipation. If human suffer from constipation, it is recommended consuming a few apricots daily. Thanks to their fiber content, wild apricots facilitate digestion and eliminate constipation. Wild apricots also support improved digestive function thanks to their vitamins, minerals, and other components (Sushma et al., 2025).

Liver and cardiovascular protection: Due to high potassium levels, wild apricots may help regulate blood pressure. Studies indicate that they have rich antioxidants and may protect the liver, helps lower inflammation from oxidative damage. Wild apricot fruits protect the liver against the damage caused by alcohol and other toxins (Sushma et al., 2025). Thanks to this property, they eliminate factors that contribute to cardiovascular diseases and prevent the development of such diseases. They protect vascular health. Studies have shown that regular apricot consumption is effective in reducing the risk of many chronic diseases. Anthocyanins and carotenoids, which are among the most important bioactive compounds found in apricots, undergo extensive metabolism during digestion, and their absorption depends on their interaction with dietary fats, fiber, and the nutrient matrix. Anthocyanins and flavonoids in apricots improve vascular health by enhancing endothelial function, reducing arterial stiffness, and lowering blood pressure. These effects are also critically important in the prevention of atherosclerosis and other cardiovascular diseases (Krga and Milenkovic, 2019; Godeshwar et al., 2023). Carotenoids, abundant in apricots, reduce the risk of age-related macular degeneration, a leading cause of blindness, especially in older individuals. Carotenoids have also been shown to exhibit chemopreventive properties against lung, prostate, and skin cancers by inhibiting oxidative stress and regulating gene expression involved in apoptosis and cell proliferation (Dehnavi et al., 2024). Therefore, consuming whole apricots instead of supplementing with isolated pigments is recommended, as there is a synergy between pigments and other phytochemicals such as polyphenols and vitamins, increasing their bioavailability and therapeutic potential together (Liu, 2004; Arts and Hollman, 2005).

Diabetes

Apricots contain hypoglycemic substances such as procyanidin, hydroxycinnamic acid derivatives, carotenoids, and anthocyanins, which, along with their synergistic effects and

FULL PAPER

antioxidant properties, can lower blood glucose levels in patients with type 2 diabetes, making apricot consumption a beneficial food for them. Compared to cultivated apricots, wild apricots contain less sugar and do not cause sudden spikes in blood sugar (Ylönen et al., 2003).

Vitality and energetic power to the body
Wild apricots are a fruit rich in zinc. Thanks to this, they provide vitality and energetic power to the body. If human constantly feel tired, they can consume wild apricots regularly to get rid of your daily fatigue.

Good for anemia
Wild apricots are rich in iron. Thanks to this feature, they are known to be good for iron deficiency. Anemia is a condition which causes deficiency of hemoglobin. Consuming wild apricot fruits provides the body with iron which raises blood hemoglobin concentrations and prevents anemia from occurring. Adult women during pregnancy require to absorb iron efficiently and vitamin C serves as a key element for this process (Sushma et al., 2025).

Strengthens bones
Thanks to its high components in particular calcium, wild apricots support bone development and help bones become stronger. Because of this feature, it is recommended that children in their developmental years and women with osteoporosis problems consume wild apricots regularly. Boron which is present in apricot fruits also aids in bone health, metabolism as well as bone repair. It improves bone mineral density (Sushma et al., 2025)

Unique taste and versatility
Wild apricot fruits offers a distinctive tart flavor that can enhance a wide variety of dishes. From sauces and jams to desserts and beverages, its unique taste makes it a favorite among chefs and home cooks alike. Its versatility means it can be used fresh, dried, or even as a flavoring agent.

Culinary Innovations
Innovative culinary applications have seen wild apricot being used in gourmet dishes and cocktails. The tartness of wild apricot pairs well with both sweet and savory ingredients, making it a flexible addition to any kitchen.

References
[1] Al-Khayri, J.M., Sahana, G.R., Nagella, P., Joseph, B.V., Alessa, F.M., Al-Mssallem, M.Q. (2022). Flavonoids as potential anti-inflammatory molecules: A review. Molecules 27 (9): 2901. https://doi.org/10.3390/molecules27092901.
[2] Al-Soufi, M.H., Alshwyeh, H.A., Alqahtani, H., Al-Zuwaid, S.K., Al-Ahmed, F.O., Al-Abdulaziz, F.T., Raed, D., Hellal, K., Mohd Nani, N.H., Zubaidi, S.N., Asni, N.S.M., Hamezah, H.S., Kamal, N., Al-Muzafar, H., Mediani, A. (2022). A review with updated perspectives on nutritional and therapeutic benefits of apricot and the industrial application of its underutilized parts. Molecules 27(15):5016. https://doi.org/10.3390/molecules27155016.
[3] Arts, I.C., Hollman, P.C. (2005). Polyphenols and disease risk in epidemiologic studies. American Journal of Clinical Nutrition 81(1): 317S-325S. https://doi.org/10.1093/ajcn/81.1.317S.
[4] Ayour, J., Harrak, H., Renard, C.M., Benichou, M. (2026). Fruit skin color: A reliable tool revealing the potential of bioactive compounds in apricots (*Prunus armeniaca* L.). Molecular Nutrition & Food Research 70 (5): e70429. https://doi.org/10.1002/mnfr.70429.

FULL PAPER

[5] Ayour, J., Audergon, J.M., Renard, C., Benichou, M., Bourvellec, C.L. (2022). Phenolic profiling in ten apricot clones using an efficient method (Thioacidolysis-UFLC) and determination of their antioxidant potential. Food Bioscience 49: 2212–4292. https://doi.org/10.1016/j.fbio.2022.101880.

[6] Celik, F. (1996). Phenological, pomological and morphological characteristics of wild apricots (*Prunus armeniaca* L.) from Ercis district.M.Sc. thesis. Yuzuncu Yil University Graduate School. pp. 83.

[7] Choo, P.P., Woi, P.J., Bastion, M.C., Omar, R., Mustapha, M., Din, N.M. (2022). Review of evidence for the usage of antioxidants for eye aging. BioMed Research International 1-11. https://doi.org/10.1155/2022/5810373.

[8] Dehnavi, M.K., Ebrahimpour-Koujan, S., Lotfi, K., Azadbakht, L. (2024). The association between circulating carotenoids and risk of breast cancer: A systematic review and dose–response meta-analysis of prospective studies. Advances in Nutrition 15 (1): 100135. https://doi.org/10.1016/j.advnut.2023.10.007.

[9] Ercisli, S. (2009). Apricot culture in Turkey. Scientific Research and Essays. 4 (8): 715-719.

[10] Ercisli, S. (2026). Wild apricots (zerdali): high morphological, biochemical and antioxidant diversity. Acta Horticulturae. 1450: 303-308.https://doi.org/10.17660/ ActaHortic.2026.1450.40.

[11] Erdogan-Orhan, I., Kartal, M. (2011). Insights into research on phytochemistry and biological activities of *Prunus armeniaca* L. (apricot). Food Research International44:1238-343. https://doi.org/10.1016/j.foodres.2010.11.014.

[12] Fatima, T., Bashir, O., Gani, G., Bhat, T.A., Jan, J. (2018). Nutritional and health benefits of apricots. International Journal of Unani and Integrative Medicine, 2(2): 5-9.

