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Biotechnological Applications of Selected Plant Species in Iraqi Kurdistan

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Abstract

The Kurdistan region is home to a wide variety of plant species that could serve as a rich source of valuable bioactive metabolites. These metabolites have been utilized globally in various environmental and industrial fields, including pharmaceuticals, insecticides, agriculture, skin care products, environmental clean-up, and food preservation applications, providing a sustainable and eco-friendly substitute to synthetic chemicals. Additionally, they contribute significantly to enhancing product quality, industrial and medical development, and aid in preserving and increasing the shelf life of natural products. While the commercial value of these metabolites is expanding in the global market, they have not been adequately utilized and researched in the Kurdistan region. This review aims to fill the research gap by providing a detailed examination of 21 different plant species, their phytochemical constituents, and potential applications in various fields. A broad literature survey was conducted to identify prominent plant species of industrial and environmental importance, and their investigated bioactive compounds are summarized to provide a comprehensive reference for future studies. Additionally, this article discusses the potential of introducing Kurdistan's phytochemicals to the world of sustainable development and global bioeconomy. Through the correlation of the broad application of these metabolites with the scientific research in the region, Kurdistan can advance both scientifically and economically, stimulating biotechnological growth and sustainable alternatives for public health and the environment.

1. Introduction

Bioactive metabolites can be defined as a heterogeneous group of metabolic products synthesized by plants, fungi, bacteria, algae, and animals (Thirumurugan *et al*., 2018). More specifically, plants are regarded as the major producers of these metabolites (Al Aboud, 2024), which are differentially distributed among limited taxonomic groups within the plant kingdom. Various plant compartments are demonstrated to contain bioactive metabolites, including roots, stems, leaves, fruits, and flowers (Jain *et al*., 2019). These metabolites have a wide range of benefits for the producer plants, which use them to interact with other organisms, defend themselves against environmental stressors, and pathogenic microorganisms. In addition, they are also utilized by humans as food additives, for therapeutic, aromatic, culinary, and many other purposes (Yang *et al*., 2018).

The global market for plant bioactive metabolites was valued at $4.6 billion in 2022 and is projected to continue growing, driven by increasing demand for natural bioactive molecules (Ghosh *et al*., 2022). Their medicinal value, on the other hand, is gaining importance throughout the world; its international trade is expected to reach USD 5 trillion by 2050. According to research, Asian countries are the major exporters of these plants and their products. Accordingly, these plants can be utilized to improve the economy of low-income countries (Zahra *et al*., 2019). The provision of regional market statistics and policy data may further complement the assimilation of Kurdistan's phytochemical resources into the global bioeconomy.

It is undeniable that there are plenty of plant species in the Kurdistan region that have various benefits and have been relied upon from ancient times to the present day for different purposes, especially in medicine, flavoring, fragrance, and food industries (Dogara, 2023; Naqishbandi, 2014; Pieroni *et al*., 2017). However, compared to the research and studies that are conducted in Iran, Turkey (Ertas *et al*., 2021; Soltanbeigi & Soltani, 2024), and even across the entire world (Chiocchio *et al*., 2021; Ramírez-Rendon *et al*., 2022), these valuable bioactive metabolites have not been well researched and utilized within the Kurdistan Region. Therefore, this article aims to fill this gap by focusing on the role of valuable plants and their bioactive compounds in various sectors that are currently underdeveloped in Kurdistan. To do so, existing studies from other countries on the potential applications of these compounds as insecticides, in agriculture, cosmetics, environmental applications, and the food industry will be discussed. Additionally, this study proposes research directions to integrate these

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metabolites into sustainable development and commercial applications.

2. Plants' bioactive metabolites

Plant's bioactive metabolites are classified into four major classes: phenolics, terpenes and terpinoids, alkaloids, and sulfur-containing compounds (Sharma *et al*., 2022). They are biosynthesized through several metabolic pathways, including Shikimic acid, Malonic acid, Mevalonic acid, and Methylerythritol-phosphate pathways (Dhaniaputri *et al*., 2022). These bioactive compounds provide the plants with survival strategies, as they are generated in response to particular abiotic stresses and pathogenic assaults (Ahmed *et al*., 2017). It is worth noting that the biosynthesis and storage of certain compounds are specific to specific organs, tissues, or cells. For example, lipophilic compounds are concentrated in glandular hairs, trichomes, resin ducts, laticifers, thylakoid membranes, or on the cuticle, while hydrophilic compounds are typically stored in vacuoles (Wink, 2010).

Typically, flowers, fruits, and seeds serve as a reservoir for various bioactive compounds, particularly in annual plants. Besides, the bark of the stems, bulbs, and roots of perennial plants also accumulates a high concentration of metabolites (Wink, 1999). Several factors contribute to the production and accumulation of metabolites in plants, including genetic, developmental, and environmental factors. For instance, the accumulation of metabolites is highly dependent on light, temperature, and soil (components, moisture, fertility, and salinity). It has been recorded that most plants are susceptible to changes in any one of these factors, even when other factors remain constant (Kandar, 2021; Yang *et al*., 2018). Thus, it can be concluded that seasonal variation and geographical regions may have a significant impact on variations in the biosynthesis of metabolites. To identify and select the plant species for this review, a comprehensive ethnobotanical survey and literature search were conducted, focusing on plants with significant applications in modern industries and environmental fields worldwide. An initial list of important plants was compiled by examining reports from botanical research institutions and regional biodiversity records. The published studies from 2000 to 2025 were included in the search, with a focus on more recent works to reflect developments in phytochemical analysis and modern applications. The following table (Table 1) represents the plant species included in this review, which are available in the Kurdistan region of Iraq, along with their constituent metabolites, as determined by global investigations.

3. Environmental and Industrial Applications of the Plant's Metabolites

Previous investigations suggest different potential applications of plant metabolites, which may be related to their diverse chemical properties and biological activities. However, several challenges are anticipated for their commercial availability and production. Factors such as variability in these natural products' concentration and the absence of regulatory guidelines hinder their environmental and industrial applications, as well as their commercialization. Here are some key applications of the metabolites for the above-mentioned plants:

3.1. Pharmaceutical applications

The bioactive metabolites of many plants are widely used in pharmaceutical products (Chihomvu *et al*., 2024; Pramanik *et al*., 2024; Sezer *et al*., 2024), such as in treating cancer (Awasthi & Srivastava, 2024), diabetes (Sezer *et al*., 2024), and managing bacterial and viral infections (Sahoo *et al*., 2024; Mahmoudieh *et al*., 2024). Further details on their pharmaceutical applications are discussed in a separate review article, which is currently under review for publication.

3.2. Insecticide applications

Plant-based bioinsecticides are an important group of pesticides composed of phytochemicals that prevent harmful insects from damaging edible crops, harming non-target fauna and flora, and spreading diseases (Cheraghi *et al*., 2016). They are considered the best alternative to chemical insecticides, as they are eco-friendly, less toxic to untargeted organisms, and less prone to pest resistance. They possess a diverse mode of actions, allowing them to act as insect repellents or anti-feedants (Khursheed *et al*., 2022). Several plants in the Kurdistan region have this property and can be used as insecticides, as shown in Table 2.

3.3. Agricultural applications

The sustainable management of crop production in modern agriculture involves dealing with many different challenges. Balancing crop productivity with environmental sustainability is one of the main challenges for agriculture worldwide (Kostina-Bednarz *et al*., 2023). As described by Kisiriko *et al*. (2021), the phenolic compounds and extracts from some medicinal and aromatic plants can be used as biostimulants and bioprotectants in agriculture, such as those from *Z. officinale*. Plant metabolites can also be utilized as eco-friendly herbicides to control weeds, thereby significantly reducing the use of synthetic herbicides. This can be achieved by spraying crop fields with the plant extracts containing allelopathic compounds (Kostina-Bednarz *et al*., 2023). To illustrate, research has shown that *M. chamomilla* is a viable source for bioherbicide production to control flixweed (*Descurainia sophia L.*) (Madadi *et al*., 2022), specifically to inhibit germination and growth of Durum wheat (*Triticum turgidum* L. subsp. durum (Desf.) Husn.) (Elbouzidi *et al*., 2021). Several allelochemical compounds in the extracts of specific plant species can be successfully used as effective bioherbicides against weeds, like phenols and flavonoid compounds in *C. sativum* seed powder (El-Rokiek *et al*., 2020), *C. sativum* essential oil (El-Rokiek *et al*., 2021; Sumalan *et al*., 2019), the extract of *N. officinale* (Khan *et al*., 2021; Wang *et al*., 2024), caryone and limonene in the essential oil of *A. graveolens* (Dorina, 2020; Mirmostafaee *et al*., 2020; Saric-Krsmanovic *et al*., 2023), the essential oils of *O. basilicum* (Anupama *et al*., 2023; Kamel *et al*., 2022), the extracts of

L. serriola (Heivachi *et al*., 2023), and *M. sylvestris* (Tatari *et al*., 2020).

Table 1. Possible Secondary Metabolite Constituents in 21 Plant Species Reported from the Kurdistan Region

Plant species in the region, according to references	**Investigated secondary metabolites with References**	
Gundelia tournefortii (Kenger) (Abdulrahman, 2023)	• Phenolics (eugenol, methyl eugenol, trans-anethole). •Terpenes (α-terpineol, α-terpinolene, α-farnesene, α-humulene, β-caryophyllene, β-sesquiphellandrene, γ-terpinene, limonene, p-cymene, terpinen-4-ol, zingiberene). • Terpenoids (α-terpinyl acetate, α-copaene, β-bisabolene, linalool acetate). • Phytosterols (campesterol, stigmasterol, *β*-sitosterol). • Phenolic monoterpenoid (carvacrol).	(Halabi *et al*., 2005; Matthäus & Özcan, 2011)
Silybum marianum (Milk thistle) (Hassan & Umer, 2023)	• Phenolics [tannins, silymarin (taxifolin, silychristin, silydianin, silybin A, silybin B, isosilybin A, isosilybin B)]. • Terpene glycosides. • Alkaloids.	(Guemari *et al*., 2020; Javeed *et al*., 2022; Viktorova *et al*., 2019)
Lepidium sativum (Garden cress) (Hassan & Shekha, 2023)	• Phenolics [tannins, flavonols (querectin, kaempferol), flavones (luteolin, apigenin), flavonones (naringin, naringenin)]. • Terpenes (saponins). • Phytosterols. • Alkaloids.	(Chatoui *et al*., 2016; L'hadj *et al*., 2019)
Rheum ribes (Rhubarb) (Amin *et al*., 2023)	•Phenolics (emodin, aloe-emodin, chrysophanol, rhein, chlorogenic acid, gallic acid, tannic acid, kaempferol, rutin, tannins, Quinone, anthraquinones). • Terpenes (curcumin, terpene glycosides). •Alkaloids.	(Abdulla *et al*., 2015; Adham & Naqishbandi, 2015; Noori *et al*., 2022)
Matricaria chamomilla (Chamomile) (Abdulrahman, 2023)	•Terpenes (α-Bisabolol oxide A, β-Farnesene, chamazulene, Guaizulene, α-Bisabolene epoxide, Germacene, Camphor, 3-carene, *β*-myrcene, *α*-phellandrene, *γ*-Terpinene, camphene, *α*-Terpinolen, *α*-Thujenal, myrtenol, sabinol, limonene, caryophyllene, *α*-Muurolene, saponins). • Terpenoids (p-camphorene, p-cymene, *α*-Curcumene, copaene). • Phenolics (2,4,5-tetramethyl1,3-cyclopentadiene, tannins). • Phenolic monoterpenoid (thymol). • Alkaloids. • Phytosterols.	(Ali, 2013; Mohammed & Abdelgadir, 2016; Qasem *et al*., 2022)
Helianthus tuberosus (Jerusalem artichoke) Bakir (2003)	• Phenolics (neochlorogenic acid, chlorogenic acid, caffeic acid, cryptochlorogenic acid, salicylic acid, salvianolic acid, quinic acid, vanillin, cinnamic acid, flavonone (Liquiritigenin), chalcones (butein, kukulkanin B), flavone(nevadensin), astragilin, hymenoxin).	(Kaszás *et al*., 2020; Mariadoss *et al*., 2021)
Beta vulgaris (Beet root) (Abdulrahman, 2023)	• Phenolics (quinone, coumarin, tannins, anthocyanin, gallic acid, catechol, chlorogenic acid, caffeic acid, benzoic acid, syringic acid, p-coumaric acid, pyrogallol, protocatchoic, apigenin, rutin, naringenin, rosmarinic acid, hesperdin, kaempferol, querectin, myricetin, catechin, cinnamic acid, ferulic acid). • Terpenes (saponin, betanin). • Alkaloids (betacyanin).	(El-Beltagi *et al*., 2022; Rehman *et al*., 2022; Zia *et al*., 2021)
Mentha pulegium (Pennyroyal) (Abdulrahman, 2023)	• Phenolics (rosmarinic acid, ellagic acid, chlorogenic acid, eriodictyol, naringenin, α-Humelene, • Terpenes (α-Pinene, β-Pinene, pulegone, piperitenone, Limonene, E-caryophyllene). • Terpenoids (isopulegol). • Phenolic monoterpenoid (thymol).	(Politeo *et al*., 2018; Zekri *et al*., 2013)
Borago officinalis (Star flower) (Ahmed, 2016)	• Phenolics (gallic acid, salicylic acid, pyrogallol, caffeic acid, rutin, myricetin, daidzein, coumarins, hydroxycinnamic acid, tannin). • Terpenes. • Terpenoids (carotenoids (β-Carotene, lutein)). • Sterols.	(Fernandes *et al*., 2019; Gilani *et al*., 2007; Karimi *et al*., 2018; Zribi *et al*., 2019)
Thymus vulgaris (Garden thyme) (Ahmed, 2016)	• Phenolic monoterpenoid (carvacrol, thymol). • Terpenes (α-Pinene, β-Pinene, sabinene, α-terpinene, camphor, 1,8-cineole, α-terpineol, carene, δ-Cadinene, terpinen-4-ol, P-cymene, o-cymene, humulene, camphene, α-thujene, D-limonene, γ-terpinene, caryophyllene, β-myrcene, (*E*)-Sesquilavandulol). • Terpenoids (linalool, borneol, α-Cadinol, Geraniol).	(Al-Asmari *et al*., 2017; Borugă *et al*., 2014; Grigore *et al*., 2010; Mancini *et al*., 2015)

Table 1. Continued.

Plant species in the region, according to references	Investigated secondary metabolites with References	
Nasturtium officinale (Watercress) (Hassan & Shekha, 2023)	• Phenolics (caffeic acid, gallic acid, salicylic acid, syringic acid, ellagic acid, chlorogenic acid, rutin, •Terpenes (E-phytol, pulegone, squalene, caryophyllene, D-limonene, β-myrcene, β-phellandrene, α-Terpinolene, γ-terpinene). • Sulfur-containing compounds (2-phenylethyl isothiocyanate, heptyl isothiocyanate, 4-phenylbutyl isothiocyanate).	(Boligon *et al*., 2013; Ercan & Dogru, 2022; Quezada-Lázaro *et al*., 2016; Taghavinia *et al*., 2022)
Zingiber officinale (Ginger) (Ahmed, 2016)	• Phenolics (gingerol, lignans (lariciresinol, matairesinol), • Terpenes (β-sesquiphellandrene, cineole, nerolidol B, farnesol 3, Saponins, Zingiberene, curcumene, α-Fernesene, β-farnesene, β-bisabolol, γ-cadinene). • Terpenoids (guaiol, zingiberenol, Carveol, germacrone, Veridiflorol). • Alkaloids.	(Bhargava *et al*., 2012; Osabor *et al*., 2015; Yousfi *et al*., 2021)
Lactuca serriola (Prickly lettuce) (Rasul, 2020)	• Terpenes (hexahydrofarnesyl acetone, phytol). • Terpenoids (α-Terpineol acetate, Germanicol, lupeol).	(Doğan & Servi, 2020; Shukurlu, 2020; Ullah *et al*., 2022)
Anethum graveolens L. (Dill) (Abdullah, 2021)	• Phenolics (tannins). • Terpenes (limonene, saponins, carvone, α-phellandrene, *α*-pinene, myrcene, camphor, p-cymene). • Phenolic monoterpenoid (thymol). • Dill ether and dill apiole.	(Al-bazaz *et al*., 2020; Jana & Shekhawat, 2010; Sharopov *et al*., 2013)
Ocimum basilicum (Basil) (Abdulrahman, 2023)	• Phenolics (rosmarinic acid, Methyl eugenol). • Terpenes (saponins, sabinene, 1,8-cineole, *α-trans-bergamotene*, Bicyclogermacrene, transcaryophyllene, *spathulenol, α-cubebene*, B-cubebene, *α-muurolene*, β-elemene, germacrene-D, germacrene-A, limonene, camphor, terpinen-4-ol, *α-humulene)*. • Terpenoids (linalool, geraniol, epi-*α-cadinol*, fenchone, neral, nerol, β-eudesmol, trans-*α-bisabolene*, β-copaene). • Alkaloids. • Phenolic monoterpenoid (carvacrol).	(Fathiazad *et al*., 2012; Oliveira *et al*., 2009; Özcan & Chalchat, 2002; Sanni *et al*., 2008)
Rosa canina (Dog rose) (Al-Mathidy *et al*., 2023)	• Terpenes (β-caryophyllene, α-pinene, β-pinene). • Terpenoids (caryophyllene oxide, linalool, δ-guaiene, β-ionone). • Phenolic (eugenol).	(Hosni *et al*., 2010)
Verbascum thapsus (Mullein) (Amin *et al*., 2020)	• Phenolics (caffeic acid, gallic acid, P-coumaric acid, ellagic acid, Rutin, quercetin, epicatechin, ferulic acid). • Terpenes (squalene). • Phytosterols (stigmasterol).	(Nadeem *et al*., 2021; Soto *et al*., 2022)
Artemisia absinthium (Tarragon) (Ali *et al*., 2021)	• Phenolics (Homorientin, Artemetin, chlorogenic acid, 4-caffeoylquinic acid, 3,4-dicaffeoylquinic acid). • Terpenes (α-Thujene, α-Pinene, α-Terpinene, β-Ocimene, Ocimenone, α-Humulene, γ-Curcumene, trans-Nerolidol, Methyl jasmonate, Chamazulene, α-Muurolene, D-limonene, 1,8-cineole, camphene). •Terpenoids (linalool, Pinocarvone, Bornyl acetate, α-Gurjunene, γ-Gurjunene, Guaiol, γ-Eudesmol, Cubenol).	(Boudjelal *et al*., 2020; Mohammed, 2022)
Malva sylvestris (Mallow) (Abdulrahman, 2023)	• Phenolics (anthocyanosides, 4-hydroxy-benzoic acid, hydroxy-cinnamic acid, ferulic acid, tannins, salicylic acid, oleic acid, apigenin, Scopoletin, coumarins). • Terpenes (phytol, saponin). • Phytosterols (campesterol, stigmasterol). • Alkaloids.	(Al-Rubaye *et al*., 2017; DellaGreca *et al*., 2009; Prod *et al*., 2012)
Spinacia oleracea (Spinach) (Ahmed, 2016)	• Phenolics (tannins). • Terpenes (saponins). •Terpenoids (carotenoids (neoxanthin, violaxanthin, lutein, β-Carotene), ferulic acid, p-coumaric acid, hydroxycinnamate, trans-p-coumarate, o-coumaric acid).	(Bunea *et al*., 2008; Okazaki *et al*., 2008; Tabassum *et al*., 2015)
Coriandrum sativum (Coriander) (Abdulrahman, 2023)	• Phenolics (tannins, coumarins, leucoanthocyanin). •Terpenes (saponins, γ-terpinene, α-Pinene, limonene, α-Thujene, Camphene, sabinene, myrcene, β-pinene, camphor, 1,8-cineole, α-terpinol, germacrene, carvone). • Terpenoids (geranyl acetate, linalool, Cis-dihydrocarvone, neral, nerol). • Alkaloids. •Phytosterols.	(Ahmed *et al*., 2018; Msaada *et al*., 2007; Sasi Kumar *et al*., 2014; Shahwar *et al*., 2012)

