Available online at www.garmian.edu.krd

Passer Journal of Basic and Applied Sciences

Passer

Passer 7 (Issue 2) (2025) 849-864

*Original Article*

# A Recent Review of Medical Uses of Bioactive Secondary Metabolites from Some Plants Available in the Kurdistan Region

**Selar Izzat*[1], Hawbash Fars[1], Honey Azad[1], Soma Sirwan[1], Soman Atta[1], Rayan Barham[1], Hillin Gulladin[1], Firdaws Hassan[1], Dyary Mahdy[1]**

[1]*Department of Biology, College of Science, University of Sulaimani, Sulaymaniyah 46001, Kurdistan region, Iraq.*

Received 3 November 2024; revised 19 March 2025;
accepted 25 May 2025; available online 19 August 2025

DOI: 10.24271/PSR.2025.486819.1802

**ABSTRACT**

Plant secondary metabolites (SM) exhibit a wide range of biological and pharmacological properties, and they have been and are still used to treat and improve many health issues and disorders. Therefore, this review highlights many important medicinal plants available in the Kurdistan region that contain potent bioactive secondary metabolites and have been investigated for their pharmacological activities by many researchers worldwide. It will provide information about the plants, their SMs, and their various applications: as antibacterial, antifungal, antiviral, antiparasitic, antidiabetic, antioxidant/anticancer agents, and human system function promoters, addressing the growing concern of bacterial resistance to synthetic drugs. This provides an opportunity to utilize them to improve human health and discover new herbal medicines. Also underscores the importance of further investigation into these natural compounds for developing novel pharmacological treatments, particularly in regions like Kurdistan.



*Keywords: Secondary metabolites, Medicinal Plant, Phytomedicine, Bioactive compounds, Herbal medicine.*

## 1 Introduction

Plant secondary metabolites (SM), including terpenes, phenolic compounds, and alkaloids, hold promising potential for medicinal and pharmaceutical use [1]. Historically, humans have primarily relied on medicinal plants to treat a variety of illnesses and infections [2]. Still, they are used by many people around the world due to their wide array of bioactive SMs with biological and pharmacological properties [3]. In modern medicine, many SMs are extracted and purified from different plant species and are used in various medical applications [4]. For example, as anticancer, antiviral, antidiabetic, and antifungal agents [5].

Recently, the use of plant phytochemicals has gained global popularity, as they are non-narcotic and typically have few or no side effects compared to chemically synthesized compounds [4]. Besides, it can be regarded as a promising option for identifying and developing novel antimicrobial drugs to combat multidrug-resistant pathogens [6].

Medicinal plants are an invaluable part of our natural resources, playing a vital role in delivering primary healthcare to underserved communities and emphasizing their significance to the national economy [7], and they can contribute to income generation and sustainable livelihoods for the people [8]. Kurdistan is home to a rich diversity of plant species that have been valued for their medicinal benefits since ancient times. Their use by the local people is based on centuries of tradition, observations, and a rich medicinal history [9,10]. However, these plants have not received enough attention from researchers, resulting in a significant gap in scientific study and understanding. Highlighting plants from the region can draw attention to lesser-known species and their potential medicinal uses, contributing to global knowledge and possibly leading to new discoveries. By focusing on recent investigations, this review article could inspire further studies and innovations on the role of plants and their active compounds as potential sources of future pharmaceuticals. Additionally, it aims to help researchers address gaps in understanding the significance and value of these plants.

* Corresponding author
*E-mail address* Selar.izzat@univsul.edu.iq (Instructor).
Peer-reviewed under the responsibility of the University of Garmian.