[13] Gecer, M.K., Kan, T., Gundogdu, M., Ercisli, S., Ilhan, G., and Sagbas, H.I. (2020). Physicochemical characteristics of wild and cultivated apricots (*Prunus armeniaca* L.) from Aras valley in Turkey. Genetic Resources and Crop Evolution 67 (4):935-945. https://doi.org/10.1007/s10722-020-00893-9.

[14] Ghodeshwar, G.K., Dube, A., Khobragade, D. (2023). Impact of lifestyle modifications on cardiovascular health: A narrative review. Cureus 15 (7): 42616. https://doi.org/10.7759/cureus.42616.

[15] Gupta, S., Chhajed, M., Arora, S., Thakur, G., Gupta, R. (2018). Medicinal value of apricot: A review. Indian Journal of Pharmaceutical Sciences 80:790-794. https://doi.org/10.4172/pharmaceutical-sciences.1000423.

[16] Ilhan, G., Sagbas, H.I., Ercisli, S., and Ozkan, G. (2020). Physicochemical characteristics of wild apricots from northeastern Turkey. Acta Horticulturae 1290:13-18. https://doi.org/10.17660/ActaHortic.2020.1290.3.

[17] Jaafar, H.J. (2021). Effects of apricot and apricot kernels on human health and nutrition: A review of recent human research. Technium BioChemMed. 2:139-162. https://doi.org/10.47577/biochemmed.v2i2.4328.

[18] Karatas, N. (2022). Evaluation of nutritional content in wild apricot fruits for sustainable apricot production. Sustainability 14 (3):1063. https://doi.org/10.3390/su14031063.

[19] Krga, I., Milenkovic, D. (2019). Anthocyanins: From sources and bioavailability to cardiovascular-health benefits and molecular mechanisms of action. Journal of Agricultural and Food Chemistry 67 (7): 1771–1783. https://doi.org/10.1021/acs.jafc.8b06737.

[20] Liu, R.H. (2004). Potential synergy of phytochemicals in cancer prevention: mechanism of action. Journal of Nutrition 134 (12): 3479S-3485S. https://doi.org/10.1093/jn/134.12.3479S.

[21] Stahl, W., Sies, H. (2012). β-Carotene and other carotenoids in protection from sunlight. American Journal of Clinical Nutrition 96 (5):1179S-1184S. https://doi.org/10.3945/ajcn.112.034819.

[22] Sushma, M., Baral, P., Thomas, A.R., Rani, S. (2025). Dried ppricot: Beta-carotene rich for vision and skin health. In book: Dry Fruits in Everyday Health: A Functional Food Approach to Wellness. Publisher: H.S.R.A Publications. p.1-24.

[23] Ylönen, K., Alfthan, G., Groop, L., Saloranta, C., Aro, A., Virtanen, S.M. (2003). Dietary intakes and plasma concentrations of carotenoids and tocopherols in relation to glucose metabolism in subjects at high risk of type 2 diabetes: the Botnia Dietary Study. The American Journal Clinical Nutrition. 77(6):1434-1441. https://doi.org/ 10.1093/ajcn/77.6.1434.

FULL PAPER

Sustainable Valorization of Medicinal and Aromatic Plants from the Moroccan Central Rif: Bridging Biodiversity, Eco-Friendly Innovation and Smart Digital Marketing

Khaoula ALAMI[1], Hasnaâ HARRAK[2]

[1] Research Unit for Resilient Agricultural Systems Development in the Central Rif, Al Hoceima, Regional Centre for Agricultural Research of Tangier, National Institute for Agricultural Research (INRA), Avenue Ennasr, PO Box 514, Rabat, Morocco,
[2] Laboratory of Agri-Food Technology and Quality, Regional Centre for Agricultural Research of Marrakesh, National Institute for Agricultural Research (INRA), Avenue Ennasr, PO Box 514, Rabat, Morocco, E-mail: hasnaa.harrak@inra.ma, ORCID ID: 0000-0003-1253-4598
correspondance: khaoula.alami@inra.ma

Abstract

Central Rif in Northern Morocco hosts a diverse array of medicinal and aromatic plants (MAP) with therapeutic, cosmetic, culinary, and industrial values. Species such as thyme, lavender, and rosemary play a crucial role in the region economic development and underpin the distinctiveness of local or *terroir* products, including honey. This review examines the potential of these resources and how they can be sustainably exploited to support circular economy. A scoping review methodology is employed to map relevant literature on recent advances in eco-friendly practices. Data are categorized according to the most widespread species in Central Rif, the applied valorization processes, quality enhancement measures and standards, as well as recent technological and scientific advances in the world. By integrating traditional knowledge with green innovation, Central Rif's MAP can provide a model for sustainable resource management, biodiversity conservation, and economic empowerment of local communities. The findings demonstrate that organic cultivation, green extraction technologies, and circular economy applications contribute to development of innovative and eco-friendly formulations. Phytochemical studies show high levels of bioactive compounds such as phenolic compounds, flavonoids, and essential oils, enabling applications in pharmaceuticals, functional foods, and cosmetics. However, challenges, including quality standardization, overexploitation, and habitat preservation, need to be addressed. The increasing demand for natural and organic products presents an incentive for cooperatives, predominantly feminine, to develop innovative green formulations that meet consumer needs. By leveraging online platforms, social media, and e-commerce tools, cooperatives can reach large clientele and communicate the distinctive qualities of local species. Furthermore, digital strategies facilitate traceability, labeling, and storytelling, which enhance the perceived value of MAP-based products and support the development of niche markets. Indeed, alliances aimed at creating capacity-building programs focused on sustainable valorization and digital marketing are crucial for MAP promotion and local economy growth.

Key Words: Moroccan Central Rif, medicinal and aromatic plants, eco-friendly innovation, sustainable practices, digital strategies, cooperatives

Introduction

FULL PAPER

Mountains are widely acknowledged as biological diversity treasure troves, greatly enhancing the functioning of the world's ecosystem (Mehta *et al.*, 2021). They are inhabited by about 10% of the world's population and encompass half of the world's biodiversity hotspots (Kohler *et al*., 2010). In mountainous regions, medicinal and aromatic plants (MAP) form an important component of livelihood of the people (Negi *et al.*, 2018). The Central Rif of Morocco serves as an example of a mountainous region in Northern Morocco, extending along the Mediterranean coastline from Tangier to the Algerian border at the east. It mainly covers the province of Al Hoceima, including the mountainous areas surrounding the city of the same name (Wikipedia, 2025). It represents fertile ground for a wide diversity of local agricultural products, a diverse range of MAP such as thyme, lavender, rosemary, and verbena.

These species are traditionally used by local communities for their various therapeutic and economic benefits. MAP have been valued for centuries for their abundant bioactive compounds, which provide a wide range of health benefits, including antioxidant, anti-inflammatory, antimicrobial, and antiviral effects (Shahane *et al.*, 2023; Kaveh *et al.*, 2024). These plants are increasingly recognized for their dual role in traditional medicine and modern pharmacology. Recently, there has been a noticeable shift toward integrating medicinal plants into food systems as functional components to promote health and well-being (Tripathy *et al.*, 2021; Tripathy et Srivastav, 2024).