Table 2. Insecticidal Activities of the Reported Plant Species

Plant Species	Bioactive constituents	Insecticidal activities	References
G. tournefortii	Extracts	Inhibit the growth of the vinegar fly *Drosophila melanogaster Meigen*	(Ghabeish, 2015)
L. sativum	Extracts	Effective against mosquito larvae	(Al-Keridis *et al*., 2021; Ayoub *et al*., 2023)
M. chamomilla	Essential oils	Effective insecticides against red, black, and hybrid imported fire ants	(Al-Ghanim *et al*., 2023; Mihyaoui *et al*., 2022), (Shah *et al*., 2023)
M. pulegium	Essential oil monoterpene and sesquiterpene hydrocarbons, and alkaloids	Effective in pest control	(Aimad *et al*., 2021; M. Domingues & Santos, 2019)
T. vulgaris	Essential oil	Has acute toxicity against the larvae of *Spodoptera littoralis* and *Culex quinquefasciatus.*	(Pavela & Sedlák, 2018).
		Reduces adult survivability, deters female egg laying, and strongly inhibits adult emergence of *Acanthoscelides obtectus*	(Lazarević *et al*., 2020)
Z. officinale	Gingerols and shogaols	Effective against: *Spodoptera* spp	(Keosaeng *et al*., 2023)
	Extracts	*Aedes aegypti* larvae	(Boekoesoe & Ahmad, 2022)
		Red flour beetle	(Kadhim & Younis, 2023)
A. graveolens	Essential oils	Effective against: *Rhyzopertha dominica*	(Jayakumar *et al*., 2021)
		Sitophilus zeamais Motschulsky	(Chaubey, 2021)
		Cochlochila bullita	Bendicion *et al*., 2020
O. basilicum	Extracts	Effective against: Tobacco cutworm *Spodoptera litura* Feb. (Lepidoptera; Noctuidae)	(Jafir *et al*., 2021)
		Acanthoscelides obtectus	(Rodríguez-González *et al*., 2019)
		South American tomato moth	(Prasannakumar *et al*., 2023)
		Sitophilus oryzae	(Bincy *et al*., 2023)
R. canina	Extracts	Effective against *Rhopalosiphum padi*	(Benslama *et al*., 2021)
C. sativum	Extracts	As an insecticide	(Amoabeng *et al*., 2019; Kassahun, 2020)

Moreover, the flavonoids and phenolic acids from extracts of *C. sativum* (Sriti *et al*., 2022), along with monoterpenes from its essential oil (Barros *et al*., 2022), were found to have strong repellent activities against different insects.

3.4. Skin Care applications

Cosmetic products contain various plant-based active ingredients that serve diverse functions, including providing nutrients for hair, increasing skin elasticity, enhancing skin collagen, exhibiting anti-aging properties, offering antioxidants to resist UV radiation, reducing hyperpigmentation, and promoting other benefits for skin health (Bashir *et al*., 2021).

The plant metabolites that are used for skin protection due to their antioxidant and UV-protection activity are illustrated in Table 3.

Plant metabolites are also utilized in hair and scalp care products. According to research, phenolic compounds, alkaloids, and other beneficial compounds extracted from the seeds of *L. sativum* are believed to reduce hair loss and prevent hair from turning grey (Syeda Kaniz *et al*., 2022). Moreover, the seed mucilage was also used in natural hair conditioners to make hair smoother, decrease hair strand friction, and make brushing easier (Patil, 2019). Other research shows that the essential oil of *M. chamomile* can lighten hair and be used in scalp care products (Mustafakulovna & Kurbonalievna, 2022), *R. canina* fruit extract can be used in aerosol hair sprays (Johnson *et al*., 2022), and the essential oil of *A. dracunculus* can be used as an active ingredient in nail, hair, and bath items (Coltun, 2021).

Skin care products may also contain plant metabolites. Some of them may be used as antiaging agents to reduce wrinkles and improve skin elasticity, especially in moisturizing products, such as silymarin in *S. marianum* extract (Drouet *et al*., 2019). Several plant extracts and essential oils have been shown to enhance skin elasticity, resulting in firmer skin, as listed in Table 4.

In addition, the essential oil of *M. chamomile*, which is a rich source of bisabolol, can soothe irritation, deodorize, fight bacteria, and provide after-shave treatments, making it widely popular for use in lip care, infant skin care, and hair removal products (Mustafakulovna & Kurbonalievna, 2022). Another research mentioned that azulene in the essential oil of chamomile flowers is valued in skincare for its gentle, soothing qualities and its ability to moisturize and help remove residue, making it a useful ingredient in products designed for sensitive skin or post-hair removal care (Elsharkawy *et al*., 2014). Jerusalem artichoke is another useful plant whose extract is used in skin care products. According to studies, it can be used in producing two-phase makeup removers (Niziol-Lukaszewska *et al*., 2020), which are related to flavonoid and phenolic compounds in its extracts. These compounds play a role in promoting skin health and supporting repair processes (Nizioł-Łuaszewska *et al*., 2018). Using color is one important feature in cosmetic products; for example, *B. vulgaris* was used as a natural dying agent, which can be added to henna for hair and skin, and also was used in producing herbal lipstick due to its high carotenoid and betacyanin (betanin) red color (Chaudhari *et al*., 2019; Insan & Vera, 2021; Obat & Bosire, 2022; Rosaini *et al*., 2021). Moreover, several compounds, like flavonoids, saponins, tannins, alkaloids, quinones, triterpenoids, and steroids in beetroot extracts, are beneficial for formulating various skincare products, such as creams, blushes, and powders (Sari *et al*., 2021).

Other benefits of plant metabolites in cosmetics include their use in treating skin infections and acting as an anti-acne agent (Table 5).

As a whitening agent, *Z. officinale* and its active ingredient, zerumbone (ZER), can decrease the expression of melanogenesis-related genes, which has the potential to be beneficial in skin-whitening products (Oh *et al*., 2018). Umbelliprenin in the seed extracts of *A. graveolens* has also been used as an anti-hyperpigmentation agent and as an ingredient in skin-lightening cosmetics (Taddeo *et al*., 2019). Some plants contain highly aromatic, bioactive compounds that can be used in the manufacture of perfumes and fragrances.

L. serriola oil extract's pleasant aroma is attributed to sesqui-sabinene hydrate, limonene oxide, thunbergol, and globulol, making it suitable for use in the perfumery industry (Elsharkawy *et al*., 2014). In addition, *A. graveolens* seeds extract (Sohm *et al*., 2011), essential oil of *O. basilicum* (Avetisyan *et al*., 2017), *R. canina* extracts (Javanmard *et al*., 2018; Johnson *et al*., 2022), and the essential oil extracted from *A. dracunculus* (Coltun, 2021) have been used in this industry.

3.5. Environmental applications

The negative impacts of conventional agricultural production and the expanding human population on the environment can be mitigated by utilizing plants with diverse metabolites (Clemensen *et al*., 2020).

One of the leading environmental roles of plants is phytoremediation, a process that decontaminates soil and water by absorbing pollutants (Khan *et al*., 2019; Singer *et al*., 2003).

Table 3. UV-protectant Bioactive Metabolites from the Reported Plant Species

Plant Species	Bioactive constituents	References
S. marianum	Silymarin	(Drouet *et al*., 2018, 2019; Fehér *et al*., 2016)
T. vulgaris	Rosmarinic acid and thymol	(Cornaghi *et al*., 2016; Sun *et al*., 2017)
O. basilicum	Essential oil	(Malapermal *et al*., 2015)
M. chamomile	Essential oil	(Mustafakulovna & Kurbonalievna, 2022)
N. officinale	Indole 3-acetonitrile-4-methoxy-2-S-β-D-glucopyranoside in its oil	(Chaudhary *et al*., 2018)
R. canina	Ascorbic acid, tannins, and phenolics	(Taneva *et al*., 2016)
S. olerancea	Carotenoids	(Michalak, 2022)
B. officinalis	Phenolics, flavonoids, and fatty acids	(Karimi *et al*., 2018)

Table 4. The Extracts and Essential Oils of Reported Plant Species that Improve Skin Texture

Plant Species	Bioactive constituents	References
M. chamomile	Essential oil	(Mustafakulovna & Kurbonalievna, 2022)
T. vulgaris	Extracts	(Caverzan et al., 2021)
N. officinale	Extracts	(Klimek-Szczykutowicz *et al*., 2018)
O. basilicum	Essential oil	(Yaldiz *et al*., 2023)
V. sinatuam	Polyphenol	(Donn *et al*., 2023)
C. sativum	Essential oil	(Salem *et al*., 2022)
A. graveolens	Carvone, d-limonene, and α-phellandrene in seed extract	(Sohm *et al*., 2011)

Table 5. Plant Species that are used to Treat Acne and Skin Infections

Plant Species	Bioactive constituents	References
T. vulgaris	Extract	(Silva *et al*., 2021)
N. officinale	Extract	(Klimek-Szczykutowicz *et al*., 2018)
Z. officinale	Extract	(Tritanti & Pranita, 2019)
R. canina	Extract	(Johnson *et al*., 2022)
L. serriola	Azulene in its oil	(Elsharkawy *et al*., 2014)

These metabolites can scavenge reactive oxygen species, precipitate, and chelate metal ions from the surrounding environment (Anjitha *et al*., 2021). This may be regarded as one of the primary methods for remediating heavy metals and degrading pollutants from soil, and as a new option for wastewater management (Amiri *et al*., 2020; Moustafa *et al*., 2020).

Several plant species have been shown to accumulate different kinds of heavy metals from contaminated soils and waters, which may suggest their strong potential as bioremediation agents. Compared to known hyperaccumulators such as *Brassica juncea*, which has been reported to accumulate up to 16.750 mg/kg of Zn in leaves and 7.170 mg/kg of Cu in stems (Sut-Lohmann *et al*., 2023), Kurdistan plant species exhibit comparable or even higher uptake capacities. For example, *G. tournefortii* has demonstrated adsorption capacities of 38.7597 mg/g for copper and 144.928 mg/g for lead (Golshan Shandi *et al*., 2019; Rahimpour *et al*., 2017). Similarly, *S. marianum* has been shown to accumulate lead, cadmium, and zinc in quantities far exceeding the maximum permissible levels (Razanov *et al*., 2020). Several other species display promising phytoremediation potential. *L. sativum* accumulates mercury (Hg) in its aerial tissues to over 12% of total Hg from polluted soil with 10 mg/kg of Hg (Smolinska & Leszczynska, 2017). *H. tuberosus was* recorded as a mercury hyperaccumulator (Lv *et al*., 2018; Montalbán *et al*., 2017), while *L. serriola* shows significant copper uptake, reaching 46 mg/kg (Abou-Shanab *et al*., 2017). Other notable phytoremediators include *C. sativum*, which phytoremediates lead and arsenic from tailing soil, with a recorded concentration of 44.52 ± 0.65 ppm arsenic in the leaves and 350.88 ± 0.33 ppm lead in the roots (Garrett *et al*., 2019; Gaur *et al*., 2017). *O. basilicum* has been found to phytoextract cadmium from soils with 116 mg/kg accumulated in the root (Adiloğlu, 2021; Alamo-Nole & Estrella-Martinez, 2022; Dinu *et al*., 2020). Additionally, *N. officinale* can inhibit urease activity in the soil and accumulate cadmium (2.23 mg/L) (Ali *et al*., 2025; Jarosz *et al*., 2023; Zhang *et al*., 2019). Further research highlights *V. thapsus* as a copper accumulator to a maximum level (492.8 mg/kg in shoots and 447.3 mg/kg in roots (Kavousi *et al*., 2021; Khan *et al*., 2024). *A. absinthium* can be used as the most practical way to remediate copper-contaminated soils (Ghazaryan *et al*., 2022), while *M. parviflora* was suggested as the best for phytoextracting heavy metals and lead cleanup with a concentration capacity of 5.76 mg/kg (Shaaban *et al*., 2025). Lastly, *S. oleracea* exhibits good potential for Cd phytoextraction with concentrations ranging from 1.59 to 50 mg/kg (Chaturvedi *et al*., 2019; Ugulu *et al*., 2022).

On the other hand, some plants have been shown to bioremediate drugs, such as *O. basilicum*, which was used to remediate amoxicillin (Bhatt & Gauba, 2021), and *S. oleracea*, which was used to remediate paracetamol (Badar *et al*., 2022). Equally important, several plant species can degrade and decrease certain pollutants in the environment. For instance, *N. officinale* is used to reduce greenhouse gases by producing urease inhibitors(Hube *et al*., 2017; Jarosz *et al*., 2023). *O. basilicum* and *R. canina* are used to absorb and remove methylene blue dye from water (Alikhani *et al*., 2022; Gupta & Verma, 2022; Karaghool *et al*., 2022). *M. parviflora* to remove Disperse Blue 183 and Maxillon Blue GRL dyes from water (Alkadir *et al*., 2022). Moreover, plants can also be used as bio-indicators for ecotoxicological diagnostics and environmental quality investigations through the use of their metabolites as biomarkers (Ferrat *et al*., 2003; Marciulioniene *et al*., 2019). To illustrate, *L. sativum* was recently used by researchers to measure soil and water phytotoxicity (Mañas & De las Heras, 2018). Furthermore, *H. tuberosus* has been used to detect phenol pollutant concentration in soil (Odaci *et al*., 2004).

Plant extracts and metabolites have been used in the green synthesis of eco-friendly nanoparticles with fewer environmental hazards (Kumar *et al*., 2020), which is useful in a broad range of fields such as healthcare, cosmetics, the chemical industry, food, and feed (Song *et al*., 2020). They could also aid in environmental bioremediation, addressing issues related to water purification and quality (Turakhia *et al*., 2018).

It is worth mentioning that some plants are toxic to some pests, including insects, fungi, and bacteria, and their effect have been associated with their secondary metabolites (Cespedes *et al*., 2015). Using these plants as pesticides can be advantageous over chemical ones in controlling pests, as they have no harmful impacts on the environment or human beings (Yadav *et al*., 2022). These beneficial plants include the flowers of *M. chamomilla*, which can be used as eco-friendly bio-fungicides (EL-Hefny *et al*., 2019), *T. vulgaris* (Lazarević *et al*., 2020; Livingstone & Matheen, 2023; Zahed *et al*., 2021), and *M. pulegium* (Attia *et al*., 2022; M. Domingues & Santos, 2019).

On the other hand, saponin is another useful, eco-friendly material due to its natural origin and biodegradability. To date, many plant-based saponins have been investigated for their surfactant properties and their activities in various fields, including antimicrobial, antidiabetic, anticancer, and adjuvant potentials, among others. These surfactants offer great potential for the replacement of toxic synthetic surfactants (Rai *et al*., 2021). For example, *G. tournefortii* was explored for its use in optimizing chemically enhanced oil recovery (EOR) applications in 2021 (Bahraminejad *et al*., 2021).

Another application is the use of plant extracts as an ideal, cost-effective, and eco-friendly alternative to traditional toxic metal corrosion inhibitors (Verma *et al*., 2018). Green corrosion-inhibiting plant extracts contain water-soluble metabolites like organic acids, quinones, phenolic compounds, flavonoids, alkaloids, catechins, terpenoids, and co-enzymes, making them easily applicable in many industrial fields (Verma *et al*., 2018). In this respect, *R. ribes* was used to protect steel and copper from corrosion (Kaya *et al*., 2023a, 2023b). *B. vulgaris* peel extract has shown anti-corrosive behavior against SS 410 surface in 15% hydrochloric acid (Bhardwaj *et al*., 2022). Spinach extract has both biocidal and corrosion inhibition properties (Parthipan *et al*., 2021). *S. oleracea* was used as a green corrosion inhibitor for carbon steel (Hameed *et al*., 2022).