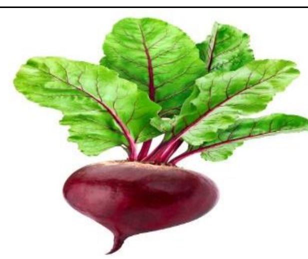
## 2 Plant Flora in the Kurdistan region

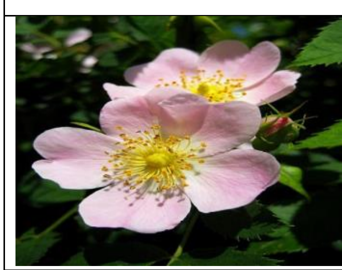
Iraq and especially the Kurdistan region is recognized as a significant hotspot for plant biodiversity due to the geographical and climatic conditions [8,11]. The exact number of plant species in the area remains unknown, while there are desperate documents and research about the diversity. For example, according to various research, 64 plant species belonging to 30 families have been documented in areas like Hawraman [12], 288 plant taxa belonging to 57 families and 200 genera were determined in Hujran Basin-Erbil [13], 41 plant species in the Choman area [14], 47 plant species within the BardaRash region [15], and ongoing research continues to uncover new species. This botanical wealth includes a wide array of species that have been integral to Kurdish culture and daily life for centuries [8].

The current review includes 21 plant species recorded in the Kurdistan region and have been investigated by global researchers as a source of bioactive SM for treating and improving human health problems (Table 1).

The plants were selected through a comprehensive search targeted web-based database and academic literature, focusing on plants deeply rooted in traditional medical practices. We utilized a combination of keywords, including the local and scientific names of the plants, and regional identifiers such as "Sulaymaniyah" and "Iraq." This approach ensured the inclusion of studies specific to our area of interest.

**Table 1:** Scientific and common names of the studied plant flora in the Kurdistan region, along with their detected SM constituents (according to the references). Photos are sourced from the web for demonstration purposes.

| Plant species | Main SM constituents | Plant species | Main SM constituents |
|---|---|---|---|
|  | • Phenolics<br>• Terpenes and Terpenoids [16,17] |  | • Phenolics<br>• Terpene<br>• Alkaloids [18–20] |
| 1. *Gundelia tournefortii* (Kenger) [15] | | 2. *Silybum marianum* (Milk thistle) [21] | |
|  | • Phenolics<br>• Terpenes<br>• Alkaloids [22,23] |  | • Phenolics<br>• Terpenes<br>• Alkaloids [24–26] |
| 3. *Lepidium sativum* (Garden cress) [27] | | 4. *Rheum ribes* (Rhubarb)[28] | |
|  | • Phenolics<br>• Alkaloids<br>• Terpenes and Terpenoids [29–31] |  | • Phenolics [32,33] |
| 5. *Matricaria chamomilla* (Chamomile flower) [15] | | 6. *Alcea kurdica* (Hollyhock) [34] | |
|  | • Phenolics [35,36] |  | • Phenolics<br>• Terpenes<br>• Alkaloids [37–39]. |

<table>
<tr><td colspan="2">7. Helianthus tuberosus (Jerusalem artichoke) [40]</td><td colspan="2">8. Beta vulgaris (Beet root) [15]</td></tr>
<tr><td></td><td>• Phenolics<br>• Terpenoids [41–44]</td><td></td><td>• Phenolics [45–48]</td></tr>
<tr><td colspan="2">9. Thymus vulgaris (Garden thyme)[8]</td><td colspan="2">10. Nasturtium officinale (Water cress)[27]</td></tr>
<tr><td></td><td>• Phenolics<br>• Alkaloids<br>• Terpenes and Terpenoids [49–51]</td><td></td><td>• Terpenes and Terpenoids [52–54]</td></tr>
<tr><td colspan="2">11. Zingiber officinale (Ginger) [8]</td><td colspan="2">12. Lactuca serriola (Prickly lattuce) [55]</td></tr>
<tr><td></td><td>• Phenolics<br>• Terpenes [56–58]</td><td></td><td>• Phenolics<br>• Alkaloids<br>• Terpenes and Terpenoids [59–62]</td></tr>
<tr><td colspan="2">13. Anethum graveolens (Dill) [63]</td><td colspan="2">14. Ociumum basilicum (Basil) [15]</td></tr>
<tr><td></td><td>• Phenolic<br>• Terpenes and Terpenoids [64]</td><td></td><td>• Phenolics<br>• Terpenes [65,66]</td></tr>
<tr><td colspan="2">15. Rosa canina (Dog rose) [67]</td><td colspan="2">16. Verbascum thapsus (Mullein) [68]</td></tr>
<tr><td></td><td>• Phenolics<br>• Terpenes and Terpenoids [69]</td><td></td><td>• Phenolics<br>• Terpenes<br>• Alkaloids [70–72]</td></tr>
</table>