The widespread use of these plants across Morocco may be attributed to their efficacy and abundance within the national territory. Scientific studies have corroborated various therapeutic properties of these plants. *Verbena* sp. has demonstrated anti-leukemic (Dobrucka *et al.*, 2021), antioxidant, antibacterial (Touati *et al.*, 2021), antifungal, anti-inflammatory (Tammar *et al.*, 2021), and anti-cryptosporidium activities (El-Wakil *et al.*, 2022). *Origanum vulgare* has shown antibacterial, antifungal, antioxidant (Ličina *et al.*, 2013), and anti-hepatocarcinoma properties (Elshafie *et al.*, 2017). *Pimpinella anisum* has exhibited anti-inflammatory (Ghlissi *et al.*, 2020), antioxidant, and antimicrobial activities (Farzaneh *et al.*, 2018; Amer, 2019).

In recent decades, there has been a significant revival in the cultivation and utilization of MAP across diverse industrial sectors. This resurgence encompasses multiple applications, ranging from therapeutic interventions such as aromatherapy to commercial uses in the fragrance industry. The pharmaceutical sector has shown particular interest in these botanicals as potential sources of novel bioactive compounds. The significance of these plants in modern medicine is underscored by the fact that more than 25,000 species are utilized in pharmacopoeias, with over 50% of available pharmaceutical products being of natural origin (Hamilton, 2004). Concurrently, the food industry has increasingly incorporated these plants as natural additives, supplements, and colorants, aligning with growing consumer demand for natural products. The agricultural sector has also recognized the potential of these plants, both as crops and as sources of biopesticides and growth promoters. This renewed focus on MAP has been driven by advancements in analytical techniques, enabling more precise identification and characterization of their bioactive constituents, as well as by the expanding market for natural alternatives to synthetic compounds across multiple industries.

Morocco's unique geographical position endows it with remarkable bioclimatic diversity and exceptional floristic richness. According to a comprehensive study conducted by the Global Diversity Foundation and the Moroccan Biodiversity and Livelihoods Association, the Moroccan

FULL PAPER

flora comprises approximately 3913 taxa, encompassing 1298 sub-species across 981 genera and 155 families. Notably, 800 of these species are endemic, resulting in an endemism rate of 20% (Aafi *et al.*, 2002). This botanical wealth has fostered a rich traditional knowledge base among Moroccan populations over centuries (Scherrer *et al.*, 2005).

However, despite the strong potential of MAP, limited attention has been devoted to the sustainable management and valorization of their by-products and residues. Few researchers have examined their integration into eco-friendly formulations, and strategies to support local cooperatives and small-scale producers in implementing green practices. This research is motivated by the urgent need to promote the eco-friendly innovation of MAP in the Central Rif. It aims to emphasize the potential of MAP by-products and their valorization for the development of environmentally friendly products. Furthermore, it underscores the crucial role of smart digital marketing in preserving biodiversity, fostering a circular economy, and supporting local economic growth.
According to the above objectives, the study proposes the three research questions to highlight its novelty:

i. How can the eco-friendly innovation of MAP in the Central Rif foster local economic growth?
ii. What are the main barriers and opportunities faced by cooperatives in transforming MAP into high-value products?
iii. How can digital tools and platforms enhance the visibility and market access of MAP-based products from the Central Rif?

Materials and Methods

A scoping review approach was employed to map relevant literature on recent advances in innovative and sustainable approaches. Data were categorized according to the most widespread species in the Central Rif, the applied valorization processes, the quality enhancement measures and standards, as well as the recent global technological and scientific advances. The review included scientific reports, books, research articles, and online resources. Notable examples were highlighted to illustrate the successful integration of upcycling and eco-friendly innovation. The information was classified according to the criteria outlined in figure 1.

FULL PAPER

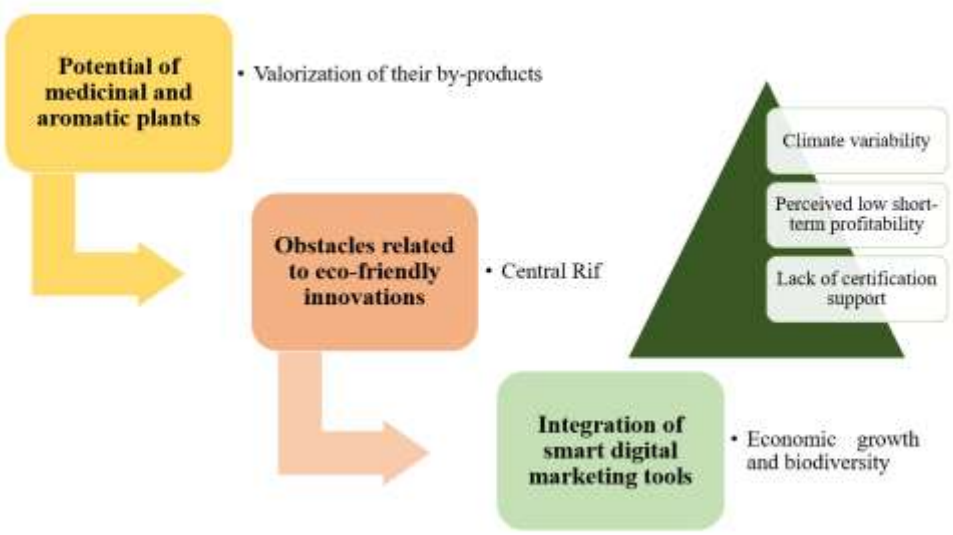


Fig. 1. Criteria of data selection for the review study.

The criteria were designed to capture high-quality, peer-reviewed publications and literature that directly address the intersection of biodiversity, sustainability, and MAP. Studies examining the potential of MAP, their valorization, by-products, endemic species in Central Rif, as well as green innovations and digital marketing strategies, were considered. Obstacles related to eco-friendly innovations were also included among the criteria. Preference was given to studies employing clear methodological frameworks, including empirical research, case studies, systematic and scoping reviews, to ensure the pertinence of findings. By applying these criteria, the review aimed to build a comprehensive, balanced, and evidence-based understanding of how eco-friendly innovations of MAP can contribute to the transition toward more sustainable and resilient digital systems and bolster local economies.

Results and Discussion

Barriers Structural Constraints and Challenges Among Agri-Food Cooperatives: Case of Moroccan Central Rif

In the Central Rif, cooperatives focusing on MAP represent only 12%, indicating an underexploited potential hindered by technical, logistical, commercial, and environmental constraints. This area is characterized by semi-arid conditions with irregular and limited rainfall. Drought reduces productivity, germination, and plant quality, which may discourage cooperatives from investing in MAP cultivation. This distribution underscores the need to develop differentiated support and capacity-building approaches that consider the specific characteristics and maturity levels of each value chain.

FULL PAPER

Regarding sustainability practices within the value chain, only 16% of cooperatives—those with a high level of awareness of upcycling and that have adopted the upcycling of food residues, particularly in the production of scrub products—demonstrate a limited but promising engagement in value addition through the utilization of by-products (Alami *et al*., 2025).