Natural fiber-reinforced composites are another environmentally safe, long-lasting, and recyclable material derived from plants (Dalmis, 2023). It is worth mentioning that metabolites like lignin, cellulose, and hemicellulose, as well as their compound types like esters, ketones, and alcohols, are the main components of natural fibers (Fan *et al*., 2012). *H. tuberosus* stalk particles are used to produce cement-bonded particleboards for construction applications (Wang *et al*., 2016), and its fiber is used for polymer-based green composites (Dalmis, 2023). The use of a naturally-derived membrane from *M. Verbascum* is considered a green technology to reduce the use of non-green chemicals (Saleh *et al*., 2021). Finally, a bio-based dye produced by *B. vulgaris* can be used as an eco-friendly dye to stain wool and cotton as a substitute for synthetic pigments, which have a hazardous impact on the environment and humans (Benli, 2022; Patel & Patel, 2022).

3.6. Food industries

With the rise of healthy food diets and people's demand for the avoidance of synthetic materials, new methods for food production and preservation are essential. Natural plant constituents are one of the most effective ways to support the food industry and production (Petropoulos, 2023). This section discusses the potential role of plant metabolites in the food industry, particularly as preserving, flavoring, texturizing, and coloring agents (Kallscheuer *et al*., 2019). Plant metabolites with antioxidative properties are finding applications as preservatives or anti-browning agents, thereby helping to preserve food and extend its shelf life, which meets consumer demands (Kallscheuer *et al*., 2019). Several plant-derived secondary metabolites are valuable as food preservatives due to their significant antioxidant capacities, as follows: The seed gum of *L. sativum* exhibited a high antioxidant capacity (~85%) when used for the preservation of beef and cheese (Esmaeili *et al*., 2021; Rehim *et al*., 2023). The antioxidant activity of *M. chamomilla* essential oil was recorded with an EC_{50} value of 2.07 mg/ml (Stanojevic *et al*., 2016). Similarly, the antioxidant activity of *M. pulegium* essential oil ranged from 7.5 to 44.7 µg/mL (Salehi *et al*., 2018). The essential oil of *T. vulgaris* was recorded to have an antioxidant capacity of 85.2 ± 0.2% (alovičová *et al*., 2021). Additionally, the extract of *Z. officinale* has been shown to exhibit a significant radical scavenging activity of 54.5% (Murphy *et al*., 2020). The essential oil of *A. graveolens* L. exhibited antioxidant capacity with an IC_{50} value of 9.02 mg/mL (Hadi *et al*., 2024), whereas the fruit extract of *R. canina* fruit recorded an IC_{50} value of 89.16 ± 2.76 µg/mL (Soltan *et al*., 2023). Moreover, the extracts of *S. oleracea* showed significant antioxidant capacity with values of 34.89 µg/mL and 35.60 µg/mL (Salehi *et al*., 2019). Finally, the free radical scavenging assay for the essential oil of *C. sativum* was noted to be 39.38 mg/L (Kačániová *et al*., 2020).

Another benefit of some of these plants in the food industry is their use as flavoring agents. Examples include the natural compounds in *Z. officinale*, which can be useful in foods as herbs, spices, flavorings, and seasonings (Mara Teles *et al*., 2020), essential oil of *T. vulgaris* (Almanea *et al*., 2019; Pavela & Sedlák, 2018), *Z. officinale* (Laelago *et al*., 2023; Shahrajabian *et al*., 2019), the essential oil of *A. graveolens* L.(Kaur *et al*., 2018), oil and oleoresin of sweet basil *O. basilicum* (Egata, 2021), and the essential oil of *C. sativum* (Al-Khayri *et al*., 2023). Food fortification is a process in the food industry that involves improving the nutritional value of food by increasing or adding micronutrients (Darnton-Hill & Nalubola, 2002). According to investigations, phytonutrients from many plants are used to biofortify food, feed, and medicines (Sreenivasulu & Fernie, 2022). Examples of plants whose metabolites are utilized in this area are included in Table 6. Moreover, the biologically active plant compounds of some of these plants have the potential to be used in food packaging as alternatives to petroleum-based polymers, which yield enormous amounts of plastic waste. According to research, compounds that can be used in food packaging as edible coatings include phenols and flavonoids (Rehim *et al*., 2023). The plants used for this purpose include *L. sativum* (Rehim *et al*., 2023) and *T. vulgaris* (Razavi *et al*., 2021; Silva *et al*., 2021). Finally, *B. vulgaris* is one of the common plants that can be used as a food colorant due to the presence of betalains in its constituents (Corleto *et al*., 2018; Domínguez *et al*., 2020; Kumar & Brooks, 2018).

4. Safety and risk assessments

While Kurdistan plants' metabolites hold high environmental and industrial potential applications, their commercial exploitation is hampered by challenges in standardization, industrial feasibility, and regulatory approval.

Currently, there are no comprehensive studies assessing the Generally Recognized As Safe (GRAS) status of metabolites derived specifically from Kurdistan's plant species (FDA, 200). Therefore, performing safety evaluations, concentrating on establishing evaluation standards, quality control, and collaborating with regulatory agencies for the approval process are considered important steps for future initiatives.

Table 6. Bioactive Plant Extracts from the Reported Plant Species used in the Food Fortification Industry

Plant Species	Bioactive constituents	References
H. tuberosus	Extracts	(Apostol *et al*., 2019; Catană *et al*., 2018)
S. marianum	Seed extracts	(Lukic *et al*., 2022) (Krystyjan *et al*., 2022) (Dabija *et al*., 2018)
L. sativum	Seed extracts	(Lahiri & Rani, 2020)
M. chamomilla	Extracts	(Caleja *et al*., 2016; Caleja *et al*., 2016)
A. graveolens	Extracts	(Paven *et al*., 2018)
R. canina	Extracts	(Kubczak *et al*., 2020)
A. absinthium	Extracts	(Bordean *et al*., 2021; Boulares *et al*., 2023)
M. pulegium	Extracts	(Habibvand *et al*., 2023)
Z. officinale	Ginger oil and oleoresin	(Imamović *et al*., 2021)

Moreover, factors such as yield optimization, extraction efficiency, and cost play a crucial role in determining whether these bioactive compounds can be produced at an economically viable scale (Sagar *et al*., 2024; Heinrich *et al*., 2022; Tariq *et al*., 2021). Furthermore, clinical and toxicological research, which explores modern techniques such as CO_2 supercritical extraction (Chen et al., 2024), may offer promising advancements in metabolite recovery for large-scale production. Similarly, metabolic engineering and tissue culture methods could enhance secondary metabolite yield (Fazili *et al*., 2022; Hesami *et al*., 2021; Mipeshwaree Devi *et al*., 2023; Ozyigit *et al*., 2023). By resolving these regulatory issues, Kurdistan's plant metabolites could gain broader acceptance in various industrial markets around the world.

5. Conclusions

Using natural bioactive compounds from plants is gaining importance worldwide as an alternative to hazardous chemicals, which necessitates researchers to investigate their potential side effects. The Kurdistan region is home to a rich diversity of plant species, many of which possess valuable metabolites and significant environmental and industrial applications. As noted in the above-mentioned works, the plant's metabolites have been utilized globally in various industries, including pharmaceuticals, insecticides, agriculture, cosmetics, environmental applications, and food. Local use in daily life and research investigations into these valuable resources are still limited. This review strongly suggests the necessity of investing in these metabolites for further research and their potential contribution to future biotechnological advancements. Furthermore, leveraging this natural wealth in additional applications may represent a promising avenue to stimulate economic growth and development. Moreover, the valuable species of high marketing value should be conserved, and their cultivation should be promoted for future use.

Conflict of interest

The authors declare no conflict of interest.

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

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References

Abdulla, K. K., Taha, E. M., & Rahim, S. M. (2015). Phenolic profile, antioxidant, and antibacterial effects of ethanol and aqueous extracts of *Rheum ribes* L. roots. *Der Pharmacia Lettre*, *7*(4).

Abdullah, A. M. (2021). Contamination of fresh vegetables with protozoan parasites, in Duhok City, Kurdistan region of Iraq. *Medical Journal of Babylon*, *18*(4), 416–420. https://doi.org/10.4103/MJBL.MJBL_69_21

Abdulrahman, M. D. (2023). Plants biodiversity utilisation in Bardarash, Kurdistan Region, Iraq. *IOP Conference Series: Earth and Environmental Science*, *1185*(1). https://doi.org/10.1088/1755-1315/1185/1/012034

Abou-Shanab, R. A. I., Tammam, A. A., El-Aggan, W. H., & Mubarak, M. M. (2017). Phytoremediation potential of wild plants collected from heavy metals contaminated soils. *International Journal of Geology, Agriculture and Environmental Sciences*, 67(3), 229-239. https://doi: 10.1515/aiht-2016-67-2829

Adham, A., & Naqishbandi, A. (2015). HPLC analysis and antidiabetic effect of *Rheum ribes* root in type 2 diabetic patients. *Zanco Journal of Medical Sciences*, *19*(2). https://doi.org/10.15218/zjms.2015.0017

Adiloğlu, S. (2021). Relation of chelated iron (Eddha-fe) applications with iron accumulation and some plant nutrient elements in basil (*Ocimum basilicum L.*). *Polish Journal of Environmental Studies*, *30*(4). https://doi.org/10.15244/pjoes/128736

Ahmed, E. H., Mohammed, A. M., Sudan Correspondence Abdelhafeez Mohammed, N. M., Sudan, N., & Abadi, R. S. (2018). Phytochemical screening, chemical composition, and antioxidant activity of seeds essential oil of *Coriandrum sativum* L. from the Sudan. *International Journal of Herbal Medicine*, *6*(1), 01-04.

Ahmed, E., Arshad, M., Zakriyya Khan, M., Shoaib Amjad, M., Mehreen Sadaf, H., Riaz, I., Sabir, S., Ahmad, N., & Sabaoon. (2017). Secondary metabolites and their multidimensional perspective in plant life. *Journal of Pharmacognosy and Phytochemistry*, *6*(2), 205-214.

Ahmed, H. M. (2016). Ethnopharmacobotanical study on the medicinal plants used by herbalists in Sulaymaniyah Province, Kurdistan, Iraq. *Journal of Ethnobiology and Ethnomedicine*, *12*(1). https://doi.org/10.1186/s13002-016-0081-3

Aimad, A., Sanae, R., Anas, F., Abdelfattah, E. M., Bourhia, M., Mohammad Salamatullah, A., . & Noureddine, E. (2021). Chemical characterization and antioxidant, antimicrobial, and insecticidal properties of essential oil from Mentha pulegium L. *Evidence-Based Complementary and Alternative Medicine*, *2021*(1), 1108133. https://doi.org/10.1155/2021/1108133

Al Aboud, N. M. (2024). Unlocking the genetic potential: Strategies for enhancing secondary metabolite biosynthesis in plants. *Journal of the Saudi Society of*

Agricultural Sciences, *223*(8), 542-554. https://doi.org/10.1016/j.jssas.2024.06.004

Alamo-Nole, L., & Estrella-Martinez, B. (2022). Phytoremediation of CdS/Te quantum dots by *Ocimum basilicum* in the presence of EDTA. *Journal of Environmental Health Science and Engineering*, *20*(2). https://doi.org/10.1007/s40201-022-00822-1

Al-Asmari, A. K., Athar, M. T., Al-Faraidy, A. A., & Almuhaiza, M. S. (2017). Chemical composition of essential oil of *Thymus vulgaris* collected from Saudi Arabian market. *Asian Pacific Journal of Tropical Biomedicine*, *7*(2). https://doi.org/10.1016/j.apjtb.2016.11.023

Al-bazaz, H. K., Abdul, Z., Alnaqqash, E., & Hasan, H. A. (2020). *GC-Mass and Phytochemical Investigation of Iraqi Anethum graveolens L. Seeds*. *5*(4), 44–50.

Al-Ghanim, K. A., Krishnappa, K., Pandiyan, J., Nicoletti, M., Gurunathan, B., & Govindarajan, M. (2023). Insecticidal Potential of *Matricaria chamomilla's* Essential Oil and Its Components (E)-β-Farnesene, Germacrene D, and α-Bisabolol Oxide A against Agricultural Pests, Malaria, and Zika Virus Vectors. *Agriculture (Switzerland)*, *13*(4). https://doi.org/10.3390/agriculture13040779

Ali, A., Ali, N., Gu, Y., Ahmad, N., Ali, N., Ahmad, I., Khan, A., Anas, M., Rehman, H. U., Ali, A., & Khan, M. I. U. (2025). Application of fertilizers improves cadmium phytoextraction efficiency of *Nasturtium officinale* R.Br. grown in cadmium-contaminated water. *Environmental Monitoring and Assessment*, *197*(2), 192. https://doi.org/10.1007/S10661-025-13638-X/METRICS

Ali, E. M. (2013). Phytochemical composition, antifungal, antiaflatoxigenic, antioxidant, and anticancer activities of *Glycyrrhiza glabra* L. and *Matricaria chamomilla* L. essential oils. *Journal of Medicinal Plants Research*, *7*(29), 2197–2207. https://doi.org/10.5897/JMPR2013.5134

Ali, R. A., Muhammad, K. A., & Qadir, O. K. (2021). A survey of Nitrate and Nitrite Contents in Vegetables to Assess the Potential Health Risks in Kurdistan, Iraq. *IOP Conference Series: Earth and Environmental Science*, *910*(1). https://doi.org/10.1088/1755-1315/910/1/012065

Alikhani, N., Hekmati, M., Karmakar, B., & Veisi, H. (2022). Green synthesis of gold nanoparticles (Au NPs) using *Rosa canina* fruit extract and evaluation of its catalytic activity in the degradation of organic dye pollutants of water. *Inorganic Chemistry Communications*, *139*. https://doi.org/10.1016/j.inoche.2022.109351

Alkadir, O. K. A., Taifi, A., Aljeboree, A. M., Bayaa, A. L. Al, Abed, S. A., & Alkaim, A. F. (2022). Environmental Removal of some Dyes from Aqueous Solution by using highly adsorbent surface derived from *Malva parviflora* plant leaves: Multifactors Studies. *IOP Conference Series: Earth and Environmental Science*, *1029*(1). https://doi.org/10.1088/1755-1315/1029/1/012022

Al-Keridis, L. A., El Hadi Mohamed, R. A., Abutaha, N., Al-Mekhlafi, F. A., Al-Doaiss, A. A., Almashaan, T. A. N., & Wadaan, M. A. (2021). Larvicidal, and cytoxicity of *Lepidium sativum* L. Seed extract against culex pipiens l. (diptera: Culicidae). *Turkish Journal of Zoology*, *45*(1). https://doi.org/10.3906/ZOO-2106-31

Al-Khayri, J. M., Banadka, A., Nandhini, M., Nagella, P., Al-Mssallem, M. Q., & Alessa, F. M. (2023). Essential Oil from *Coriandrum sativum*: A review on Its Phytochemistry and Biological Activity. *Molecules*, *28*(2). https://doi.org/10.3390/molecules28020696

Almanea, A., Abd El-Aziz, G. S., & Ahmed, M. M. M. (2019). The potential gastrointestinal health benefits of *Thymus vulgaris* essential oil: A review. *Biomedical and Pharmacology Journal*, *12*(4). https://doi.org/10.13005/bpj/1810

Al-Mathidy, A., Al-Doskey, Z. A. S., & Shehab, M. O. M. (2023). Numerical Taxonomy of the Genus *Rosa L.* (Rosaceae) Grown in the Kurdistan Region of Iraq. *Sabrao Journal of Breeding and Genetics*, *55*(2). https://doi.org/10.54910/sabrao2023.55.2.16

Al-Rubaye, A. F., Kaizal, A. F., & Hameed, I. H. (2017). Phytochemical Screening of Methanolic Leaves Extract of Malva sylvestris. *International Journal of Pharmacognosy and Phytochemical Research*, *9*(4). https://doi.org/10.25258/phyto.v9i4.8127

Amin, H. D. M., Lazim, Z. S., & Nashi, T. A. W. (2023). Phytochemical Screening of *Rheum ribes* Root, Leaves and Flowering Stem and Biological Activity of the Root. *IOP Conference Series: Earth and Environmental Science*, *1158*(4). https://doi.org/10.1088/1755-1315/1158/4/042068

Amin, H. I. M., Hussain, F. H. S., Gilardoni, G., Thu, Z. M., Clericuzio, M., & Vidari, G. (2020). Phytochemistry of verbascum species growing in Iraqi kurdistan and bioactive iridoids from the flowers of *Verbascum calvum*. *Plants*, *9*(9). https://doi.org/10.3390/plants9091066

Amiri, S., Nafez, A. H., & Amiri, N. (2020). Effects of water pollution on some physiological parameters and phytoremediation performance of watercress (*Nasturtium officinale*). *Environmental Quality Management*, *29*(4). https://doi.org/10.1002/tqem.21685

Amoabeng, B. W., Johnson, A. C., & Gurr, G. M. (2019). Natural enemy enhancement and botanical insecticide source: a review of dual-use companion plants. In *Applied Entomology and Zoology*, *54*(1). https://doi.org/10.1007/s13355-018-00602-0

Anjitha, K. S., Sameena, P. P., & Puthur, J. T. (2021). Functional aspects of plant secondary metabolites in metal stress tolerance and their importance in pharmacology. *Plant Stress*, *2*, 100038. https://doi.org/10.1016/J.STRESS.2021.100038