| | | | |
|---|---|---|---|
| *17. Artemisia absinthium* (Tarragon) [73] | | 18. *Malva sylvestris* (Mallow) [15] | |
|  | • Phenolics<br>• Terpenes and Terpenoids [74–76] |  | • Phenolics<br>• Alkaloids<br>• Terpenes and Terpenoids [77–80] |
| *19. Spinacia oleracea* (Spinach) [8] | | *20. Coriandrum sativum* (Coriander) [15] | |
|  | • Phenolics<br>• Terpenes and Terpenoids [81,82] | | |
| *21. Mentha pulegium (*Pennyroyal) [15] | | | |

## 3 Global research on medical usage of the plant's SMs

According to global investigations, the bioactive SMs from the selected plant species (Section 2) possess several potent properties that make them ideal for future research, and potential medical applications, as outlined below:

### 3.1 As antibacterial agents

Infection by bacteria has been a major problem from the past to the present, causing several diseases. To address this issue, traditional antibacterial agents have been widely used as a treatment option [83]. However, the emergence of bacterial resistance to synthetic drugs, coupled with their serious side effects [84,85], and the high cost of new antibiotic production [86], has prompted the urgent need to discover alternative antibacterial sources with novel chemical structures and unique mechanisms of action [87–89].

One promising alternative is the use of plant SMs, which may exhibit strong antibacterial activity against several pathogenic bacteria [86]. Despite the discovery of many biologically active compounds of plant origin, many others remain undiscovered [90]. This highlights the importance of identifying and utilizing these bioactive compounds in pharmacological designs [91,92].

It has been suggested that plant secondary metabolites may impede microbial growth through mechanisms similar to those of antibiotics. These mechanisms include the inhibition of cell wall synthesis, activation of enzymes that degrade the cell wall, disruption of cell membrane permeability, interference with protein synthesis, and modification of nucleic acid metabolism [93,94]. For further details, the mechanism of action of phenolic compounds involves disrupting the cytoplasmic membrane, and inhibiting enzymes such as topoisomerase, NADH-reductase, and ATP synthase [95]. Alkaloids have also been shown to disrupt membrane efflux pumps and membrane integrity [94]. Additionally, phenol derivatives can alter pH, permeability, and efflux pumping of the membrane [96]. Tannins have been demonstrated to impair the metabolic processes and induce damage to bacterial membranes [97]. Furthermore, flavonoids are thought to inhibit proteins associated with the cell wall, as well as those involved in metabolism and DNA synthesis [98].

Multiple studies have reported the antibacterial activity of extracts and essential oils derived from various plant species. For instance, the rhizome extract of *Zingiber officinale* has been shown to inhibit the growth of *Escherichia coli*, *Bacillus subtilis*, *Staphylococcus aureus*, and *Pseudomonas aeruginosa* [88]. Additionally, both aqueous and methanolic leaf extracts of *Lactuca serriola* exhibited significant activity against multi-drug-resistant clinical isolates of *P. aeruginosa* [99]. The ethanolic extracts of *Rheum ribes* root have also demonstrated antibacterial effects against *E. coli*, *Enterobacter aerogenes*, *S. aureus*, and *P. aeruginosa* [100]. Another investigation revealed that extracts of *Ocimum basilicum* exhibited the largest inhibition zone against *S. aureus* as a gram-positive bacterium and *P. aeruginosa* as a gram-negative bacterium [83]. Furthermore, research indicated that *Alcea kurdica* exhibited activity against several bacterial strains, including *S. aureus*, *Enterococcus faecalis*, and *Acinetobacter baumannii* [101]. Moreover, the seed oil of *Anethum graveolens* was found to completely inhibit the growth of *B. subtilis*, *S. aureus*, *B. cereus*, *E. coli*, and *P. aeruginosa* [102]. According to

[103] the antibacterial activity of *Artemisia dracunculus* essential oil was effective against *S. aureus*, *Listeria monocytogenes*, *B. cereus*, *E. coli*, *Yersinia enterocolitica*, and *Salmonella Typhimurium*.