Potential of Medicinal and Aromatic Plants (MAP) in Product Development

MAP is a rich source of bioactive molecules which can be used in functional beverages production due to their chemical composition, aroma, flavor and health promoting effects (Khan *et al.*, 2014; Manousi *et al.*, 2019). The Lamiaceae family comprises numerous MAP which provide a wide range of health benefits and may be useful in the functional beverages industry. Among them, peppermint, rosemary, sage, thyme, lavender and lemon balm are the most widely utilized (Carovi´c-Stanko *et al.*, 2016). The total content of flavonoids (0.37–0.90%), phenolic acids (3.55–12.44%), tannins (1.22–2.60%), and anthocyanins (0.03–0.08%) was determined in Salvia leaves (Mervi´c *et al.*, 2022). For example, the main polyphenols in the leaves of Dalmatian sage (*Salvia officinalis* L.) were rosmarinic acid (2460–3844 mg/100 g) and luteolin3-glucuronide (634–840 mg/100 g) (Dent *et al.*, 2017), but rosmarinic acid derivatives, salbeicumarin, and sageric acid are also frequently present (Lu and Foo, 2001). Many sage plants are known for their ability to improve memory and delay age-related cognitive decline as well as to alleviate digestive and circulation disturbances, respiratory diseases, mouth and throat inflammation, and excessive sweating (Lopresti, 2017; Poulios *et al.*, 2020;). Rosemary (*Rosmarinus* officinalis L.) is used in traditional medicine as an antimicrobial, anti-inflammatory and anticancer agents as well as to relieve pain and enhance memory (Allegra *et al.*, 2020; Sharifi-Rad *et al.*, 2020). The phenolic diterpenes carnosol and carnosic acid (5% of the dry weight) and rosmarinic and ursolic acids are the most abundant polyphenolic compounds in rosemary (Huang *et al.*, 1994; Petiwala *et al.*, 2013). Thymus species are traditional remedies for cold, flu, cough, headache, neurosis, digestive complaints, high blood cholesterol levels, nephritis and inflammation related diseases. Their essential oils (EO) components and polyphenols possess a wide range of biological activities, including antimicrobial, antioxidant, anti-inflammatory, and cytotoxic effects (Kindl *et al.*, 2019; Li *et al.*, 2019). The potential of these plants can be exploited sustainably in the Rif Central. Reconciling traditional knowledge with green approaches such as upcycling, plays a key role in promoting the region and attracting new clients.

Many aromatic plant species are cultivated and considered crops, the most widespread worldwide being *Mentha* spp. L. (mint), *Lavandula* spp. Mill. (lavender), *Ocimum basilicum* L. (basil), *Cymbopogon citratus* (DC.) Stapf (lemongrass), *Rosmarinus officinalis* L. (rosemary), *Thymus vulgaris* L. (thyme), *Salvia officinalis* L. (sage), *Origanum vulgare* L. (oregano) or *Matricaria chamomilla* L. (camomile) (Pandey *et al.*, 2020; Dikr, 2022). In 2021, these crops accounted for a total global production of 91 million tons, harvested from 13 million hectares (Spina *et al*., 2023). Aromatic crops offer multiple agronomic advantages and are becoming increasingly relevant in sustainable agricultural systems. Many of these species are adaptable to harsh environments, grow well on marginal soils, and often require fewer agrochemical inputs compared to conventional crops, making them suitable for low-input agriculture and ecological practices (Dikr, 2022; Singh *et al.*, 2024).

FULL PAPER

Circular Economy: A Path Towards Sustainable Innovation and Inclusive Territorial Growth

The circular economy model places emphasis on the valorization of waste through sustainable processes that generate both economic and environmental benefits. MAP residues offer a promising opportunity for integration into biorefinery systems. The thermochemical conversion of these materials into solid fuels, biochar, or other value-added products has been explored as an alternative to traditional disposal methods (Li, 2024). The versatility of these residues allows for their transformation into biofuels, biochemicals, and specialty polymers, thereby reinforcing the shift towards renewable and decentralised energy systems.

Several studies have been conducted on valorization strategies for MAP residues. Marín-Valencia *et al.* (2021) evaluated a biorefinery model based on *Thymus vulgaris*, combining the extraction of phenolic compounds with anaerobic digestion. While the standalone extraction process proved more economically viable at smaller scales (23 t/day), the biorefinery model achieved higher resource efficiency and sustainability, despite increased energy demands. In a similar manner, Saha *et al.* (2022) investigated *Mentha arvensis* distillation waste, extracting antioxidant compounds with 75% aqueous methanol and converting the remaining biomass into biochar for soil improvement, thereby demonstrating both waste valorization and environmental benefit.

Eco-Friendly Valorization of MAP By-Products

MAP contain a variety of aromatic organic compounds in their leaves, stems, and reproductive organs (Dordas, 2012; Katsiotis and Chatzopoulou, 2019). This variety of complex chemical compounds and, therefore, make MAP to be generally considered as "natural biochemical factories" or "chemical gold mines" (Skaria *et al.*, 2020).

In recent years, there has been a growing demand for plant biomass, mainly derived from MAP, which is intended for the preparation of healthy and flavour-enhanced foods, fragrant, therapeutic infusions and cosmetology products (Maloupa *et al.*, 2013). Subsequently, the wastes generated by the industrial processes of distillation process of biomass towards the EO isolation, have also been increased. Therefore, it is necessary to create and establish a sustainable management system for MAP waste (Marcelino *et al.*, 2023), that could transform such waste into high value-added products, such as biofuels, promoting also ecological perspectives and economic opportunities (Saha and Basak, 2020).

The industrial processing of aromatic crops primarily aims to extract EO and other bioactive compounds, using methods that preserve their bioactive properties. The most commonly employed techniques include steam distillation, hydro distillation, solvent extraction, and, more recently, supercritical CO_2 extraction (Beemnet *et al.*, 2010, Pandey *et al.*, 2020). Steam distillation remains the dominant method, especially for crops such as mint, lavender, lavandin and lemongrass, where plant material is exposed to steam to release and condense volatile oils. Solvent extraction and supercritical CO_2 methods are preferred for more delicate compounds, as they avoid high temperatures and yield purer extracts (Beemnet *et al.*, 2010; Pandey *et al.*, 2020).

FULL PAPER

After obtaining the EO (or other extracts), the remaining plant biomass still contains valuable phytochemicals, fiber and organic matter. In addition to distilled biomass, other by-products/residues are obtained, such as hydrosols or aromatic waters, which are the aqueous extracts resulting from the distillation process (Beemnet *et al.*, 2010; Singh *et al.*, 2024).

The primary products of these processes are the EO themselves, which are used in the fragrance, flavor, cosmetic, and pharmaceutical industries. By-products/wastes include hydrosols (or hydrolates or wastewaters), often applied in skincare and aromatherapy, and fibrous residues, that can be transformed into mulch, animal feed additives or soil amendments (Beemnet *et al.*, 2010; Singh *et al.*, 2024). Both industrial products and by-products/residues obtained from aromatic crops contain potent bioactive compounds with biocidal properties (Russo and Palla, 2023; Almeida *et al.*, 2024), which can be specifically used for the development of bioherbicides.

In addition, another major group of bioherbicides is made up of plant extracts and by-products, which include potent allelochemical compounds against weeds (Kostina-Bednarz *et al.*, 2023). Plant extracts rich in phytotoxic compounds are obtained by macerating plant tissues and using different solvents (water, ethanol, methanol, etc.) for their extraction or by distilling these tissues to obtain EO (Valino *et al.*, 2023). Importantly, significant progress has recently been made in translating plant-based bioherbicides from laboratory approaches to field-scale applications, which represents a substantial innovation in the sector. For instance, an encapsulated bioherbicide formulated from plant-derived phytotoxic compounds demonstrated effective weed suppression across three different field locations while maintaining selectivity toward durum wheat (Scavo *et al.*, 2025).