Anupama, Deepika, Singh, A. K., & Khare, P. (2023). An insight into herbicidal properties of Ocimum leaf and oil-loaded biochar formulations. *Industrial Crops and Products*, *205*(1). https://doi.org/10.1016/j.indcrop.2023.117440

Apostol, L., Belc, N., Gaceu, L., Vladut, V., & Oprea, O. B. (2019). Chemical composition and rheological parameters of *Helianthus tuberosus* flour used as a source of bioactive compounds in bakery. *Revista de Chimie*, *70*(6). https://doi.org/10.37358/rc.19.6.7273

Attia, S., Mansour, R., Abdennour, N., Sahraoui, H., Blel, A., Rahmouni, R., Grissa Lebdi, K., & Mazzeo, G. (2022). Toxicity of *Mentha pulegium* essential oil and chemical pesticides toward citrus pest scale insects and the coccinellid predator Cryptolaemus montrouzieri. *International Journal of Tropical Insect Science*, *42*(5). https://doi.org/10.1007/s42690-022-00870-y

Avetisyan, A., Markosian, A., Petrosyan, M., Sahakyan, N., Babayan, A., Aloyan, S., & Trchounian, A. (2017). Chemical composition and some biological activities of the essential oils from basil Ocimum different cultivars. *BMC Complementary and Alternative Medicine*, *17*(1). https://doi.org/10.1186/s12906-017-1587-5

Awasthi, A., & Srivastava, Y. (2024). Effect of Plant and Vegetable-Based Secondary Metabolites on Cancer Treatment. In *Plant Metabolites and Vegetables as Nutraceuticals* (pp. 145-199). Apple Academic Press. https://doi.org/10.1201/9781032680125-9

Ayoub, N., Nawal, L., Soumaya, R., Nadia, I., & Amrani Souad, E. (2023). Evaluation of the phytotoxicity of a pesticide (TRACTOR 10E) based on Alpha-cypermethrin in two plant species: lentils (*Lens culinaris*) and watercress (*Lepidium sativum*). *Pollution*, *9*(4), 1386–1395. https://doi.org/10.22059/POLL.2023.356198.1812

Badar, Z., Shanableh, A., El-Keblawy, A., Mosa, K. A., Semerjian, L., Mutery, A. Al, Hussain, M. I., Bhattacharjee, S., Tsombou, F. M., Ayyaril, S. S., Ahmady, I. M., Elnaggar, A., Mousa, M., & Semreen, M. H. (2022). Assessment of Uptake, Accumulation and Degradation of Paracetamol in Spinach (*Spinacia oleracea* L.) under Controlled Laboratory Conditions. *Plants*, *11*(13). https://doi.org/10.3390/plants11131626

Bahraminejad, H., Manshad, A. K., & Keshavarz, A. (2021). Characterization, Micellization Behavior, and Performance of a Novel Surfactant Derived from *Gundelia tournefortii* Plant during Chemical Enhanced Oil Recovery. *Energy and Fuels*, *35*(2). https://doi.org/10.1021/acs.energyfuels.0c03272

Bakir, S. N. (2003). Plant Pests and Diseases. (1st Edition). Agriculture Printing Press.

Barros, F. A. P., Radünz, M., Scariot, M. A., Camargo, T. M., Nunes, C. F. P., de Souza, R. R., Gilson, I. K., Hackbart, H. C. S., Radünz, L. L., Oliveira, J. V., Tramontin, M. A., Radünz, A. L., & Magro, J. D. (2022). Efficacy of encapsulated and non-encapsulated thyme essential oil (*Thymus vulgaris* L.) in the control of *Sitophilus zeamais* and its effects on the quality of corn grains throughout storage. *Crop Protection*, *153*. https://doi.org/10.1016/j.cropro.2021.105885

Bashir, R., Maqbool, M., Zehravi, M., & Ara, I. (2021). Utilization of herbal cosmetics: A brief overview. *Adv. J. Chem. Sect. B*, *3*, 277-288. https://doi.org/10.22034/ajcb.2021.297472.1090

Bendicion, G. B. F., Dael, A. P. C., Genterola, S. K. S., Aban, A. J. O. Y. P., & Seredrica, M. A. V. C. (2020). Potential antifeedant bioactivity of *Anethum graveolens* (dill) essential oil against *Cochlochila* bullita (lace bugs) on *Ocimum kilimandscharicum* (sweet basil). *3*(1), 63–67.

Benli, H. (2022). Coloration of Cotton and Wool Fabric by Using Bio-Based Red Beetroot (*Beta Vulgaris* L.). *Journal of Natural Fibers*, *19*(10). https://doi.org/10.1080/15440478.2020.1848725

Benslama, O., Mansouri, N., & Arhab, R. (2021). Effect of Polyphenolic Compounds of *Rosa Canina* (L.) against the Acetylcholinesterase Activity of *Rhopalosiphum Padi* (L.) (Homoptera: Aphididae). *IOP Conference Series: Earth and Environmental Science*, *910*(1). https://doi.org/10.1088/1755-1315/910/1/012023

Beristain-Bauza, S. D. C., Hernández-Carranza, P., Cid-Pérez, T. S., Ávila-Sosa, R., Ruiz-López, I. I., & Ochoa-Velasco, C. E. (2019). Antimicrobial Activity of Ginger (*Zingiber Officinale*) and Its Application in Food Products. In *Food Reviews International*, *35*(5). https://doi.org/10.1080/87559129.2019.1573829

Bhardwaj, N., Sharma, P., Guo, L., Dagdag, O., & Kumar, V. (2022). Molecular dynamic simulation and Quantum chemical calculation of phytochemicals present in Beta vulgaris and electrochemical behaviour of Beta vulgaris peel extract as green corrosion inhibitor for stainless steel (SS-410) in acidic medium. *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, *632*, 127707. https://doi.org/10.1016/j.colsurfa.2021.127707

Bhargava, S., Dhabhai, K., Batra, A., Sharma, A., & Malhotra, B. (2012). *Zingiber Officinale* : Chemical and Phytochemical Screening and Evaluation of Its Antimicrobial Activities. *Journal of Chemical and Pharmaceutical Research*, *4*(1), 360-364.

Bhatt, E., & Gauba, P. (2021). View of A Sustainable approach for Phytoremediation of Amoxicillin using *Ocimum basilicum*. *Current Trends in Biotechnology and Pharmacy*, *15*(4), 426 - 435. https://doi:10.5530/ctbp.2021.4.45

Bincy, K., Remesh, A. V., Prabhakar, P. R., & Vivek Babu, C. S. (2023). Chemical composition and insecticidal activity of *Ocimum basilicum* (Lamiaceae) essential oil and its major constituent, estragole, against *Sitophilus oryzae* (Coleoptera: Curculionidae). *Journal of Plant Diseases and Protection*, *130*(3). https://doi.org/10.1007/s41348-022-00695-4

Boekoesoe, L., & Ahmad, Z. F. (2022). The Extraction of *Zingiber Officinale* Rosc as a Natural Insecticide for Aedes Aegypti Larvae. *Kemas*, *18*(2). https://doi.org/10.15294/kemas.v18i2.37638

Boligon, A. A., Janovik, V., Boligon, A. A., Pivetta, C. R., Pereira, R. P., Rocha, J. B. T. Da, & Athayde, M. L. (2013). HPLC analysis of polyphenolic compounds and antioxidant activity in *Nasturtium officinale*. *International Journal of Food Properties*, *16*(1). https://doi.org/10.1080/10942912.2010.528111

Bordean, M.-E., Muste, S., Marțiș, G. S., Mureșan, V., & Buican, B.-C. (2021). Health effects of wormwood (*Artemisia absinthium* L.): From antioxidant to nutraceutical. *Journal of Agroalimentary Processes and Technologies*, *27*(2), 211–218.

Borugă, O., Jianu, C., Mişcă, C., Goleţ, I., Gruia, A. T., & Horhat, F. G. (2014). *Thymus vulgaris* essential oil: chemical composition and antimicrobial activity. *Journal of Medicine and Life*, *7*(3), 56–60.

Boudjelal, A., Smeriglio, A., Ginestra, G., Denaro, M., & Trombetta, D. (2020). Phytochemical profile, safety assessment and wound healing activity of *Artemisia absinthium* L. *Plants*, *9*(12), 1–14. https://doi.org/10.3390/plants9121744

Boulares, M., Bezzezi, A., Zarroug, Y., Moussa, O. Ben, Mahmoudi, I., & Hassouna, M. (2023). Production and Stabilization of Functional Butter with *Artemisia absinthium* L. Essential Oil Incorporation. *Journal of Agricultural Science and Technology*, *25*(3), 623-634.

Bunea, A., Andjelkovic, M., Socaciu, C., Bobis, O., Neacsu, M., Verhé, R., & Camp, J. Van. (2008). Total and individual carotenoids and phenolic acids content in fresh, refrigerated and processed spinach (*Spinacia oleracea* L.). *Food Chemistry*, *108*(2). https://doi.org/10.1016/j.foodchem.2007.11.056

Caleja, C., Barros, L., Antonio, A. L., Carocho, M., Oliveira, M. B. P., & Ferreira, I. C. (2016). Fortification of yogurts with different antioxidant preservatives: A comparative study between natural and synthetic additives. *Food chemistry*, *210*, 262-268. https://doi.org/10.1016/j.foodchem.2016.04.114

Caleja, C., Ribeiro, A., Barros, L., Barreira, J. C. M., Antonio, A. L., Oliveira, M. B. P. P., Barreiro, M. F., & Ferreira, I. C. F. R. (2016). Cottage cheeses functionalized with fennel and chamomile extracts: Comparative performance between free and microencapsulated forms. *Food Chemistry*, *199*. https://doi.org/10.1016/j.foodchem.2015.12.085

Catană, L., Catană, M., Iorga, E., Lazăr, A.-G., Lazăr, M.-A., Teodorescu, R. I., Asănică, A. C., Belc, N., & Iancu, A. (2018). Valorification of Jerusalem Artichoke Tubers (*Helianthus tuberosus*) for Achieving of Functional Ingredients with High Nutritional Value. *"Agriculture for Life, Life for Agriculture" Conference Proceedings*, *1*(1). https://doi.org/10.2478/alife-2018-0041

Caverzan, J., Mussi, L., Sufi, B., Padovani, G., Nazato, L., Camargo, F. B., Magalhães, W. V., & Di Stasi, L. C. (2021). A new phytocosmetic preparation from *Thymus vulgaris* stimulates adipogenesis and controls skin aging process: In vitro studies and topical effects in a double-blind placebo-controlled clinical trial. *Journal of Cosmetic Dermatology*, *20*(7). https://doi.org/10.1111/jocd.13818

Cespedes, C. L., Alarcon, J. E., Aqueveque, P., Seigler, D. S., & Kubo, I. (2015). In the search for new secondary metabolites with biopesticidal properties. *Israel Journal of Plant Sciences*, *62*(4). https://doi.org/10.1080/07929978.2015.1006424

Chatoui, K., Talbaoui, A., Aneb, M., Bakri, Y., Harhar, H., & Tabyaoui, M. (2016). Phytochemical screening, antioxidant and antibacterial activity of *Lepidium sativum* seeds from Morocco. *Journal of Materials and Environmental Science*, *7*(2), 57-66. https://10.5604/01.3001.0054.6835

Chaturvedi, R., Favas, P. J., Pratas, J., Varun, M., & Paul, M. S. (2019). Metal(loid) induced toxicity and defense mechanimetabolites in *Spinacia oleracea* L.: Ecological hazard and Prospects for phytoremediation. *Ecotoxicology and Environmental Safety*, *183*. https://doi.org/10.1016/j.ecoenv.2019.109570

Chaubey, M. K. (2021). Insecticidal activities of *Anethum graveolens* L. and *Illicium verum* Hook. Essential oils against *Sitophilus zeamais* Motschulsky. *Revista de Ciencias Agrícolas*, *38*(1). https://doi.org/10.22267/rcia.213801.143

Chaudhari, N. P., Chaudhari, H. A., Chaudhari, N. U., Premchandani, L. A., Dhankani, A. R., & Pawar, S. P. (2019). Formulation and Evaluation of Herbal Lipstick from *Beta vulagaris* Taproot. *Indian Journal of Drugs*, *7*(1).

DOI:10.47583/ijpsrr.2022.v75i01.017

Chaudhary, S., Hisham, H., & Mohamed, D. (2018). A review on phytochemical and pharmacological potential of watercress plant. *Asian Journal of Pharmaceutical and Clinical Research*, *11*(12). https://doi.org/10.22159/ajpcr.2018.v11i12.29422

Chen, Y., Wang, Y., He, L., Wang, L., Zhao, J., Yang, Z., Li, Q., & Shi, R. (2024). Supercritical CO2 Extraction of Terpenoids from Indocalamus latifolius Leaves: Optimization, Purification, and Antioxidant Activity. *Foods*, *13*(11), 1719. https://doi.org/10.3390/FOODS13111719/S1

Cheraghi N. M., Farzaei, M. H., Karimpour-Razkenari, E. E., Amin, G., Khanavi, M., Akbarzadeh, T., & Shams-Ardekani, M. R. (2016). An evidence-based review on medicinal plants used as insecticide and insect repellent in traditional Iranian medicine. *Iranian Red Crescent Medical Journal*, *18*(2). https://doi.org/10.5812/ircmj.22361

Chihomvu, P., Ganesan, A., Gibbons, S., Woollard, K., & Hayes, M. A. (2024). Phytochemicals in Drug Discovery—A Confluence of Tradition and Innovation. *International Journal of Molecular Sciences 2024, Vol. 25, Page 8792*, *25*(16), 8792. https://doi.org/10.3390/IJMS25168792

Chiocchio, I., Mandrone, M., Tomasi, P., Marincich, L., & Poli, F. (2021). Plant Secondary Metabolites: An Opportunity for Circular Economy. *Molecules*, 26 (2), 495. https://doi.org/10.3390/MOLECULES26020495

Clemensen, A. K., Provenza, F. D., Hendrickson, J. R., & Grusak, M. A. (2020). Ecological Implications of Plant Secondary Metabolites - Phytochemical Diversity Can Enhance Agricultural Sustainability. *Frontiers in Sustainable Food Systems, 4*. https://doi.org/10.3389/fsufs.2020.547826

Coltun, M. (2021). The role of aromatic plants in phytocosmetics. *Journal of Botany*, *XII*(2(21), 171–172. https://doi.org/10.52240/1857-2367.2020.2(21).42

Corleto, K. A., Singh, J., Jayaprakasha, G. K., & Patil, B. S. (2018). Storage Stability of Dietary Nitrate and Phenolic Compounds in Beetroot (Beta vulgaris) and Arugula (Eruca sativa) Juices. *Journal of Food Science*, *83*(5). https://doi.org/10.1111/1750-3841.14129

Cornaghi, L., Arnaboldi, F., Calò, R., Landoni, F., Baruffaldi Preis, W. F., Marabini, L., & Donetti, E. (2016). Effects of UV rays and Thymol/*Thymus vulgaris* L. extract in an ex vivo human skin model: Morphological and genotoxicological assessment. *Cells Tissues Organs*, *201*(3). https://doi.org/10.1159/000444361

Crespo, Y. A., Bravo Sánchez, L. R., Quintana, Y. G., Cabrera, A. S. T., Bermúdez del Sol, A., & Mayancha, D. M. G. (2019). Evaluation of the synergistic effects of antioxidant activity on mixtures of the essential oil from *Apium graveolens* L., *Thymus vulgaris* L. and *Coriandrum sativum* L. using simplex-lattice design. *Heliyon*, *5*(6). https://doi.org/10.1016/j.heliyon.2019.e01942

Dabija, A., Codină, G. G., Ropciuc, S., Gâtlan, A. M., & Rusu, L. (2018). Assessment of the antioxidant activity and quality attributes of yogurt enhanced with wild herbs extracts. *Journal of Food Quality*, *2018*. https://doi.org/10.1155/2018/5329386

Dalmis, R. (2023). Description of a new cellulosic natural fiber extracted from *Helianthus tuberosus* L. as a composite reinforcement material. *Physiologia Plantarum*, *175*(4). https://doi.org/10.1111/ppl.13960

Darnton-Hill, I., & Nalubola, R. (2002). Fortification strategies to meet micronutrient needs: successes and failures. *Proceedings of the Nutrition Society*, *61*(2), 231–241. https://doi.org/10.1079/PNS2002150

Das, S., Singh, V. K., Dwivedy, A. K., Chaudhari, A. K., & Dubey, N. K. (2021). *Anethum graveolens* Essential Oil Encapsulation in Chitosan Nanomatrix: Investigations on In Vitro Release Behavior, Organoleptic Attributes, and Efficacy as Potential Delivery Vehicles Against Biodeterioration of Rice (Oryza sativa L.). *Food and Bioprocess Technology*, *14*(5). https://doi.org/10.1007/s11947-021-02589-z

Das, S., Singh, V. K., Dwivedy, A. K., Chaudhari, A. K., Upadhyay, N., Singh, P., Sharma, S., & Dubey, N. K. (2019). Encapsulation in chitosan-based nanomatrix as an efficient green technology to boost the antimicrobial, antioxidant and in situ efficacy of *Coriandrum sativum* essential oil. *International Journal of Biological Macromolecules*, *133*. https://doi.org/10.1016/j.ijbiomac.2019.04.070

DellaGreca, M., Cutillo, F., D'Abrosca, B., Fiorentino, A., Pacifico, S., & Zarrelli, A. (2009). Antioxidant and radical scavenging properties of *Malva sylvestris*. *Natural Product Communications*, *4*(7). https://doi.org/10.1177/1934578x0900400702

Dhaniaputri, R., Suwono, H., Amin, M., & Lukiati, B. (2022). Introduction to Plant Metabolism, Secondary Metabolites Biosynthetic Pathway, and In-Silico Molecular Docking for Determination of Plant Medicinal Compounds: An Overview. *Proceedings of the 7th International Conference on Biological Science (ICBS 2021)*, *22*. https://doi.org/10.2991/absr.k.220406.053

Dinu, C., Vasile, G. G., Buleandra, M., Popa, D. E., Gheorghe, S., & Ungureanu, E. M. (2020). Translocation and accumulation of heavy metals in *Ocimum basilicum* L. plants grown in a mining-contaminated soil. *Journal of Soils and Sediments*, *20*(4). https://doi.org/10.1007/s11368-019-02550-w

Doğan, A., & Servi, H. (2020). Chemical Composition of Essential Oil From Aerial Parts of *Lactuca serriola* L. *Aurum Journal of Health Sciences*, *2*(2), 83–90.