Several other studies have shown the antibacterial activity of plant extracts against specific bacterial species, such as the essential oil of *Matricaria chamomilae* against both *Bacillus cereus* and *Bacillus subtilis* [104]. *Silybum marianum* has been shown to inhibit the growth and biofilm formation of both gram-positive and gram-negative standard bacterial strains [105]. Methanolic extracts of *Rosa canina* seed exhibit antibacterial activity against *Lactobacillus plantarum*, *Staphylococcus epidermidis*, and *Proteus mirabilis* [106], *Beta vulgaris* root extracts demonstrate activity against *S. aureus* and *P. aeruginosa* [107]. The hydro-alcoholic extract of *Nasturtium oficinale* shows activity against common oral pathogens, i.e., *Streptococcus mutants*, *S. aureus*, *Lactobacillus acidophilus*, *E. faecalis*, and *P. aeruginosa* [108]. Finally, *Thymus vulgaris* leaf extracts exhibit activity against methicillin-resistant *S. aureus* (MRSA) and multi-drug-resistant *A. baumannii* [109].

## 3.2 As antifungal agents

Numerous plant SMs with various chemical structures have been discovered to possess antifungal activities. These compounds are used to prevent the growth of spoilage fungi in food as well as various harmful fungi that cause infections in humans, animals, and crops [110].

Since there are few commercially available botanical fungicides and a large number of products have been developed as a result of intense study [111], showing the fungicidal potential of the aforementioned plant species may open new avenues for developing green fungicides with various applications in the Kurdistan region.

One of the most common plants in the region is *Gundella tournefortii*. A study demonstrated that its leaf extract effectively acted as an antifungal agent against different *Candida* spp., including *Candida krusei*, *Candida guilliermondii*, *Candida glabrata*, and *Candida albicans* [112].

Similarly, *Silybum marianum* has been shown to have anti-*Candida* activity, as confirmed by multiple research groups, including a study by [113], which highlighted its activity against *C. albicans, C. glabrata*, *Candida parapsilosis*, *Candida tropicalis, and C. krusei*. These researchers reported that the primary constituent of the extracts, silymarin, may inhibit biofilm formation and the secretion of phospholipases and proteinases (key virulence factors). Therefore, they recommended silymarin as a potential future treatment for candidiasis. Dichloromethane extracts of *Silybum marianum* fruit, obtained from Duhok (Iraq), have been found to have potent anti-Candida properties [114]. In another study from Turkey, researchers found that the extracts of *Silybum marianum* were effective against *Aspergillus niger* as well as *C. albicans* at different concentrations [115]. *Rheum ribes* is another plant that has anti-candida properties. According to [116], it is effective against *C. tropicalis, C. krusei, C. albicans, and C. glabrata*. Moreover, *Matricaria chamomilla* has also been demonstrated to be a potent antifungal agent, especially against *Candida spp*. [117,118] and against *A. niger*, *Aspergillus terreus, Aspergillus flavus*, and *Fusarium culmorum* [119].

In the same way, *Helianthus tuberosus* has been used as an anti-Candida agent [120]. Another study suggests that its leaves, which have a high phenolic content, could serve as a potential natural fungicide [121]. *Mentha pulegium* is another plant with potential antifungal activity. A study revealed its effectiveness in inhibiting *C. albicans* germ tube formation at a dose well below the minimum inhibitory concentration (MIC) of 0.16 µL/mL [122]. In another study, silver nanoparticles (AgNPs) synthesized from *Mentha pulegium* leaf extracts were utilized as an inexpensive, nontoxic, environmentally friendly fungicide that inhibited the growth and spread of *Alternaria alternata* and *Fusarium solani* in the agricultural sector [123]. *Thymus vulgaris* extracts have also been reported to act as antifungal agents, specifically against *Aspergillus spp.* and *Candida spp.* [124,125].

The extracts of some other plant species have also been shown to have antifungal effects in investigations. For example, the ethanolic extracts of *Lactuca serriola* were effective against *Alternaria solani* and *A. flavus* [111]. The extracts of *Ocimum basilicum* have shown activity against *Rhizopus solanai, Penicillium* species, *A. flavus, A. niger, Aspergillus fumigates, A. alternata, and Cladosporium* [126], as well as *Cochliobolus* and *Bipolaris* species [127].