This successful integration of by-products underscores the urgent need to raise awareness about upcycling, to conduct further research on scalable techniques, and to facilitate knowledge transfer among small-scale producers and cooperatives, particularly in rural areas such as the Central Rif, where awareness of sustainable approaches remains insufficient. Leading capacity-building programs and directing the attention of producers and cooperatives toward the biodiverse treasure they possess will bolster sustainable practices, enhance local innovation, and promote the effective valorization of MAP.

Role of Innovation, Digitalization and Marketing Strategies in Enhancing MAP Promotion, Preservation, and Biodiversity Conservation

Technological innovation plays a pivotal role in enhancing energy efficiency and reducing food loss within the horticultural value chain (Huang and Wang, 2024; Nasso *et al.*, 2024; Castillo-Díaz *et al.*, 2025). By incorporating software-based solutions, stakeholders can better address challenges associated with climate change adaptation and mitigation, particularly through waste reduction at various supply chain stages. For instance, in the postharvest phase, the use of wireless sensors and Internet of Things technologies enables continuous, real-time monitoring of produce during storage and transport (Lamberty and Kreyenschmidt, 2025; Protopappas *et al.*, 2025). This allows for timely interventions, significantly lowering the risk of spoilage and product loss. Furthermore, food producers can optimize the efficiency of processes in postharvest activities such as fermentation, drying, cooling, extraction, packing, and smart materials and mobile apps powered by artificial intelligence to cut down on waste and energy consumption (Fadiji *et al.*, 2023; Du *et al.*, 2025). Basically, software and digital solutions are the engines that drive

FULL PAPER

sustainable practices. They minimize environmental harm, increase energy efficiency, and cut down on food loss across the agricultural value chain.

Although these technologies benefit from precision crop management suited to particular locations, their adoption may come with financial expenses and require learning, purchasing novel tools and skills, and sharing data with input and technology providers (Khan *et al.*, 2024). Economically, the global market for MAP, especially EO and natural aromatic products continues to expand. Therefore, aromatic crops promote rural development (Pandey *et al.*, 2020). Additionally, integrating aromatic crops into intercropping systems with vegetables or fruit crops can enhance land-use efficiency, pest management and biodiversity, aligning with sustainable intensification strategies (Dikr, 2022; Singh *et al.*, 2024).

Digital transformation has become a strategic imperative across all sectors, reshaping how organizations operate, deliver value, and interact with stakeholders (Vial, 2019). It serves as a strategic tool for cooperatives and small producers to promote *terroir* products, enhance their value, assess consumer expectations, and reach new market segments. Digitalization refers to the holistic integration of digital technologies into processes, structures, and organizational cultures to drive sustainable innovation and performance improvement (Bughin and Zeebroeck, 2017). Despite significant advancements in digital technologies, notable gaps persist in their adoption, particularly among small producers and rural cooperatives. Evidence from the Moroccan Central Rif indicates that although 50% of cooperatives are aware of digital platforms such as social media and e-commerce, only 12% have incorporated them into their operational practices.This indicates a significant implementation gap, which can be linked to limited access to capacity-building programs and insufficient digital competencies (Alami *et al.*, 2025). Additionally, in terms of marketing strategies, most cooperatives in the Central Rif, including those involved in the valorization of MAP, continue to rely primarily on traditional and direct sales channels, while modern digital marketing pathways remain underutilized. Indeed, advancements in technology have transformed how marketers connect with their target audiences, giving rise to what is now known as digital brand engagement (Sakas *et al.*, 2024).

Digital brand engagement refers to the use of digital tools to interact with consumers. Through digital brand engagement, there are possibilities of consumer engagement using modern tools and technology which manifest in digital form (Chamboko-Mpotaringa and Tichaawa, 2021). The creation and distribution of valuable, relevant and consistent content to attract and retain a clearly defined audience, is now possible through digital technologies such as video marketing, blogging and infographics (Silalahi and Guna, 2024). These digital technologies underscore the importance of storytelling and providing useful information to engage consumers (Nyagadza *et al.*, 2019). Regularly publishing informative and engaging content can help in building trust and credibility (Manyanga *et al.*, 2024). For instance, the promotion of MAP through the lens of Moroccan traditional practices—such as their use in hammam rituals, natural skincare routines, and ancestral beauty traditions—can create a strong cultural and emotional appeal. This form of cultural storytelling not only enhances product authenticity but also reinforces consumer appreciation of local heritage.

By highlighting these traditional uses, cooperatives can encourage consumers to support local economies and directly connect with producers, thereby strengthening value chains and improving market access for rural MAP-based cooperatives. Furthermore, the widespread use of

FULL PAPER

these tools can lead to changes in consumer behaviour as these digital platforms change how consumers consume information, interact with brands and perceive reality (Mulyani *et al.*, 2021). Video marketing allows companies such as cooperatives to showcase their products in action, providing a clear and engaging way to demonstrate features and benefits (Nada, 2023). Also, these digital technologies result in global reach and data-driven consumer insights (Ali and Anwar, 2021).

Digital marketing has increased the number of touchpoints available for brand managers to engage and communicate with customers (Lee *et al*., 2021). Brands may cater to all stages of the consumer journey by establishing a strong digital media presence (Jamil *et al*., 2022). Improving communication throughout the process can enhance brand relationships and attitudes (Şenyapar, 2024).

Companies engage heavily in creating brand associations that connect with customers' identities, making digital marketing an effective medium for reaching out to them (Gaura *et al.*, 2021). In fact, digital tools can enable cooperatives to expand their commercial channels, promote their territory, and highlight traditional knowledge and practices related MAP. At the same time, they encourage cooperatives to move beyond their comfort zones and adopt new sustainable strategies for the valorization of these products.

Conclusion

This study sought to assess the potential of MAP in the Central Rif and to investigate sustainable pathways for their exploitation within a circular economy framework. The findings concluded that eco-friendly sustainable innovation is a must to boost the region and help locals to turn challenges into opportunities. The underestimation of MAP by-products can be addressed through a workshops and capacity building programs to show cooperatives concretly the potential of these by-products, how to integrate them in functional formulations and respond to consumer needs. Additionally, digitalization and the use of smart marketing strategies are key approaches to help cooperatives in the Central Rif to expand knowledge around MAP, embody creativity, and identify consumer preferences. Furthermore, digital technology play a pivotal role to support green innovations, enhance digital brand engagement, and dominate new markets.

Acknowledgements

The authors extend sincere gratitude to the organizations and researchers whose rigorous, insightful, and inspiring work laid the foundation for this review.Their expertise and valuable insights have significantly enriched this study and helped shape the presented perspectives.

Conflict of Interest

The authors declare no conflict of interest.

References

[1] Aafi, A., Taleb, M. S., and Fechtal, M. (2002). *Espèces remarquables de la flore du Maroc*. MCEF, Rabat, Maroc.