Dogara, A. M. (2023). Medicinally Wild Edible Vegetables and Fruits of Kurdistan Region of Iraq. *Applied Biological Research*, *25*(4). https://doi.org/10.5958/0974-4517.2023.00041.1

Domínguez, R., Munekata, P. E. S., Pateiro, M., Maggiolino, A., Bohrer, B., & Lorenzo, J. M. (2020). Red beetroot. A potential source of natural additives for the meat industry. In *Applied Sciences (Switzerland)* 10(23). https://doi.org/10.3390/app10238340

Donn, P., Barciela, P., Perez-Vazquez, A., Cassani, L., Simal-Gandara, J., & Prieto, M. A. (2023). Bioactive Compounds of *Verbascum sinuatum* L.: Health Benefits and Potential as New Ingredients for Industrial Applications. In *Biomolecule*, 13(3). https://doi.org/10.3390/biom13030427

Dorina, B. (2020). Allelopathic potential of dill on germination and growth parameters of maize seedlings. *Annals of the University of Craiova - Agriculture, Montanology, Cadastre Series*, *49*(2), 50–55.

Drouet, S., Abbasi, B. H., Falguières, A., Ahmad, W., Sumaira, Ferroud, C., Doussot, J., Vanier, J. R., Lainé, E., & Hano, C. (2018). Single laboratory validation of a quantitative core shell-based LC separation for the evaluation of silymarin variability and associated antioxidant activity of Pakistani ecotypes of milk thistle (*Silybum marianum* L.). *Molecules*, *23*(4). https://doi.org/10.3390/molecules23040904

Drouet, S., Leclerc, E. A., Garros, L., Tungmunnithum, D., Kabra, A., Abbasi, B. H., Lainé, É., & Hano, C. (2019). A green ultrasound-assisted extraction optimization of the natural antioxidant and anti-aging flavonolignans from milk thistle *Silybum marianum* (L.) gaertn. fruits for cosmetic applications. *Antioxidants*, *8*(8). https://doi.org/10.3390/antiox8080304

Egata, D. (2021). Benefit and use of Sweet Basil (*Ocimum Basilicum* l.) In Ethiopia: -A Review. *Nutrition and Food Processing*, *04*(5). https://doi.org/10.31579/2637-8914/057

El-Beltagi, H. S., El-Mogy, M. M., Parmar, A., Mansour, A. T., Shalaby, T. A., & Ali, M. R. (2022). Phytochemical Characterization and Utilization of Dried Red Beetroot (*Beta vulgaris*) Peel Extract in Maintaining the Quality of Nile Tilapia Fish Fillet. *Antioxidants*, *11*(5). https://doi.org/10.3390/antiox11050906

Elbouzidi, A., Bencheikh, N., Seddoqi, S., Bouhrim, M., Bouramdane, Y., & Addi, M. (2021). Investigation of the Allelopathic Effect of *Matricaria chamomilla* L. Parts' Aqueous Extracts on Germination and Seedling Growth of Two Moroccan Varieties of Durum Wheat. *International Journal of Agronomy*, *2021*. https://doi.org/10.1155/2021/4451181

EL-Hefny, M., Abo Elgat, W. A. A., Al-Huqail, A. A., & Ali, H. M. (2019). Essential and recovery oils from *Matricaria chamomilla* flowers as environmentally friendly fungicides against four fungi isolated from cultural heritage objects. *Processes*, *7*(11). https://doi.org/10.3390/pr7110809

El-Rokiek, K. G., Ahmed, S. A. A., Messiha, N. K., Mohamed, S. A., & El-Masry, R. R. (2020). Allelopathic properties of the seed powder of either *Petroselinum crispum* or *Coriandrum sativum* on the growth and yield of Glycine max and associated weeds. *Middle East*

Journal of Applied Sciences, *10*(3). https://doi.org/10.36632/mejas/2020.10.3.46

El-Rokiek, K., Ibrahim, M., … S. E.-D.-J. of M., & 2021, undefined. (2021). Bioactivity of Essential Oil Isolated from *Coriandrum sativum* Plant Against the Weed Avena fatua Associated Wheat Plants. *Journal of Materials and Environmental Sciences,* 12(6), 899–911.

El-Sayed, S. M., & El-Sayed, H. S. (2021). Antimicrobial nanoemulsion formulation based on thyme (*Thymus vulgaris*) essential oil for UF labneh preservation. *Journal of Materials Research and Technology*, *10*. https://doi.org/10.1016/j.jmrt.2020.12.073

Elsharkawy, E., Alshathly, M., & Helal, M. (2014). Anti-inflammatory and Chemical Composition of Two Plants Family Asteraceae Growing in Saudi Arabia. *Journal of Chemistry and Chemical Engineering*, *8*(2014), 157-162.

Ercan, L., & Dogru, M. (2022). Determination of Antimicrobial Activity of *Nasturtium officinale* and Its Content of Volatile Organic Compounds and Fatty Acids. *Kahramanmaraş Sütçü İmam Üniversitesi Tarım ve Doğa Dergisi*, *25*(1). https://doi.org/10.18016/ksutarimdoga.vi.1001837

Ertas, A., Cakirca, H., Yener, I., Akdeniz, M., Firat, M., Topcu, G., & Kolak, U. (2021). Bioguided isolation of secondary metabolites from *Salvia cerino-pruinosa* Rech. f. var. cerino-pruinosa. Records of Natural Products, 15(6), 585–592. https://doi.org/10.25135/RNP.248.21.01.1933

Fan, M., Dai, D., Huang, B., Fan, M., Dai, D., & Huang, B. (2012). Fourier Transform Infrared Spectroscopy for Natural Fibres. In *Fourier Transform - Materials Analysis*. IntechOpen. https://doi.org/10.5772/35482

Fathiazad, F., Matlobi, A., Khorrami, A., Hamedeyazdan, S., Soraya, H., Hammami, M., Maleki-Dizaji, N., & Garjani, A. (2012). Phytochemical screening and evaluation of cardioprotective activity of ethanolic extract of *Ocimum basilicum* L. (basil) against isoproterenol induced myocardial infarction in rats. *DARU, Journal of Pharmaceutical Sciences*, *20*(1). https://doi.org/10.1186/2008-2231-20-87

Fazili, M. A., Bashir, I., Ahmad, M., Yaqoob, U., & Geelani, S. N. (2022). In vitro strategies for the enhancement of secondary metabolite production in plants: a review. *Bulletin of the National Research Centre*, *46*(1), 1–12. https://doi.org/10.1186/S42269-022-00717-Z

FDA. (2025). *GRAS Substances (SCOGS) Database | Food and Drug Aadminstration*. https://www.fda.gov/food/generally-recognized-safe-gras/gras-substances-scogs-database

Fehér, P., Ujhelyi, Z., Váradi, J., Fenyvesi, F., Róka, E., Juhász, B., Varga, B., Bombicz, M., Priksz, D., Bácskay, I., & Vecsernyés, M. (2016). Efficacy of pre- and post-treatment by topical formulations containing dissolved and suspended *Silybum marianum* against UVB-induced oxidative stress in guinea pig and on HaCaT keratinocytes. *Molecules*, *21*(10). https://doi.org/10.3390/molecules21101269

Fernandes, L., Pereira, J. A., Saraiva, J. A., Ramalhosa, E., & Casal, S. (2019). Phytochemical characterization of *Borago officinalis* L. and *Centaurea cyanus* L. during flower development. *Food Research International*, *123*. https://doi.org/10.1016/j.foodres.2019.05.014

Ferrat, L., Pergent-Martini, C., & Roméo, M. (2003). Assessment of the use of biomarkers in aquatic plants for the evaluation of environmental quality: Application to seagrasses. *Aquatic Toxicology*, *65*(2). https://doi.org/10.1016/S0166-445X(03)00133-4

Galovičová, L., Borotová, P., Valková, V., Vukovic, N. L., Vukic, M., Štefániková, J., Ďúranová, H., Kowalczewski, P. Ł., Čmiková, N., & Kačániová, M. (2021). *Thymus vulgaris* essential oil and its biological activity. *Plants*, *10*(9). https://doi.org/10.3390/plants10091959

Garrett, S. D., Trott, T. D., & Trott, T. D. (2019). The Phytoremediative Effects of Cilantro (*Coriandrum sativum*) in Lead Contaminated Soil. *Research in Biology*, 14. https://knowledge.e.southern.edu/research_bio/14

Gaur, N., Kukreja, A., Yadav, M., & Tiwari, A. (2017). Assessment of phytoremediation ability of Coriander sativum for soil and water co-contaminated with lead and arsenic: a small-scale study. *3 Biotech*, *7*(3). https://doi.org/10.1007/s13205-017-0794-6

Ghabeish, I. H. (2015). Insecticidal Activity and Synergistic Effect of *Gundelia Tournefortii* L. (Asteraceae : Compositae) Extracts and Some Pure Constituents on *Drosophila Melanogaster* Meigen (Drosophilidae : Diptera). *Jordan Journal of Agricultural Sciences*, *11*(2). https://doi.org/10.12816/0030431

Ghazaryan, K. A., Movsesyan, H. S., Minkina, T. M., Nevidomskaya, D. G., & Rajput, V. D. (2022). Phytoremediation of copper-contaminated soil by *Artemisia absinthium*: comparative effect of chelating agents. *Environmental Geochemistry and Health*, *44*(4). https://doi.org/10.1007/s10653-021-01151-2

Gilani, A. H., Bashir, S., & Khan, A. Ullah. (2007). Pharmacological basis for the use of *Borago officinalis* in gastrointestinal, respiratory and cardiovascular disorders. *Journal of Ethnopharmacology*, *114*(3). https://doi.org/10.1016/j.jep.2007.08.032

Golshan Shandi, S., Doulati Ardejani, F., & Sharifi, F. (2019). Assessment of Cu (II) removal from an aqueous solution by raw *Gundelia tournefortii* as a new low-cost biosorbent: Experiments and modelling. *Chinese Journal of Chemical Engineering*, *27*(8). https://doi.org/10.1016/j.cjche.2018.12.027

Grigore, A., Paraschiv, I., Colceru-Mihul, S., Bubueanu, C., Draghici, E., & Ichim, M. (2010). Chemical composition and antioxidant activity of *Thymus vulgaris* L. volatile oil obtained by two different methods. *Romanian Biotechnological Letters*, *15*(4).

Guemari, F., Laouini, S. E., Rebiai, A., & Bouafia, A. (2020). Phytochemical screening and Identification of Polyphenols, Evaluation of Antioxidant activity and study of Biological properties of extract *Silybum marianum* (L.). *Asian Journal of Research in Chemistry*, *13*(3). https://doi.org/10.5958/0974-4150.2020.00037.1

Gupta, A. K., & Verma, R. K. (2022). Understanding the Effect of Irrigation with Chromium Loaded Tannery Effluent on *Ocimum basilicum* L. vis-a-vis Metal

Uptake. *Bulletin of Environmental Contamination and Toxicology*, *109*(5). https://doi.org/10.1007/s00128-022-03599-z

Habibvand, M., Yousefi, M., Ahmed, S. A., & Hassanzadeh, H. (2023). Formulation of nanoemulsion carriers containing Pennyroyal (*Mentha pulegium*) and Gijavash (*Froriepia subpinnata*) essential oils for enriching Doogh (Iranian dairy drink). *IET Nanobiotechnology*, *17*(2). https://doi.org/10.1049/nbt2.12106

Hadi, N., Drioiche, A., Bouchra, E. M., Baammi, S., Abdelaziz Shahat, A., Tagnaout, I., Radi, M., Remok, F., Bouzoubaa, A., & Zair, T. (2024). Phytochemical Analysis and Evaluation of Antioxidant and Antimicrobial Properties of Essential Oils and Seed Extracts of *Anethum graveolens* from Southern Morocco: In Vitro and In Silico Approach for a Natural Alternative to Synthetic Preservatives. *Pharmaceuticals*, *17*(7), 862. https://doi.org/10.3390/PH17070862/S1

Halabi, S., Battah, A. A., Aburjai, T., & Hudaib, M. (2005). Phytochemical and antiplatelet investigation of *Gundelia tournifortii*. *Pharmaceutical Biology*, *43*(6). https://doi.org/10.1080/13880200500220268

Hameed, R. S. A., Aleid, G. M. S., Mohammad, D., Badr, M. M., Huwaimel, B., Suliman, M. S., Alshammary, F., & Abdallah, M. (2022). *Spinacia oleracea* Extract as Green Corrosion Inhibitor for Carbon Steel in Hydrochloric Acid Solution. *International Journal of Electrochemical Science*, *17*. https://doi.org/10.20964/2022.10.31

Hassan, H., & Shekha, Y. (2023). Detection of Parasitic Contamination of Cress Crop Irrigated with Two Types of Water in Jumka Village, Erbil – Iraq. *Rafidain Journal of Science*, *32*(2). https://doi.org/10.33899/rjs.2023.178570

Hassan, N. E., & Umer, M. I. (2023). Potential of Local Plants as Phytoremediators of Polluted Soil in Kwashe Industrial Area of Duhok Province, Kurdistan Region. *Journal of Jilin University*, 42(1). https://doi.org/10.17605/OSF.IO/4ZGHV

Heinrich, M., Jalil, B., Abdel-Tawab, M., Echeverria, J., Kulić, Ž., McGaw, L. J., Pezzuto, J. M., Potterat, O., & Wang, J. B. (2022). Best Practice in the chemical characterisation of extracts used in pharmacological and toxicological research—The ConPhyMP—Guidelines. *Frontiers in Pharmacology*, *13*, 953205. https://doi.org/10.3389/FPHAR.2022.953205/BIBTEX

Heivachi, M., Alamdari, E. G., Zeinab Avarseji, & Habibi, M. (2023). Effect of the *Lactuca serriola* L. extract on the cytogenetic behaviors of Crocus sativus L. roots and its allelopathic potential. *South African Journal of Botany*, *160*, 525–534. https://doi.org/10.1016/j.sajb.2023.07.026

Hesami, M., Baiton, A., Alizadeh, M., Pepe, M., Torkamaneh, D., & Jones, A. M. P. (2021). Advances and Perspectives in Tissue Culture and Genetic Engineering of Cannabis. *International Journal of Molecular Sciences*, *22*(11), 5671. https://doi.org/10.3390/IJMS22115671

Hosni, K., Kerkenni, A., Medfei, W., Ben Brahim, N., & Sebei, H. (2010). Volatile Oil Constituents of *Rosa canina* L.: Quality as Affected by the Distillation Method. *Organic Chemistry International*, *2010*. https://doi.org/10.1155/2010/621967

Hube, S., Alfaro, M. A., Scheer, C., Brunk, C., Ramírez, L., Rowlings, D., & Grace, P. (2017). Effect of nitrification and urease inhibitors on nitrous oxide and methane emissions from an oat crop in a volcanic ash soil. *Agriculture, Ecosystems and Environment*, *238*. https://doi.org/10.1016/j.agee.2016.06.040

Imamović, B., Komlen, V., Gavrić, T., Sunulahpašić, A., Lalević, B., & Hamidović, S. (2021). Antimicrobial activity of ginger (*Zingiber officinale*) and rosemary (*Rosmarinus officinalis*) essential oils. *Agriculture and Forestry*, *67*(1). https://doi.org/10.17707/AgricultForest.67.1.19

Insan, H. N., & Vera, Y. (2021). Evaluation and Formulation of Lip Balm Preparation From Aloe Vera (*Aloe Vera*) and Bit (Beta *Vulgaris*) Fruit Extract as Natural Dye. *Journal of Public Health and Pharmacy*, *1*(2). https://doi.org/10.56338/jphp.v1i2.3717

Jafir, M., Ahmad, J. N., Arif, M. J., Ali, S., & Ahmad, S. J. N. (2021). Characterization of *Ocimum basilicum* synthesized silver nanoparticles and its relative toxicity to some insecticides against tobacco cutworm, Spodoptera litura Feb. (Lepidoptera; Noctuidae). *Ecotoxicology and Environmental Safety*, *218*. https://doi.org/10.1016/j.ecoenv.2021.112278

Jain, C., Khatana, S. & Vijayvergia, R. (2019). Bioactivity of secondary metabolites of various plants: A review. International Journal of Pharmaceutical Sciences and Research, 10(2). https://doi.org/10.13040/IJPSR.0975-8232.10(2).494-04

Jana, S., & Shekhawat, G. S. (2010). Phytochemical analysis and antibacterial screening of in vivo and in vitro extracts of indian medicinal herb: *Anethum graveolens*. *Research Journal of Medicinal Plant*, *4*(4). https://doi.org/10.3923/rjmp.2010.206.212

Jarosz, K., Olech, Z., & Padoł, S. (2023). Watercress (*Nasturtium officinale*) as a Novel Plant-based Alternative to Synthetic Soil Urease Inhibitor Sources. *Journal of Soil Science and Plant Nutrition*, 23,4212–4217. https://doi.org/10.1007/s42729-023-01337-w

Javanmard, M., Asadi-Gharneh, H. A., & Nikneshan, P. (2018). Characterization of biochemical traits of dog rose (*Rosa canina* L.) ecotypes in the central part of Iran. *Natural Product Research*, *32*(14). https://doi.org/10.1080/14786419.2017.1396591

Javeed, A., Ahmed, M., Sajid, A. R., Sikandar, A., Aslam, M., Ul Hassan, T., Samiullah, Nazir, Z., Ji, M., & Li, C. (2022). Comparative Assessment of Phytoconstituents, Antioxidant Activity and Chemical Analysis of Different Parts of Milk Thistle *Silybum marianum* L. *Molecules*, *27*(9). https://doi.org/10.3390/molecules27092641

Jayakumar, M., Ramachandran, M., Krishnaveni, T., & Nattudurai, G. (2021). Toxicity and biochemical effects of essential oils of *Anethum graveolens* L. and *Melaleuca cajuputi* Powell against Rhyzopertha dominica (F.) (Coleoptera: Bostrichidae). *International Journal of Tropical Insect Science*, *41*(2). https://doi.org/10.1007/s42690-020-00359-6

Johnson, W., Bergfeld, W. F., Belsito, D. V., Hill, R. A., Klaassen, C. D., Liebler, D. C., Marks, J. G., Shank, R. C., Slaga, T. J., Snyder, P. W., Gill, L. J., & Heldreth, B. (2022). Safety Assessment of *Rosa canina*-derived Ingredients as Used in Cosmetics. *International Journal of Toxicology*, *41*(1_suppl). https://doi.org/10.1177/10915818221080088

Kačániová, M., Galovičová, L., Ivanišová, E., Vukovic, N. L., Štefániková, J., Valková, V., Borotová, P., Žiarovská, J., Terentjeva, M., Felšöciová, S., & Tvrdá, E. (2020). Antioxidant, Antimicrobial and Antibiofilm Activity of Coriander (*Coriandrum sativum* L.) Essential Oil for Its Application in Foods. *Foods*, *9*(3). https://doi.org/10.3390/foods9030282

Kadhim, M. S., & Younis, M. I. (2023). Efficiency of *Zingiber officinale* and *Myrtus communis* extracts against Red flour beetle, *Tribolium castaneum*. *Caspian Journal of Environmental Sciences*, *21*(1). https://doi.org/10.22124/cjes.2023.6202

Kalhoro, M. T., Zhang, H., Kalhoro, G. M., Wang, F., Chen, T., Faqir, Y., & Nabi, F. (2022). Fungicidal properties of ginger (*Zingiber officinale*) essential oils against *Phytophthora colocasiae*. *Scientific Reports*, *12*(1). https://doi.org/10.1038/s41598-022-06321-5

Kallscheuer, N., Classen, T., Drepper, T., & Marienhagen, J. (2019). Production of plant metabolites with applications in the food industry using engineered microorganimetabolites. In *Current Opinion in Biotechnology* 56. https://doi.org/10.1016/j.copbio.2018.07.008

Kamel, E. M., Eid, S. D. M., & Elian, H. M. A. (2022). Allelochemicals Effect of Aqueous Sweet Basil (*Ocimum basilicum* L.) on Weed Control in Peanut and Cowpea Crops. *Egyptian Journal of Chemistry*, *65*(5). https://doi.org/10.21608/EJCHEM.2021.93101.4455

Kandar, C. C. (2021). Secondary Metabolites from Plant Sources. In *Advanced Structured Materials* (Vol. 140). https://doi.org/10.1007/978-3-030-54027-2_10

Karaghool, H. A. K., Hashim, K., Kot, P., & Muradov, M. (2022). Preliminary Studies of Methylene Blue Remotion from Aqueous Solutions by *Ocimum basilicum*. *Environments - MDPI*, *9*(2). https://doi.org/10.3390/environments9020017

Karimi, E., Oskoueian, E., Karimi, A., Noura, R., & Ebrahimi, M. (2018). *Borago officinalis* L. flower: a comprehensive study on bioactive compounds and its health-promoting properties. *Journal of Food Measurement and Characterization*, *12*(2). https://doi.org/10.1007/s11694-017-9697-9

Kassahun, B. M. (2020). Unleashing the exploitation of coriander (*Coriander sativum* L.) for biological, industrial and pharmaceutical applications. *Academic Research Journal of Agricultural Science and Research*, *8*(6), 552-564.

Kaszás, L., Alshaal, T., El-Ramady, H., Kovács, Z., Koroknai, J., Elhawat, N., Nagy, É., Cziáky, Z., Fári, M., & Domokos-Szabolcsy, É. (2020). Identification of bioactive phytochemicals in leaf protein concentrate of *Jerusalem artichoke* (Helianthus tuberosus l.). *Plants*, *9*(7). https://doi.org/10.3390/plants9070889

Kaur, N., Chahal, K. K., Singh, R., & Urvashi. (2018). Phytochemical screening and antioxidant activity of *Anethum graveolens* L. seed extracts. *The Pharma Innovation Journal*, *7*(6).

Kavousi, H. R., Karimi, M. R., & Neghab, M. G. (2021). Assessment the copper-induced changes in antioxidant defense mechanimetabolites and copper phytoremediation potential of common mullein (*Verbascum thapsus* L.). *Environmental Science and Pollution Research*, *28*(14). https://doi.org/10.1007/s11356-020-11903-9

Kaya, F., Solmaz, R., & Geçibesler, İ. H. (2023a). Adsorption and corrosion inhibition capability of *Rheum ribes* root extract (Işgın) for mild steel protection in acidic medium: A comprehensive electrochemical, surface characterization, synergistic inhibition effect, and stability study. *Journal of Molecular Liquids*, *372*. https://doi.org/10.1016/j.molliq.2023.121219

Kaya, F., Solmaz, R., & Geçibesler, İ. H. (2023b). Investigation of adsorption, corrosion inhibition, synergistic inhibition effect and stability studies of *Rheum ribes* leaf extract on mild steel in 1 M HCl solution. *Journal of the Taiwan Institute of Chemical Engineers*, *143*. https://doi.org/10.1016/j.jtice.2023.104712

Keosaeng, K., Songoen, W., Yooboon, T., Bullangpoti, V., & Pluempanupat, W. (2023). Insecticidal activity of isolated gingerols and shogaols from *Zingiber officinale* Roscoe rhizomes against Spodoptera spp. (Lepidoptera: Noctuidae). *Natural Product Research*, *37*(4). https://doi.org/10.1080/14786419.2022.2078818

Khan, M. A., Ullah, N., Khan, T., Jamal, M., Shah, N. A., & Ali, H. (2019). *Phytoremediation of Electronic Waste: A Mechanistic Overview and Role of Plant Secondary Metabolites*. https://doi.org/10.1007/978-3-030-26615-8_16

Khan, Q., Zahoor, M., Salman, S. M., Wahab, M., & Ul Bari, W. (2024). Phytoremediation of toxic heavy metals in polluted soils and water of Dargai District Malakand Khyber Pakhtunkhwa, Pakistan. *Brazilian Journal of Biology*, *84*. https://doi.org/10.1590/1519-6984.265278

Khan, S., Rana, T., Kalsoom, S., Shinwari, M. I., Mohibullah, M., Anwar, T., & Qureshi, H. (2021). In vitro screening of *Coronopus didymus* and *Nasturtium officinale* for weed and pest control in Agro-ecosystems. *Annali Di Botanica*, *11*. https://doi.org/10.13133/2239-3129/16591

Khursheed, A., Rather, M. A., Jain, V., Wani, A. R., Rasool, S., Nazir, R., Malik, N. A., & Majid, S. A. (2022). Plant-based natural products as potential eco-friendly and safer biopesticides: A comprehensive overview of their advantages over conventional pesticides, limitations and regulatory aspects. In *Microbial Pathogenesis*,173. https://doi.org/10.1016/j.micpath.2022.105854

Kisiriko, M., Anastasiadi, M., Terry, L. A., Yasri, A., Beale, M. H., & Ward, J. L. (2021). Phenolics from medicinal and aromatic plants: Characterisation and potential as biostimulants and bioprotectants. In *Molecules* 26(21). https://doi.org/10.3390/molecules26216343

Kızılet, H., Yilmaz, B., & Uysal, H. (2019). Herbal medicine against genotoxicity of dimethoate, an insecticide, in mammalian somatic cells. *Heliyon*, *5*(3). https://doi.org/10.1016/j.heliyon.2019.e01337

Klimek-Szczykutowicz, M., Szopa, A., & Ekiert, H. (2018). Chemical composition, traditional and professional use in medicine, application in environmental protection, position in food and cosmetics industries, and biotechnological studies of *Nasturtium officinale* (watercress) – a review. In *Fitoterapia*,129. https://doi.org/10.1016/j.fitote.2018.05.031

Kostina-Bednarz, M., Płonka, J., & Barchanska, H. (2023). Allelopathy as a source of bioherbicides: challenges and prospects for sustainable agriculture. *Reviews in Environmental Science and Biotechnology*, 22(2). https://doi.org/10.1007/s11157-023-09656-1

Krystyjan, M., Gumul, D., & Adamczyk, G. (2022). The Effect of Milk Thistle (*Silybum marianum* L.) Fortification, Rich in Dietary Fibre and Antioxidants, on Structure and Physicochemical Properties of Biscuits. *Applied Sciences*, *12*(23). https://doi.org/10.3390/app122312501

Kubczak, M., Khassenova, A. B., Skalski, B., Michlewska, S., Wielanek, M., Aralbayeva, A. N., Murzakhmetova, M. K., Zamaraeva, M., Skłodowska, M., Bryszewska, M., & Ionov, M. (2020). Bioactive compounds and antiradical activity of the *Rosa canina* l. Leaf and twig extracts. *Agronomy*, *10*(12). https://doi.org/10.3390/agronomy10121897

Kumar, S. J., Akshay, V.R., Vasundhara, M., & Muthu, A. (2020). Biosynthesis of multiphase iron nanoparticles using Syzygium aromaticum and their magnetic properties. *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, 603. https://doi.org/10.1016/j.colsurfa.2020.125241

Kumar, S., & Brooks, M. S. L. (2018). Use of Red Beet (*Beta vulgaris* L.) for Antimicrobial Applications—a Critical Review. In *Food and Bioprocess Technology*, 11(1). https://doi.org/10.1007/s11947-017-1942-z

L'hadj, I., Azzi, R., Lahfa, F., Koceir, E. A., & Omari, N. (2019). The nutraceutical potential of *Lepidium sativum* L. seed flavonoid-rich extract in managing metabolic syndrome components. *Journal of Food Biochemistry*, *43*(3). https://doi.org/10.1111/jfbc.12725

Laelago Ersedo, T., Teka, T. A., Fikreyesus Forsido, S., Dessalegn, E., Adebo, J. A., Tamiru, M., & Astatkie, T. (2023). Food flavor enhancement, preservation, and bio-functionality of ginger (*Zingiber officinale*): a review. In *International Journal of Food Properties*, 26(1). https://doi.org/10.1080/10942912.2023.2194576

Lahiri, B., & Rani, R. (2020). Garden Cress Seeds: chemistry, medicinal properties, application in dairy and food industry: A Review. *Emergent Life Sciences Research*, 06(02). https://doi.org/10.31783/elsr.2020.620104

Lasram, S., Zemni, H., Hamdi, Z., Chenenaoui, S., Houissa, H., Saidani Tounsi, M., & Ghorbel, A. (2019). Antifungal and antiaflatoxinogenic activities of *Carum carvi* L., *Coriandrum sativum* L. seed essential oils and their major terpene component against *Aspergillus flavus*. *Industrial Crops and Products*, *134*. https://doi.org/10.1016/j.indcrop.2019.03.037

Lazarević, J., Jevremović, S., Kostić, I., Kostić, M., Vuleta, A., Jovanović, S. M., & Jovanović, D. Š. (2020). Toxic, oviposition deterrent and oxidative stress effects of *Thymus vulgaris* essential oil against acanthoscelides obtectus. *Insects*, *11*(9). https://doi.org/10.3390/insects11090563

Livingstone, A. R., & Matheen, F. (2023). Formulation, characterization, and evaluation of the insecticidal activity of *Thymus vulgaris* oil nanoemulsion against the agricultural pest Aulacophora foveicollis (Red pumpkin beetle) (Chrysomelidae: Coleoptera), *International Journal of Entomology Research*, 6(3) 5–10.

Lukic, I., Milovanovic, S., Pantic, M., Srbljak, I., Djuric, A., Tadic, V., & Tyśkiewicz, K. (2022). Separation of high-value extracts from Silybum marianum seeds: Influence of extraction technique and storage on composition and bioactivity. *LWT*, *160*. https://doi.org/10.1016/j.lwt.2022.113319

Lv, S., Yang, B., Kou, Y., Zeng, J., Wang, R., Xiao, Y., Li, F., Lu, Y., Mu, Y., & Zhao, C. (2018). Assessing the difference of tolerance and phytoremediation potential in mercury-contaminated soil of a non-food energy crop, *Helianthus tuberosus* L. (Jerusalem artichoke). *PeerJ*, *2018*(2). https://doi.org/10.7717/peerj.4325

M. Domingues, P., & Santos, L. (2019). Essential oil of pennyroyal (Mentha pulegium): Composition and applications as alternatives to pesticides—New tendencies. In *Industrial Crops and Products*, 139. https://doi.org/10.1016/j.indcrop.2019.111534

M. H., Sun, W., Cheng, Q., Shahrajabian, M. H., Sun, W., & Cheng, Q. (2019). Pharmacological Uses and Health Benefits of Ginger (*Zingiber officinale*) in Traditional Asian and Ancient Chinese Medicine, and Modern Practice. *Notulae Scientia Biologicae*, *11*(3). https://doi.org/10.15835/NSB11310419

Madadi, E., Fallah, S., Sadeghpour, A., & Barani-Beiranvand, H. (2022). Exploring the use of chamomile (*Matricaria chamomilla* L.) bioactive compounds to control flixweed (Descurainia sophia L.) in bread wheat (*Triticum aestivum* L.): Implication for reducing chemical herbicide pollution. *Saudi Journal of Biological Sciences*, *29*(11). https://doi.org/10.1016/j.sjbs.2022.103421

Mahmoudieh, M., Naghavi, M. R., Sobri, Z. M., Azzeme, A. M., Abd-Aziz, N., Nik Abd Rahman, N. M. A., Alitheen, N. B., Hussin, Y., Bahmanrokh, G., & Baharum, N. A. (2024). Biotechnological approaches in the production of plant secondary metabolites for treating human viral diseases: Prospects and challenges. *Biocatalysis and Agricultural Biotechnology*, *59*, 103249. https://doi.org/10.1016/J.BCAB.2024.103249

Malapermal, V., Mbatha, J. N., Gengan, R. M., & Anand, K. (2015). Biosynthesis of bimetallic Au-Ag nanoparticles using *Ocimum basilicum* (L.) with antidiabetic and antimicrobial properties. *Advanced Materials Letters*, *6*(12). https://doi.org/10.5185/amlett.2015.5997

Mañas, P., & De las Heras, J. (2018). Phytotoxicity test applied to sewage sludge using Lactuca sativa L. and *Lepidium sativum* L. seeds. *International Journal of Environmental Science and Technology*, *15*(2). https://doi.org/10.1007/s13762-017-1386-z

Mancini, E., Senatore, F., Del Monte, D., De Martino, L., Grulova, D., Scognamiglio, M., Snoussi, M., & De Feo, V. (2015). Studies on chemical composition, antimicrobial and antioxidant activities of five *Thymus vulgaris* L. essential oils. *Molecules*, *20*(7). https://doi.org/10.3390/molecules200712016

Mara Teles, A., Araújo dos Santos, B., Gomes Ferreira, C., Nascimento Mouchreck, A., da Silva Calabrese, K., Lucia Abreu-Silva, A., & Almeida-Souza, F. (2020). Ginger (*Zingiber officinale*) Antimicrobial Potential: A Review. *Ginger Cultivation and Its Antimicrobial and Pharmacological Potentials*. https://doi.org/10.5772/intechopen.89780

Marciulioniene, D., Montvydiene, D., Karlaviciene, V., & Hogland, W. (2019). *Lepidium sativum* L. as test-organism for assessment of environmental pollution. *The Second Baltic Symposium on Environmental Chemistry*. https://doi.org/10.15626/eco-tech.2005.055

Mariadoss, A. V. A., Park, S., Saravanakumar, K., Sathiyaseelan, A., & Wang, M. H. (2021). Ethyl acetate fraction of *Helianthus tuberosus* l. Induces anti-diabetic and wound-healing activities in insulin-resistant human liver cancer and mouse fibroblast cells. *Antioxidants*, *10*(1), 1–22. https://doi.org/10.3390/antiox10010099

Matthäus, B., & Özcan, M. M. (2011). Chemical evaluation of flower bud and oils of tumbleweed (*Gundelia tourneforti* l.) as a new potential nutrition sources. *Journal of Food Biochemistry*, *35*(4). https://doi.org/10.1111/j.1745-4514.2010.00449.x

Mehdizadeh, T., Mojaddar Langroodi, A., Shakouri, R., & Khorshidi, S. (2019). Physicochemical, microbiological, and sensory characteristics of probiotic yogurt enhanced with *Anethum graveolens* essential oil. *Journal of Food Safety*, *39*(5). https://doi.org/10.1111/jfs.12683

Michalak, M. (2022). Plant-Derived Antioxidants: Significance in Skin Health and the Ageing Process. *International Journal of Molecular Sciences*, *23*(2). https://doi.org/10.3390/IJMS23020585

Mihyaoui, A. El, Esteves Da Silva, J. C. G., Charfi, S., Castillo, M. E. C., Lamarti, A., & Arnao, M. B. (2022). Chamomile (*Matricaria chamomilla* L.): A Review of Ethnomedicinal Use, Phytochemistry and Pharmacological Uses. *Life*, *12*(4). https://doi.org/10.3390/life12040479

Mipeshwaree Devi, A., Khedashwori Devi, K., Premi Devi, P., Lakshmipriyari Devi, M., & Das, S. (2023). Metabolic engineering of plant secondary metabolites: prospects and its technological challenges. *Frontiers in Plant Science*, *14*, 1171154. https://doi.org/10.3389/FPLS.2023.1171154/XML/NLM

Mirmostafaee, S., Azizi, M., & Fujii, Y. (2020). Study of allelopathic interaction of essential oils from medicinal and aromatic plants on seed germination and seedling growth of lettuce. *Agronomy*, *10*(2). https://doi.org/10.3390/agronomy10020163

Mohammed, H. A. (2022). Phytochemical Analysis, Antioxidant Potential, and Cytotoxicity Evaluation of Traditionally Used *Artemisia absinthium* L. (Wormwood) Growing in the Central Region of Saudi Arabia. *Plants*, *11*(8). https://doi.org/10.3390/plants11081028

Mohammed, R. A., Abdelgadir A. E. (2016). Antibacterial activity and phytochemical constituents of *Cinnamomum verum* and *Matricaria chamomilla* from Sudan. *Bio Bulletin*, *2*(2),01-05.