FULL PAPER

[2] Amer, A. M. (2019). Antioxidant and antibacterial properties of anise (*Pimpinella anisum* L.). *Egyptian Pharmaceutical Journal, 18*(1), 68–73. https://www.epj.eg.net/article.asp?issn=1687-4315;year=2019;volume=18;issue=1;spage=68;epage=73;aulast=Amer

[3] Alami, K., Chentouf, M., and Harrak, H. (2025). Eco-friendly innovation, market access, and digital transformation: Exploring barriers faced by Central Rif agri-food cooperatives. *International Journal of Renewable Energy and Sustainability (RES), 4*(2), 85–97. https://cnpsi.com/RES/Vol4-Iss2.html

[4] Ali, B. J., and Anwar, G. (2021). Marketing strategy: Pricing strategies and its influence on consumer purchasing decision. *International Journal of Rural Development, Environment and Health Research, 5*(2), 26–39. https://doi.org/10.22161/ijreh.5.2.4

[5] Allegra, A., Tonacci, A., Pioggia, G., Musolino, C., and Gangemi, S. (2020). Anticancer activity of *Rosmarinus officinalis* L.: Mechanisms of action and therapeutic potentials. *Nutrients, 12*(6), 1739, 1–20. https://doi.org/10.3390/nu12061739

[6] Almeida, H. H., Fernandes, I. P., Amaral, J. S., Rodrigues, A. E., and Barreiro, M. F. (2024). Unlocking the potential of hydrosols: Transforming essential oil byproducts into valuable resources. *Molecules, 29*, 4660, 18–22. https://doi.org/10.3390/molecules29194660

[7] Beemnet, M., Omarsherif, M., Tsion, T., and Solomon, A. (2010). *Production, processing and utilization of aromatic plants*. Ethiopian Institute of Agricultural Research (EIAR), 1–126.

[8] Bughin, J., and Van Zeebroeck, N. (2017). The best response to digital disruption. *MIT Sloan Management Review, 58*(4), 80–86.

[9] Carović-Stanko, K., Petek, M., Grdisa, M., Pintar, J., Bedeković, D., *et al.* (2016). Medicinal plants of the family Lamiaceae as functional foods – A review. *Czech Journal of Food Sciences, 34*(5), 377–390. https://doi.org/10.17221/504/2015-CJFS

[10] Castillo-Díaz, F. J., Belmonte-Ureña, L. J., Gálvez-Sánchez, F. J., and Camacho-Ferre, F. (2025). Sustainable technological innovations in agriculture: Financial challenges and investment priorities under the European Green Deal. *Journal of Environmental Management, 389*, 126150, 18–22. https://doi.org/10.1016/j.jenvman.2025.126150

[11] Chamboko-Mpotaringa, M., and Tichaawa, T. M. (2021). Tourism digital marketing tools and views on future trends: A systematic review of literature. *African Journal of Hospitality, Tourism and Leisure, 10*(2), 712–726. https://doi.org/10.46222/ajhtl.19770720-128

[12] Dent, M., Kovačević, D. B., Bosiljkov, T., and Dragović-Uzelac, V. (2017). Polyphenolic composition and antioxidant capacity of indigenous wild Dalmatian sage (*Salvia officinalis* L.). *Croatica Chemica Acta, 90*, 451–460. https://doi.org/10.5562/cca3231

[13] Dikr, W. (2022). Role of intercropping some aromatic and medicinal plants with fruit vegetable crops: A review. *Global Academic Journal of Agriculture and Biosciences, 4*, 22–30. https://doi.org/10.36348/gajab.2022.v04i02.002

[14] Dobrucka, R., Romaniuk-Drapała, A., Kaczmarek, M., *et al.* (2021). Anti-leukemia activity of Au/CuO/ZnO nanoparticles synthesized using *Verbena officinalis* extract. *Journal of Inorganic and Organometallic Polymers and Materials, 31*(1), 191–202. https://doi.org/10.1007/s10904-020-01690-8

[15] Dordas, C., (2012). Aromatic and medicinal plants. In: *Aromatic and medicinal plants*. (Synchroni Paidia Publications, Thessaloniki), 1–358.

[16] Du, L., Huang, X., Li, Z., Qin, Z., Zhang, N., *et al.* (2025). Application of smart packaging in fruit and vegetable preservation: A review. *Foods, 14*(3), 4–47. https://doi.org/10.3390/foods14030447

[17] El-Wakil, E. S., El-Shazly, M. A. M., El-Ashkar, A. M., Aboushousha, T., and Ghareeb, M. A. (2022). Chemical profiling of *Verbena officinalis* and assessment of its anti-cryptosporidial activity in experimentally infected immunocompromised mice. *Arabian Journal of Chemistry, 15*(7), 103945, 1–16. https://doi.org/10.1016/j.arabjc.2022.103945

[18] Elshafie, H. S., Armentano, M. F., Carmosino, M., Bufo, S. A., De Feo, V., *et al. (*2017). Cytotoxic activity of *Origanum vulgare* L. on hepatocellular carcinoma cell line HepG2 and evaluation of its biological activity. *Molecules, 22*(9), 1435, 18–22. https://doi.org/10.3390/molecules22091435