Montalbán, B., Thijs, S., Lobo, M. C., Weyens, N., Ameloot, M., Vangronsveld, J., & Pérez-Sanz, A. (2017). Cultivar and metal-specific effects of endophytic bacteria in *Helianthus tuberosus* exposed to Cd and Zn. *International Journal of Molecular Sciences*, *18*(10). https://doi.org/10.3390/ijms18102026

Moustafa, M., Taha, T., Mansy, A. E., Al-Emam, A., Alamri, S., Alghamdii, H., Shati, A., Alrumman, S., Temerk, H., & Maghraby, T. (2020). Dual exploitation of clove powder for bioremediation of heavy metals and decontaminating microbes from wastewater. *Desalination and Water Treatment*, *207*. https://doi.org/10.5004/dwt.2020.26440

Msaada, K., Hosni, K., Taarit, M. Ben, Chahed, T., Kchouk, M. E., & Marzouk, B. (2007). Changes on essential oil composition of coriander (*Coriandrum sativum* L.) fruits during three stages of maturity. *Food Chemistry*, *102*(4). https://doi.org/10.1016/j.foodchem.2006.06.046

Murphy, A., Norton, E., Montgomery, F., Jaiswal, A. K., & Jaiswal, S. (2020). Ultrasound-assisted extraction of polyphenols from ginger (*Zingiber officinale*) and evaluation of its antioxidant and antimicrobial properties. *Journal of Food Chemistry and Nanotechnology*, *6*(2). https://doi.org/10.17756/jfcn.2020-088

Mustafakulovna, M. M., & Kurbonalievna, S. M. (2022). Pharmacological Action of the Components of Chamomile Pharmacy and Its Use in Cosmetics. *World Bulletin of Public Health (WBPH)*, *17*. ISSN: 2749-3644. https://www.scholarexpress.net

Nadeem, A., Ahmed, B., Shahzad, H., Craker, L. E., & Muntean, T. (2021). *Verbascum thapsus* (mullein) versatile polarity extracts: GC-MS analysis, phytochemical profiling, anti-bacterial potential and anti-oxidant activity. *Pharmacognosy Journal*, *13*(6). https://doi.org/10.5530/PJ.2021.13.189

Naqishbandi, A. (2014). Plants used in Iraqi traditional medicine in Erbil - Kurdistan region. *Zanco Journal of Medical Sciences*, *18*(3), 811–815. https://doi.org/10.15218/ZJMS.2014.0038

Nizioł-ŁUkaszewska, Z., Furman-Toczek, D., & Zagórska-Dziok, M. (2018). Antioxidant activity and cytotoxicity of *Jerusalem artichoke* tubers and leaves extract on HaCaT and BJ fibroblast cells. *Lipids in Health and Disease*, *17*(1). https://doi.org/10.1186/s12944-018-0929-8

Niziol-Lukaszewska, Z., Ziemlewska, A., Zagórska-Dziok, M., Bujak, T., & Wasilewski, T. (2020). Innovative Model Two-Phase Makeup Remover Containing of *Jerusalem Artichoke* Tubers Extract. *Journal of Pharmaceutical Sciences and Research*, *12*(9).

Noori, S., Kiasat, A. R., Kolahi, M., Mirzajani, R., & Seyyed Nejad, S. M. (2022). Determination of secondary metabolites including curcumin in *Rheum ribes* L. and surveying of its antioxidant and anticancer activity. *Journal of Saudi Chemical Society*, *26*(3). https://doi.org/10.1016/j.jscs.2022.101479

Obat, R., & Bosire, C. (2022). Formulation and evaluation of herbal lipstick using *Beta vulgaris* and *Lawsonia inermis* as natural colorants. *Journal of Physical and Applied Sciences (JPAS)*, *1*(1). https://doi.org/10.51317/jpas.v2i1.233

Odaci, D., Timur, S., & Telefoncu, A. (2004). Immobilized Jerusalem artichoke (*Helianthus tuberosus*) tissue electrode for phenol detection. *Artificial Cells, Blood Substitutes, and Immobilization Biotechnology*, *32*(2). https://doi.org/10.1081/BIO-120037836

Oh, T. I., Jung, H. J., Lee, Y. M., Lee, S., Kim, G. H., Kan, S. Y., Kang, H., Oh, T., Ko, H. M., Kwak, K. C., & Lim, J. H. (2018). Zerumbone, a tropical ginger sesquiterpene of *Zingiber officinale* Roscoe, attenuates α-MSH-induced melanogenesis in B16F10 cells. *International Journal of Molecular Sciences*, *19*(10). https://doi.org/10.3390/ijms19103149

Okazaki, K., Oka, N., Shinano, T., Osaki, M., & Takebe, M. (2008). Differences in the metabolite profiles of spinach (*Spinacia oleracea* L.) leaf in different concentrations of nitrate in the culture solution. *Plant and Cell Physiology*, *49*(2), 170–177. https://doi.org/10.1093/pcp/pcm173

Oliveira, J. S., Porto, L. A., Estevam, C. S., Siqueira, R. S., Alves, P. B., Niculau, E. S., Blank, A. F., Almeida, R. N., Marchioro, M., & Quintans, L. J. (2009). Phytochemical screening and anticonvulsant property of *Ocimum basilicum* leaf essential oil. *Boletin Latinoamericano y Del Caribe de Plantas Medicinales y Aromaticas*, *8*(3).

Osabor, V., Bassey, F., & Umoh, U. (2015). Phytochemical Screening and Quantitative Evaluation of Nutritional Values of *Zingiber officinale* (Ginger). *American Chemical Science Journal*, *8*(4). https://doi.org/10.9734/acsj/2015/16915

Özcan, M., & Chalchat, J.-C. (2002). Essential oil composition of *Ocimum basilicum* L. and *Ocimum minimum* L. in Turkey. *Czech Journal of Food Sciences*, *20*(6). https://doi.org/10.17221/3536-cjfs

Ozyigit, I. I., Dogan, I., Hocaoglu-Ozyigit, A., Yalcin, B., Erdogan, A., Yalcin, I. E., Cabi, E., & Kaya, Y. (2023). Production of secondary metabolites using tissue culture-based biotechnological applications. *Frontiers in Plant Science*, *14*, 1132555. https://doi.org/10.3389/FPLS.2023.1132555/XML/NLM

Parthipan, P., AlSalhi, M. S., Devanesan, S., & Rajasekar, A. (2021). Evaluation of *Syzygium aromaticum* aqueous extract as an eco-friendly inhibitor for microbiologically influenced corrosion of carbon steel in oil reservoir environment. *Bioprocess and Biosystems Engineering*, *44*(7). https://doi.org/10.1007/s00449-021-02524-8

Patel, M., & Patel, P. (2022). HPTLC fingerprinting analysis of phytoconstituents from *Bixa orellana* and *Beta vulgaris* plant pigment. *Journal of Advanced Biotechnology and Experimental Therapeutics*, *5*(2). https://doi.org/10.5455/jabet.2022.d116

Patil, M. A. (2019). Phytochemical and in-vitro evaluation of formulated polyherbal hair conditioner. *Journal of Pharmacognosy and Phytochemistry*, *8*(6), 35-39.

Pavela, R., & Sedlák, P. (2018). Post-application temperature as a factor influencing the insecticidal activity of essential oil from *Thymus vulgaris*. *Industrial Crops and Products*, *113*. https://doi.org/10.1016/j.indcrop.2018.01.021

Pavela, R., Žabka, M., Vrchotová, N., & Tříska, J. (2018). Effect of foliar nutrition on the essential oil yield of Thyme (*Thymus vulgaris* L.). *Industrial Crops and Products*, *112*. https://doi.org/10.1016/j.indcrop.2018.01.012

Paven, C. S. J., Radu, D., Alexa, E., Pintilie, S., & Rivis, A. (2018). Anethum graveolens - An important source of antioxidant compounds for food industry. *International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM*, *18*(6.2). https://doi.org/10.5593/sgem2018/6.2/S25.002

Petropoulos, S.A. (2023). *Applications of Plant Secondary Metabolites in the Food Industry*. In: Carocho, M., Heleno, S.A., Barros, L. (eds) Natural Secondary Metabolites. Springer, Cham. https://doi.org/10.1007/978-3-031-18587-8_23

Pieroni, A., Ahmed, H. M., & Zahir, H. (2017). The spring has arrived: Traditional wild vegetables gathered by Yarsanis (Ahl-e Haqq) and Sunni Muslims in Western Hawraman, SE Kurdistan (Iraq). *Acta Societatis Botanicorum Poloniae*, *86*(1). https://doi.org/10.5586/asbp.3519

Politeo, O., Bektašević, M., Carev, I., Jurin, M., & Roje, M. (2018). Phytochemical Composition, Antioxidant Potential and Cholinesterase Inhibition Potential of Extracts from *Mentha pulegium* L. *Chemistry and Biodiversity*, *15*(12). https://doi.org/10.1002/cbdv.201800374

Pramanik, J., Kumar, A., Rustagi, S., Katyal, M., Thakur, S., Bora, J., Malik, S., Trehan, A., Talukdar, N., & Slama, P. (2024). A perspective review on the biosynthesis of plant-based secondary metabolites and their application as potent drugs. *Biocell*, *48*(4), 541–557. https://doi.org/10.32604/BIOCELL.2023.029031

Prasannakumar, N. R., Jyothi, N., Saroja, S., & Lokesha, A. N. (2023). Insecticidal properties of *Ocimum basilicum* and *Mentha piperita* essential oils against South American Tomato moth, Phthorimaea absoluta (Meyrick) (Lepidoptera: Gelichiidae). *Pesticide Biochemistry and Physiology*, *190*. https://doi.org/10.1016/j.pestbp.2022.105329

Preedy, V., & Watson, R. (2020). *Nuts and seeds in health and disease prevention*. Ronald Ross Watson https://doi.org/10.1016/C2009-0-01960-6

Prod, J. N., Resour, P., Zohra, S. F., Meriem, B., Samira, S., & S, A. M. M. (2012). Phytochemical Screening and identification of some compounds from Mallow. *Journal of Natural Product and Plant Resources* *2*(4), 512–516.

Qasem, A., Assaggaf, H., Montesano, D., Khalil, Z., Al-Mijalli, S. H., Baaboua, A. E. L., El Omari, N., El Menyiy, N., Bakrim, S., Sheikh, R. A., Alshahrani, M. M., Awadh, A. A. Al, Zengin, G., Bouyahya, A., & Mrabti, H. N. (2022). Determination of Chemical Compounds and Investigation of Biological Properties of *Matricaria chamomilla* Essential Oils, Honey, and Their Mixture. *Molecules*, *27*(18). https://doi.org/10.3390/molecules27185850

Quezada-Lázaro, R., Fernández-Zuñiga, E. A., García, A., Garza-González, E., Alvarez, L., & Camacho-Corona, M. del R. (2016). Antimycobacterial compounds from *Nasturtium officinale*. *African Journal of Traditional, Complementary and Alternative Medicines*, *13*(2). https://doi.org/10.4314/ajtcam.v13i2.3

Rahimpour, F., Shojaeimehr, T., & Sadeghi, M. (2017). Biosorption of Pb(II) using Gundelia tournefortii: Kinetics, equilibrium, and thermodynamics. *Separation Science and Technology (Philadelphia)*, *52*(4). https://doi.org/10.1080/01496395.2016.1260140

Rai, S., Acharya-Siwakoti, E., Kafle, A., Devkota, H. P., & Bhattarai, A. (2021). Plant-Derived Saponins: A Review of Their Surfactant Properties and Applications. *Sci*, 3(4). https://doi.org/10.3390/sci3040044

Ramírez-Rendon, D., Passari, A. K., Ruiz-Villafán, B., Rodríguez-Sanoja, R., Sánchez, S., & Demain, A. L. (2022). Impact of novel microbial secondary metabolites on the pharma industry. *Applied Microbiology and Biotechnology 2022 106:5*, *106*(5), 1855–1878. https://doi.org/10.1007/S00253-022-11821-5

Rasul, N. (2020). Growth Performance and Microflora in Growing Quail Fed Diet Supplemented with *Lactuca serriola* Powder. *Mesopotamia Journal of Agriculture*, *48*(4). https://doi.org/10.33899/magrj.2020.128996.1094

Razanov, S. F., Tkachuk, O. P., Razanova, A. M., Bakhmat, M. I., & Bakhmat, O. M. (2020). Intensity of heavy metal accumulation in plants of *Silybum marianum* L. in conditions of field rotation. *Ukrainian Journal of Ecology*, *10*(2), 131–136. https://doi.org/10.15421/2020

Razavi, R., Maghsoudlou, Y., Aalami, M., & Ghorbani, M. (2021). Impact of carboxymethyl cellulose coating enriched with *Thymus vulgaris* L. extract on physicochemical, microbial, and sensorial properties of fresh hazelnut (*Corylus avellana* L.) during storage. *Journal of Food Processing and Preservation*, *45*(4). https://doi.org/10.1111/jfpp.15313

Rehim, M. A., Zahran, H. A., & Al-Moghazy, M. (2023). Synthesis of active packaging films from *Lepidium sativum* gum/polyvinyl alcohol composites and their application in preserving cheddar cheese. *Scientific Reports*, *13*(1). https://doi.org/10.1038/s41598-023-28173-3

Rehman, S., Ashfaq, U. A., Sufyan, M., Shahid, I., Ijaz, B., & Hussain, M. (2022). The Insight of In Silico and In Vitro evaluation of *Beta vulgaris* phytochemicals against Alzheimer's disease targeting acetylcholinesterase. *PLoS ONE*, *17*(3 March). https://doi.org/10.1371/journal.pone.0264074

Rodríguez-González, Á., Álvarez-García, S., González-López, Ó., da Silva, F., & Casquero, P. A. (2019). Insecticidal properties of *Ocimum basilicum* and *Cymbopogon winterianus* against Acanthoscelides obtectus, insect pest of the common bean (*Phaseolus vulgaris*, L.). *Insects*, *10*(5). https://doi.org/10.3390/insects10050151

Rosaini, H., Efrida, V., Halim, A., Makmur, I., & Desniyetti, R. (2021). Stability Test Of Dyes From Beetroot Extract (*Beta Vulgaris* L.) In Hair Dye Cream. *International Journal of Pharmaceutical Research and Applications*, *6*(4), 715–722. https://doi.org/10.35629/7781-0604715722

Sagar, P. K., Sajwan, S. & Ahmed, N., Z. (2024). Scientific Standardization, Quality Control, Antimicrobial Potential, Toxological Studies Having Effective Therapeutic Uses (Woodfordia Fruticosa (Linn.) Kurz) Flowers Part. *World journal pharmacy and pharmaceutical science*, 13(6), 1301-1323. https://10.20959/wjpps20246-27478

Sahoo, A., Yadav, P. K., Mandal, A. K., Dwivedi, K., & Rahman, M. (2024). Key role of secondary metabolites in topical infectious disorders: nanomedicine in its effective delivery. *Nanostructured Drug Delivery Systems in Infectious Disease Treatment*, 411–424. https://doi.org/10.1016/B978-0-443-13337-4.00006-9

Saleh, M., Arslan, H., Isik, Z., Yalvac, M., & Dizge, N. (2021). The Use of Verbascum Thapsus L as a Biomembrane for Activated Sludge Filtration. *Avicenna Journal of Environmental Health Engineering*, *8*(2). https://doi.org/10.34172/ajehe.2021.13

Salehi, B., Stojanović-Radić, Z., Matejić, J., Sharopov, F., Antolak, H., Kręgiel, D., Sen, S., Sharifi-Rad, M., Acharya, K., Sharifi-Rad, R., Martorell, M., Sureda, A., Martins, N., & Sharifi-Rad, J. (2018). Plants of genus Mentha: From farm to food factory. In *Plants*,7(3). https://doi.org/10.3390/plants7030070

Salehi, B., Tumer, T. B., Ozleyen, A., Peron, G., Dall'Acqua, S., Rajkovic, J., Naz, R., Nosheen, A., Mudau, F. N., Labanca, F., Milella, L., de Tommasi, N., Coutinho, H. D., Sharifi-Rad, J., Verma, D. R., Martorell, M., & Martins, N. (2019). Plants of the genus Spinacia: From bioactive molecules to food and phytopharmacological applications. In *Trends in Food Science and Technology*, 88. https://doi.org/10.1016/j.tifs.2019.03.028

Salem, M. A., Manaa, E. G., Osama, N., Aborehab, N. M., Ragab, M. F., Haggag, Y. A., Ibrahim, M. T., & Hamdan, D. I. (2022). Coriander (*Coriandrum sativum* L.) essential oil and oil-loaded nano-formulations as an anti-aging potentiality via TGFβ/SMAD pathway. *Scientific Reports*, *12*(1). https://doi.org/10.1038/s41598-022-10494-4

Sanni, S., Onyeyili, P. A., & Sanni, F. S. (2008). Phytochemical Analysis, Elemental Determination and Some in vitro Antibacterial Activity of *Ocimum basilicum* L. Leaf Extracts. *Research Journal of Phytochemistry*, *2*(2). https://doi.org/10.3923/rjphyto.2008.77.83

Sari, S. W., Djamil, R., & Faizatun. (2021). Formulation of blush preparations by using natural coloring from red beetroot extract (*Beta vulgaris* l.). *Indonesian Journal of Chemistry*, *21*(4). https://doi.org/10.22146/ijc.60414

Saric-Krsmanovic, M., Gajic-Umiljendic, J., Radivojevic, L., Santric, L., Djordjevic, T., & Djurovic-Pejcev, R. (2023). Sensitivity of Cuscuta species and their hosts to *Anethum graveolens* essential oil. *Pesticidi i Fitomedicina*, *38*(1). https://doi.org/10.2298/pif2301033s

Sasi Kumar, R., Balasubramanian, P., Govindaraj, P., Krishnaveni, T., & Kumar, R. S. (2014). Preliminary studies on phytochemicals and antimicrobial activity of solvent extracts of *Coriandrum sativum* L. roots (Coriander). *Journal of Pharmacognosy and Phytochemistry JPP*, *2*(26).