FULL PAPER

[19] Fadiji, T., Bokaba, T., Fawole, O. A., and Twinomurinzi, H. (2023). Artificial intelligence in postharvest agriculture: Mapping a research agenda. *Frontiers in Sustainable Food Systems, 7*, 1226583, 1–19. https://doi.org/10.3389/fsufs.2023.1226583
[20] Farzaneh, V., Gominho, J., Pereira, H., and Carvalho, I. S. (2018). Screening of the antioxidant and enzyme inhibition potentials of Portuguese *Pimpinella anisum* L. seeds by GC-MS. *Food Analytical Methods, 11*(10), 2645–2656. https://doi.org/10.1007/s12161-018-1250-x
[21] Gaura, K. C., Manyanga, W., and Chikazhe, L. (2021). The effect of corporate social responsibility on brand awareness: Evidence from the insurance sector in Zimbabwe. *Journal of Marketing and Consumer Behaviour in Emerging Markets, 2021*(2), 22–36. https://doi.org/10.7172/2449-6634.jmcbem.2021.2.2
[22] Ghlissi, Z., Kallel, R., Krichen, F., Ahmed, H., Zeghal, K, *et al.* (2020). Polysaccharide from *Pimpinella anisum* seeds: Structural characterization, anti-inflammatory, and laser burn wound healing in mice. *International Journal of Biological Macromolecules, 156*, 1530–1538. https://doi.org/10.1016/j.ijbiomac.2019.11.201
[23] Hamilton, A. C. (2004). Medicinal plants, conservation and livelihoods. *Biodiversity and Conservation, 13*, 1477–1517. https://doi.org/10.1023/B:BIOC.0000021333.23413.42
[24] Huang, M.-T., Ho, C.-T., Wang, Z. Y., Ferraro, T., Lou, Y.-R.., *et al.* (1994). Inhibition of skin tumorigenesis by rosemary and its constituents carnosol and ursolic acid. *Cancer Research, 54*(3), 701–708.
[25] Huang, W., and Wang, X. (2024). The impact of technological innovations on agricultural productivity and environmental sustainability in China. *Sustainability, 16*(19), 8480. https://doi.org/10.3390/su16198480
[26] Jamil, K., Dunnan, L., Gul, R. F., Shehzad, M. U., Gillani, S. H. M., *et al.* (2022). Role of social media marketing activities in influencing customer intentions: A perspective of a new emerging era. *Frontiers in Psychology, 12*, 808525. https://doi.org/10.3389/fpsyg.2021.808525
[27] Katsiotis, S., and Chatzopoulou, P., (2019). Aromatic medicinal plants and essential oils. In: *Aromatic medicinal plants and essential oils*. (Kyriakides Publications, Thessaloniki), 656 p.
[28] Kaveh, M., Zomorodi, S., Szypłowska, M., and Dziwulska-Hunek, A. (2024). Determination of drying characteristics and physicochemical properties of mint (*Mentha spicata* L.) leaves dried in refractance window. *Foods, 13*(18), 2867, 16–20.
[29] Khan, F. U., Nouman, M., Negruț, L., Abban, J., Cismas, L. M., *et al.* (2024). Constraints to agricultural finance in underdeveloped and developing countries: A systematic literature review. *International Journal of Agricultural Sustainability, 22*(1), 2329388, 18–25. https://doi.org/10.1080/14735903.2024.2329388
[30] Khan, N., Al-Daghri, N. M., Al-Ajlan, A. S., and Alokai, M. S. (2014). The use of natural and derived sources of flavonoids and antioxidants in Saudi Arabia. *Integrative Food, Nutrition and Metabolism, 1*(2), 100–106. https://doi.org/10.15761/IFNM.1000109
[31] Kindl, M., Bucar, F., Jelić, D., Brajša, K., Blažeković, B., *et al.* (2019). Comparative study of polyphenolic composition and anti-inflammatory activity of *Thymus* species. *European Food Research and Technology, 245*, 1951–1962. https://doi.org/10.1007/s00217-019-03297-x
[32] Kohler, T., Giger, M., Hurni, H., Ott, C., Wiesmann, U., *et al.* (2010). Mountains and climate change: a global concern. Mountain Research and Development, 30(1), 53–55. https://doi.org/10.1659/MRD-JOURNAL-D-09-00024.1
[33] Kostina-Bednarz, M., Płonka, J., and Barchanska, H. (2023). Allelopathy as a source of bioherbicides: Challenges and prospects for sustainable agriculture. *Reviews in Environmental Science and Bio/Technology, 22*, 471–504. https://doi.org/10.1007/s11157-023-09656-1
[34] Lamberty, A., and Kreyenschmidt, J. (2025). Technical, process-related and sustainability requirements for IoT-based temperature monitoring in fruit and vegetable supply chains. *Discover Food, 5*(1), 151, 1–18. https://doi.org/10.1007/s44187-025-00427-1
[35] Lee, P. Y., Koseoglu, M. A., Qi, L., Liu, E. C., and King, B. (2021). The sway of influencer marketing: Evidence from a restaurant group. *International Journal of Hospitality Management, 98*, 103022, 12–18 https://doi.org/10.1016/j.ijhm.2021.103022

FULL PAPER

[36] Li, R. (2024). Techno-economic and environmental characterization of municipal food waste-to-energy biorefineries: Integrating pathway with compositional dynamics. *Renewable Energy, 223*, 120038, 18–22.
[37] Li, X., He, T., Wang, X., Shen, M., Yan, X., *et al.* (2019). Traditional uses, chemical constituents and biological activities of plants from the genus *Thymus*. *Chemistry & Biodiversity, 16*(9), 1900254, 20–26. https://doi.org/10.1002/cbdv.201900254
[38] Ličina, B. Z., Stefanović, O. D., Vasić, S. M., Radojević, I. D., Dekić, M. S., *et al.* (2013). Biological activities of extracts from wild growing *Origanum vulgare* L. *Food Control, 33*(2), 498–504. https://doi.org/10.1016/j.foodcont.2013.03.020
[39] Lopresti, A. L. (2017). *Salvia* (sage): A review of its potential cognitive-enhancing and protective effects. *Drugs in R&D, 17*(1), 53–64. https://doi.org/10.1007/s40268-016-0157-5
[40] Lu, Y., and Foo, L. Y. (2001). Antioxidant activities of polyphenols from sage (*Salvia officinalis*). *Food Chemistry, 75*(2), 197–202. https://doi.org/10.1016/S0308-8146(01)00198-4
[41] Maloupa, E., Grigoriadou, K., Lazaris, D., and Kriga, N. (2013). *Cultivation, processing and quality assurance of Greek aromatic medicinal plants: Basic principles of vertically integrated production*. Malliaris Paidia Publications, 1–272.
[42] Manousi, N., Sarakatsianos, I., and Samanidou, V. (2019). Extraction techniques of phenolic compounds and other bioactive compounds from medicinal and aromatic plants. In A. M. Grumezescu & A. M. Holban (Eds.), *Engineering tools in the beverage industry,* Woodhead Publishing, 83–314. https://doi.org/10.1016/B978-0-12-815258-4.00010-X
[43] Manyanga, W., Kanyepe, J., Chikazhe, L., and Manyanga, T. (2024). The effect of social media marketing on brand loyalty in the hospitality industry in Zimbabwe: The moderating role of age. *Cogent Business & Management, 11*(1), 2302311, 1–15. https://doi.org/10.1080/23311975.2024.2302311
[44] Marcelino, S., Gaspar, P. D., and Paço, A. (2023). Sustainable waste management in the production of medicinal and aromatic plants: A systematic review. *Sustainability, 15*(18), 13333, 1–24. https://doi.org/10.3390/su151813333
[45] Marín-Valencia, P. A., Carmona-García, E., Poveda Giraldo, J. A., Arias Duque, N. P., Ballesteros, L. F., *et al.* (2021). The integral use of aromatic plants: Prefeasibility comparison of stand-alone and biorefinery processes using thyme (*Thymus vulgaris*) as base case. *Biomass Conversion and Biorefinery, 11*, 681–691.
[46] Mehta, P., Bisht, K., and Sekar, K.C., (2021). Diversity of threatened medicinal plants of Indian Himalayan region. Plant Biosystems – An International Journal Dealing with All Aspects of Plant Biology, 155(6), 1121–1132. https://doi.org/10.1080/11263504.2020.1855456
[47] Mervić, M., Bival Stefan, M., Kindl, M., Blažeković, B., Marijan, M., *et al.* (2022). Comparative antioxidant, anti-acetylcholinesterase, and anti-α-glucosidase activities of Mediterranean *Salvia* species. *Plants, 11*(5), 625, 1–18. https://doi.org/10.3390/plants11050625
[48] Mulyani, V. G., Najib, M. F., and Guterres, A. D. (2021). The effect of perceived usefulness, trust, and visual information on attitude and purchase intention of Instagram food blogger. *Journal of Marketing Innovation, 1*(1), 78–93. https://doi.org/10.35313/jmi.v1i01.12
[49] Nada, M. (2023). Content criteria for brands' visual storytelling narratives on social media platforms: An experimental study with graphic design and branding students. *Arts and Architecture Journal, 4*(1), 182–207. https://doi.org/10.21608/aaj.2024.250849.1048
[50] Nasso, M., Blasi, E., Pezzoli, F., and Cicatiello, C. (2024). Investigating co-innovation strategies to prevent food loss in the fruits and vegetables sector. *Journal of Cleaner Production, 467*, 142984, 1–19. https://doi.org/10.1016/j.jclepro.2024.142984
[51] Negi, V.S., Kewlani, P., Pathak, R., Bhatt, D., Bhatt, I.D., *et al.* (2018). Criteria and indicators for promoting cultivation and conservation of medicinal and aromatic plants in Western Himalaya, India. *Ecological Indicators*, 93, 434–446. https://doi.org/10.1016/j.ecolind.2018.05.055
[52] Nyagadza, B., Kadembo, E. M., and Makasi, A. (2019). An application of impression management theory on corporate storytelling for branding in examining internal stakeholders' corporate brand perceptions. *Retail Marketing Review, 15*(2), 39–50.

FULL PAPER

[53] Pandey, A.K., Kumar, P., Saxena, M.J., Maurya, P., 2020. Distribution of aromatic plants in the world and their properties. In: Puniya, A.K. (Ed.), Feed Addit. Academic Press, London, 89–114. https://doi.org/10.1016/B978-0-12-814700-9.00006-6.
[54] Petiwala, S. M., Puthenveetil, A. G., and Johnson, J. J. (2013). Polyphenols from the Mediterranean herb rosemary (*Rosmarinus officinalis*) for prostate cancer. *Frontiers in Pharmacology, 4*, 29, 1–10. https://doi.org/10.3389/fphar.2013.00029
[55] Poulios, E., Giaginis, C., and Vasios, G. K. (2020). Current state of the art on the antioxidant activity of sage (*Salvia* spp.) and its bioactive components. *Planta Medica, 86*(4), 224–238. https://doi.org/10.1055/a-1087-8276
[56] Protopappas, L., Bechtsis, D., and Tsotsolas, N. (2025). IoT services for monitoring food supply chains. *Applied Sciences, 15*(13), 7602, 1–22. https://doi.org/10.3390/app15137602
[57] Russo, R., and Palla, F. (2023). Plant essential oils as biocides in sustainable strategies for the conservation of cultural heritage. *Sustainability, 15*, 8522, 1–21. https://doi.org/10.3390/su15118522
[58] Saha, A., Basak, B. B., and Banerjee, A. (2022). In-vitro antioxidant evaluation and production of biochar from distillation waste biomass of *Mentha arvensis*. *Journal of Applied Research on Medicinal and Aromatic Plants, 31*, 100428, 1–14.
[59] Saha, A., and Basak, B. B. (2020). Scope of value addition and utilization of residual biomass from medicinal and aromatic plants. *Industrial Crops and Products, 145*, 111979, 1–17. https://doi.org/10.1016/j.indcrop.2019.111979
[60] Sakas, D. P., Giannakopoulos, N. T., Terzi, M. C., Kamperos, I. D. G., and Kanellos, N. (2024). What is the connection between fintechs' video marketing and their vulnerable customers' brand engagement during crises? *International Journal of Bank Marketing, 42*(6), 1313–1347. https://doi.org/10.1108/IJBM-03-2023-0142
[61] Scavo, A., Rodríguez-Mejías, F. J., Chinchilla, N., Molinillo, J. M., Schwaiger, S., *et al.* (2025). Field efficacy of a bioherbicide mimic (DiS-NH2) in a nanoparticle formulation for weed control in durum wheat. *Pest Management Science, 81*, 3796–3810. https://doi.org/10.1002/ps.8749
[62] Scherrer, A. M., Motti, R., and Weckerle, C. S. (2005). Traditional plant use in the areas of Monte Vesole and Ascea, Cilento National Park (Campania, southern Italy). *Journal of Ethnopharmacology, 97*(1), 129–143. https://doi.org/10.1016/j.jep.2004.11.002
[63] Şenyapar, H. N. D. (2024). A comprehensive analysis of influencer types in digital marketing. *International Journal of Management and Administration, 8*(15), 75–100. https://doi.org/10.29064/ijma.1417291
[64] Shahane, K., Kshirsagar, M., Tambe, S., Jain, D., Rout, S., *et al.* (2023). An updated review on the multifaceted therapeutic potential of *Calendula officinalis* L. *Pharmaceuticals, 16*(4), 611, 1–24.
[65] Sharifi-Rad, J., Ezzat, S. M., El Bishbishy, M. H., Mnayer, D., Sharopov, *et al.* (2020). Rosmarinus plants: Key farm concepts towards food applications. *Phytotherapy Research, 34*(7), 1474–1518. https://doi.org/10.1002/ptr.6622

[66] Silalahi, H., and Guna, S. (2024). Enhancing brand awareness through content marketing strategy analysis in the digital landscape. *Journal of Economics, Management, Business and Technology, 3*(1), 9–18. https://doi.org/10.35335/jembut.v3i1.222
[67] Singh, S., Mishra, P., Chauhan, S. S., Lal, R. K., Rout, P. K., *et al.* (2024). Aromatic crops cultivation: A promising option in Indian agricultural system to support circular economy: A sustainable approach. *Sustainable Chemistry and Pharmacy, 42*, 101863, 1–16. https://doi.org/10.1016/j.scp.2024.101863
[68] Skaria, B. P., Mathew, S., Mathew, G., Joseph, A., and Joseph, R. (2020). *Aromatic plants, Horticulture Science*, 01, 85–112. New India Publishing Agency.
[69] Tammar, S., Salem, N., Aidi Wannes, W., Limam, H., Bourgou, S., *et al.* (2021). Chemometric profiling and bioactivity of *Verbena (Aloysia citrodora)* methanolic extract from four localities in Tunisia. *Foods, 10*(12), 2912, 16–20. https://doi.org/10.3390/foods10122912
[70] Touati, Z., Guemghar, M., Bedjaoui, K., Djerrada, N. E., Djaoud, K., *et al.* (2021). Optimization of microwave-assisted extraction and biological activities of polyphenols from lemon verbena leaves. *The*

FULL PAPER

Annals of the University Dunarea de Jos of Galati. Fascicle VI - Food Technology, 45(1), 157–177. https://doi.org/10.35219/foodtechnology.2021.1.11

[71] Tripathy, S., Verma, D. K., Thakur, M., Patel, A. R., Srivastav, P. P., *et al.* (2021). Curcumin extraction, isolation, quantification and its application in functional foods: A review with a focus on immune enhancement activities and COVID-19. *Frontiers in Nutrition, 8*, 747956, 18–22. https://doi.org/10.3389/fnut.2021.747956

[72] Tripathy, S., and Srivastav, P.P. (2024). Synergistic effects of dielectric barrier discharge (DBD) cold plasma pretreatment combined with microwave drying on the physicochemical and functional properties of *Centella asiatica* leaves. *Food and Bioprocess Technology*, 1–20.

[73] Valiño, A., Pardo-Muras, M., Puig, C. G., López-Periago, J. E., and Pedrol, N. (2023). Biomass from allelopathic agroforestry and invasive plant species as soil amendments for weed control—a review. *Agronomy, 13*, 2880, 1–24. https://doi.org/10.3390/agronomy13122880

[74] Vial, G. (2019). Understanding digital transformation: A review and a research agenda. *The Journal of Strategic Information Systems, 28*(2), 118–144. https://doi.org/10.1016/j.jsis.2019.01.003

[75] Wikipedia, (2025). Rif: Situation, topographie. https://fr.wikipedia.org/wiki/Rif