Sezer, F., Deniz, S., Sevim, D., Chaachouay, N., & Zidane, L. (2024). Plant-Derived Natural Products: A Source for Drug Discovery and Development. *Drugs and Drug Candidates*, *3(1), 184-207*. https://doi.org/10.3390/DDC3010011

Shaaban, B. E., Touliaba, H. E. (2025). Assessment of heavy metals uptake of native plant species naturally grown in soil irrigated treated wastewater at Serapium Agro Forest, Ismailia city. *Egyptian Journal of Botany*, *65*(2), 39–45. https://doi.org/10.21608/EJBO.2025.291967.2859

Shah, F. M., Guddeti, D. K., Paudel, P., Chen, J., Li, X. C., Khan, I. A., & Ali, A. (2023). *Matricaria chamomilla* Essential Oils: Repellency and Toxicity against Imported Fire Ants (Hymenoptera: Formicidae). *Molecules*, *28*(14). https://doi.org/10.3390/molecules28145584

Shahwar, M. K., El-Ghorab, A. H., Anjum, F. M., Butt, M. S., Hussain, S., & Nadeem, M. (2012). Characterization of coriander (*Coriandrum sativum* L.) seeds and leaves: Volatile and non volatile extracts. *International Journal of Food Properties*, *15*(4). https://doi.org/10.1080/10942912.2010.500068

Sharma, A., Sharma, S., Kumar, A., Kumar, V., & Sharma, A. K. (2022). Plant Secondary Metabolites: An Introduction of Their Chemistry and Biological Significance with Physicochemical Aspect. In *Plant Secondary Metabolites: Physico-Chemical Properties and Therapeutic Applications*. https://doi.org/10.1007/978-981-16-4779-6_1

Sharopov, F. S., Wink, M., Gulmurodov, I. S., Isupov, S. J., Zhang, H., & Setzer, W. N. (2013). Composition and bioactivity of the essential oil of *Anethum graveolens* L. from Tajikistan. *International Journal of Medicinal and Aromatic Plants*, *3*(2).

Shukurlu, E. (2020). Chemical Content of *L. Serriola*: Fatty Acid Esters and Triterpene Compounds From the Roots. *Plant & Fungal Research*, *1*(1), 61–65. https://doi.org/10.29228/plantfungalres.70

Silva, A. S., Tewari, D., Sureda, A., Suntar, I., Belwal, T., Battino, M., Nabavi, S. M., & Nabavi, S. F. (2021). The evidence of health benefits and food applications of *Thymus vulgaris* L. In *Trends in Food Science and Technology*, 117. https://doi.org/10.1016/j.tifs.2021.11.010

Singer, A. C., Crowley, D. E., & Thompson, I. P. (2003). Secondary plant metabolites in phytoremediation and biotransformation. In *Trends in Biotechnology*, 21(3). https://doi.org/10.1016/S0167-7799(02)00041-0

Smolinska, B., & Leszczynska, J. (2017). Photosynthetic pigments and peroxidase activity of *Lepidium sativum* L. during assisted Hg phytoextraction. *Environmental Science and Pollution Research*, *24*(15). https://doi.org/10.1007/s11356-017-8951-3

Smolinska, B., & Szczodrowska, A. (2017). Antioxidative response of *Lepidium sativum* L. during assisted phytoremediation of Hg-contaminated soil. *New Biotechnology*, *38*. https://doi.org/10.1016/j.nbt.2016.07.004

Sohm, B., Cenizo, V., André, V., Zahouani, H., Pailler-Mattei, C., & Vogelgesang, B. (2011). Evaluation of the efficacy of a dill extract in vitro and in vivo. *International Journal of Cosmetic Science*, *33*(2). https://doi.org/10.1111/j.1468-2494.2010.00606.x

Soltan, O. I. A., Gazwi, H. S. S., Ragab, A. E., Aljohani, A. S. M., El-Ashmawy, I. M., Batiha, G. E. S., Hafiz, A. A., & Abdel-Hameed, S. M. (2023). Assessment of Bioactive Phytochemicals and Utilization of *Rosa canina* Fruit Extract as a Novel Natural Antioxidant for Mayonnaise. *Molecules*, *28*(8). https://doi.org/10.3390/molecules28083350

Soltanbeigi, E., & Soltani, M. (2024). The Role of Plant Secondary Metabolites in Industry, Medicine, and Health Care. *Journal of Biochemicals and Phytomedicine*, *3*(1), 5–7. https://doi.org/10.34172/JBP.2024.3

Song, Y., Wang, Y., Yang, P., & Li, J. (2020). Photo- and electro-catalysis evolution of superior thin g-C3N4 nanosheets with their microstructure and Ni Fe oxide composite. *Materials Characterization*, *169*. https://doi.org/10.1016/J.MATCHAR.2020.110655

Soto, K. M., Luzardo-Ocampo, I., López-Romero, J. M., Mendoza, S., Loarca-Piña, G., Rivera-Muñoz, E. M., & Manzano-Ramírez, A. (2022). Gold Nanoparticles Synthesized with Common Mullein (*Verbascum thapsus*) and Castor Bean (*Ricinus communis*) Ethanolic Extracts Displayed Antiproliferative Effects and Induced Caspase 3 Activity in Human HT29 and SW480 Cancer Cells. *Pharmaceutics*, *14*(10). https://doi.org/10.3390/pharmaceutics14102069

Sreenivasulu, N., & Fernie, A. R. (2022). Diversity: current and prospective secondary metabolites for nutrition and medicine. *Current Opinion in Biotechnology*, 74. https://doi.org/10.1016/j.copbio.2021.11.010

Sriti, J., Aidi Wannes, W., Bachrouch, O., Aouini, J., Boushih, E., Limam, F., & Mediouni Ben Jemaa, J. (2022). Phenolic constitutents, antioxidant and repellent activities of coriander (*Coriandrum sativum* L.) fruits using different solvent extracts. *International Journal of Environmental Health Research*, *34*(1),225-237. https://doi.org/10.1080/09603123.2022.2143483

Stanojevic, L. P., Marjanovic-Balaban, Z. R., Kalaba, V. D., Stanojevic, J. S., & Cvetkovic, D. J. (2016). Chemical Composition, Antioxidant and Antimicrobial Activity of Chamomile Flowers Essential Oil (*Matricaria chamomilla* L.). *Journal of Essential Oil-Bearing Plants*, *19*(8). https://doi.org/10.1080/0972060X.2016.1224689

Sumalan, R. M., Alexa, E., Popescu, I., Negrea, M., Radulov, I., Obistioiu, D., & Cocan, I. (2019). Exploring ecological alternatives for crop protection using *Coriandrum sativum* essential oil. *Molecules*, *24*(11). https://doi.org/10.3390/molecules24112040

Sun, Z., Park, S. Y., Hwang, E., Zhang, M., Seo, S. A., Lin, P., & Yi, T. H. (2017). *Thymus vulgaris* alleviates UVB irradiation induced skin damage via inhibition of

MAPK/AP-1 and activation of Nrf2-ARE antioxidant system. *Journal of Cellular and Molecular Medicine*, *21*(2). https://doi.org/10.1111/jcmm.12968

Sut-Lohmann, M., Grimm, M., Kästner, F., Raab, T., Heinrich, M., & Fischer, T. (2023). *Brassica juncea* as a Feasible Hyperaccumulator of Chosen Potentially Toxic Metals Under Extreme Environmental Conditions. *International Journal of Environmental Research*, *17*(3), 1–10. https://doi.org/10.1007/S41742-023-00528-8/TABLES/4

Syeda Kaniz, T., Bader Ul Ain, H., Tufail, T., Nazia, H., Rizwan, B., Islam, Z., Shamim, F., Imran, S., Hussain, R., Butt, M., Riaz, M., Batool Qaisrani, T., & Shehzad Muzammil, H. (2022). Therapeutic Potential And Nutraceuticals Aspects Of *Lepidium Sativum*. *Pakistan BioMedical Journal*. https://doi.org/10.54393/pbmj.v5i7.649

Tabassum, B., Babu, S. R., & Raja, A. (2015). Preliminary Phytochemical Screening of *Spinacia oleracea* L. *World Journal of Pharmacy and Pharmaceutical Sciences*, *4*(06).

Taddeo, V. A., Epifano, F., Preziuso, F., Fiorito, S., Caron, N., Rives, A., De Medina, P., Poirot, M., Silvente-Poirot, S., & Genovese, S. (2019). HPLC analysis and skin whitening effects of umbelliprenin-containing extracts of *Anethum graveolens*, *Pimpinella anisum*, and *Ferulago campestris*. *Molecules*, *24*(3). https://doi.org/10.3390/molecules24030501

Taghavinia, F., Teymouri, F., Farokhrouz, F., Bagherabad, E. H., Farjami, S., Karimi, E., & Shakeri, M. (2022). Nanoliposome-loaded phenolics from Nasturtium officinale improves health parameters in a colorectal cancer mouse model. *Animals*, *12*(24), 3492. https://doi.org/10.3390/ani12243492

Taneva, I., Petkova, N., Dimov, I., Ivanov, I., & Denev, P. (2016). Characterization of rose hip (Rosa canina L.) fruits extracts and evaluation of their in vitro antioxidant activity. *J. Pharmacogn. Phytochem*, *5*(2), 35-38.

Tariq, L., Bhat, B. A., Hamdani, S. S., & Mir, R. A. (2021). Phytochemistry, pharmacology and toxicity of medicinal plants. In *Medicinal and Aromatic Plants: Healthcare and Industrial Applications* (pp. 217-240). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-58975-2_8

Tatari, M., Ebrahim Gholamalipour Alamdari, Avarseji, Z., & Zare, M. (2020). Aqueous Extract Effect of Different Organs of *Malva sylvestris* Weed on Germination Characteristics and Photosynthetic Pigments of Echinochloa crus-galli. *Iranian Journal of Seed Research*, *6*(2), 151–161.

Turakhia, B., Turakhia, P., & Shah, S. (2018). Green synthesis of zero valent iron nanoparticles from Spinacia oleracea (spinach) and its application in waste water treatment. *J Adv Res Appl Sci*, *5*(1), 46-51. https://doi.org/10.5772/INTECHOPEN.79766

Tritanti, A., & Pranita, I. (2019). The making of red ginger (*Zingiber officinale* rovb. var. rubra) natural essential oil. *Journal of Physics: Conference Series*, *1273*(1). https://doi.org/10.1088/1742-6596/1273/1/012053

Turakhia, B., Turakhia, P., & Shah, S. (2018). Green synthesis of zero valent iron nanoparticles from Spinacia oleracea (spinach) and its application in waste water treatment. *J Adv Res Appl Sci*, *5*(1), 46-51.

Ugulu, I., Bibi, S., Khan, Z. I., Ahmad, K., Munir, M., & Malik, I. S. (2022). Potentially Toxic Metal Accumulation in Spinach (*Spinacia oleracea* L.) Irrigated with Industrial Wastewater and Health Risk Assessment from Consumption. *Bulletin of Environmental Contamination and Toxicology*, *109*(6). https://doi.org/10.1007/s00128-022-03606-3

Ullah, M. I., Anwar, R., Kamran, S., Gul, B., Elhady, S. S., & Youssef, F. S. (2022). Evaluation of the Anxiolytic and Anti-Epileptogenic Potential of *Lactuca Serriola* Seed Using Pentylenetetrazol-Induced Kindling in Mice and Metabolic Profiling of Its Bioactive Extract. *Antioxidants*, *11*(11). https://doi.org/10.3390/antiox11112232

Verma, C., Ebenso, E. E., Bahadur, I., & Quraishi, M. A. (2018). An overview on plant extracts as environmentally sustainable and green corrosion inhibitors for metals and alloys in aggressive corrosive media. *Journal of molecular liquids*, *266*, 577-590. https://doi.org/10.1016/j.molliq.2018.06.110

Viktorova, J., Stranska-Zachariasova, M., Fenclova, M., Vitek, L., Hajslova, J., Kren, V., & Ruml, T. (2019). Complex evaluation of antioxidant capacity of milk thistle dietary supplements. *Antioxidants*, *8*(8). https://doi.org/10.3390/antiox8080317

Wang, J., Xu, X., Zhou, K., Xu, Y., Jin, X., Xiao, Y., Xia, X., Hu, R., & Lin, L. (2024). Effects of water extract from *Nasturtium officinale* R. Br. straw on growth and selenium uptake of peach seedlings. *Environmental Progress & Sustainable Energy*, *43*(4), e14418. https://doi.org/10.1002/EP.14418

Wang, L., Chen, S. S., Tsang, D. C. W., Poon, C. S., & Shih, K. (2016). Value-added recycling of construction waste wood into noise and thermal insulating cement-bonded particleboards. *Construction and Building Materials*, *125*, 316–325. https://doi.org/10.1016/J.CONBUILDMAT.2016.08.053

Wink, M. (2010). Introduction: Biochemistry, Physiology and Ecological Functions of Secondary Metabolites. *Annual Plant Reviews*, *40*, 1–19. https://doi.org/10.1002/9781444320503.CH1

Wink, M. (1999). Biochemistry of Plant Secondary Metabolism (Sheffield Annual Plant Reviews).

Yadav, R., Singh, S., & Singh, A. N. (2022). *Biopesticides: Current status and future prospects*. *12*(3), 211–233.

Yaldiz, G., Camlica, M., Pradhan, Y., & Ali, A. (2022). Chemical characterization, biological activities, and some medicinal uses of different sweet basil (Ocimum basilicum L.) genotypes. Inm*Natural Product Experiments in Drug Discovery* (pp. 41-61). New York, NY: Springer US. https://doi.org/10.1007/978-1-0716-2683-2_3

Yang, L., Wen, K. S., Ruan, X., Zhao, Y. X., Wei, F., & Wang, Q. (2018). Response of plant secondary metabolites to environmental factors. *Molecules*, *23*(4), 762. https://doi.org/10.3390/molecules23040762

Yousfi, F., Abrigach, F., Petrovic, J. D., Sokovic, M., & Ramdani, M. (2021). Phytochemical screening and evaluation of the antioxidant and antibacterial potential of Zingiber officinale extracts. *South African Journal of Botany*, *142*, 433-440. https://doi.org/10.1016/j.sajb.2021.07.010

Zahed, K., Souttou, K., Hamza, F., & Zamoum, M. (2021). Chemical composition and larvicidal activities in vitro and in vivo of essential oils of Thymus vulgaris (L) and Lavandula angustifolia (Mill) against pine processionary moth Thaumetopoea pityocampa Den. & Schiff. in Ain Defla (Algeria). *Journal of Plant Diseases and Protection*, *128*(1), 121-137. https://doi.org/10.1007/s41348-020-00389-9

Zekri, N., Amalich, S., Boughdad, A., El Belghiti, M. A., & Zair, T. (2013). Phytochemical study and insecticidal activity of Mentha pulegium L. oils from Morocco against Sitophilus Oryzae. *Mediterranean Journal of Chemistry*, *2*(4), 607-619. https://doi.org/10.13171/mjc.2.4.2013.08.11.23

Zhang, X., Zhang, F., Wang, J., Lin, L., Liao, M., Tang, Y., Sun, G., Wang, X., Lv, X., Deng, Q., Chen, C., & Ren, W. (2019). Cutting after grafting affects the growth and cadmium accumulation of *Nasturtium officinale*. *Environmental Science and Pollution Research*, *26*, 15436–15442. https://doi.org/10.1007/s11356-019-04977-7

Zia, P., Sunita, M., & Sneha, S. (2021). EAS Journal of Nutrition and Food Sciences Abbreviated Key Title:EAS J Nutr Food Sci Extraction of Natural Colour from Beet Root (*Beta vulgaris*) its Phytochemical Analysis and Antibacterial Activity. *Original Research Article*, *1873*(4), 2663–7308. https://doi.org/10.36349/easjnfs.2021.v03i04.002

Zribi, I., Bleton, J., Moussa, F., & Abderrabba, M. (2019). GC-MS analysis of the volatile profile and the essential oil compositions of Tunisian Borago Officinalis L.: Regional locality and organ dependency. *Industrial Crops and Products*, *129*, 290-298. https://doi.org/10.1016/j.indcrop.2018.12.021

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