Moreover, *Rosa canina* has demonstrated antifungal effects against *C. albicans*. [128] and *Syzygium aromaticum* has shown activity against pathogenic *Aspergillus species*, *Candida spp.*, *Tricophyton rubrum*, *Tricophyton mentagrophytes* var. *interdigitale*, and *Epidermophyton flocosum* [129–131]. *Artemisia dracunculus* has shown activity against *Penicillium funiculosum*, *A. fumigatus*, *Aspergillus versicolour, Aspergillus ochraceus, Trichoderma viride and* Ochrochloron penicillium [132].

The leaf extracts of *Malva parviflora* has demonstrated activity against *Helminthosporium rostratum*, *F. solani*, *Fusarium oxysporum*, *and A. alternata* [133]. Finally, the essential oil of *Coriandrum sativum* has been shown to inhibit *F. culmorum* and *Zymoseptoria tritici*, which cause Fusarium head blight and Septoria tritici blotch on cereals, respectively [134–136].

## 3.3 As antiviral agents

This section of the review will discuss plant species that contain valuable SMs with antiviral activities. In recent years, COVID-19 has posed a significant threat to humanity, and there is still no specific approved drug for its treatment [137]. Recent research recommended several plant SMs as potential therapeutics for treating SARS-CoV-2. For example, *Matricaria chamomilla* is highlighted due to its two major flavonoid components, Apigenin and Luteolin [138]. Other examples include the essential oil and monoterpenes in *Mentha pulegium* [139], the essential oil of *Thymus vulgaris* [140], Apigenin-7-glucuronide and dihydrokaempferol-3-glucoside compounds in *Ocimum* *basilicum* [141], 6-Gingerol derived from *Zingiber officinale* [142], *and* silymarin from *Silybum* marianum [143].

On the other hand, viral hepatitis remains as a serious threat to human health [144]. The plant species and their SMs recorded to have anti-hepatitis activity include verbascoside (acteoside) in *Verbascum thapsus* [144] and artemisinin derived from *Artemisia absinthium* [145,146] against hepatitis B virus. While phytochemicals in *Lepidium sativum* [147], gingerol in *Zingiber officinale* [148], eugenol in *S. aromaticum* [149], linalool in *Ociumum basilicum* [150], and silymarin in *Silybum marianum* [151,152] have shown activity against hepatitis C virus.

Another significant threat is the herpes simplex virus (HSV), which can cause oral or genital lesions and even encephalitis with high infection rates across different age groups [153]. Recent studies have shown that eugenol in *S. aromaticum* [154], phenolic and flavonoid compounds in *Zingiber officinale* [155], and flavonoids and phenyl-ethanoid glycosides in *Verbascum thapsus* have antiviral activity against HSV-2.

Moreover, chikungunya virus (CHIKV), which causes a febrile illness known as chikungunya fever (CHIKF), recently re-emerged in many parts of the world, causing large-scale outbreaks [156]. Recent studies have shown several SMs in plants as a potent anti-chikungunya virus, such as silymarin in *Silybum marianum* [157] and 6-gingerol in *Zingiber officinale* [158]. Additional antiviral activities of plant SM include allicin, an active compound in *Zingiber officinale* against Influenza A and B viruses [159], *Matricaria chamomilla* essential oil against Bovine Herpesvirus 1, strain TN41 [160], and, rosmarinic acid in *Ociumum basilicum* against Dengue Virus serotype 2 [161].

### 3.4 As antiparasitic agents

There are several medicinal plants with diverse SMs around the world, including those found in Kurdistan that possess anti-parasitic properties. These plants can serve as alternative remedies for combating parasitic diseases, particularly as many parasites have developed resistance to standard medications [162]. In this review, we will highlight some of the plants found in Kurdistan, and explore their anti-parasitic benefits.

First and foremost, there is *Lepidium sativum*. Studies have shown that its seed crude extract exhibit anti-trypanosomal properties [163] [164]. Additionally, the extract can reduce the viability of the *Echinococcus granulosus* protoscolices of sheep origin [165]. *Rheum ribes* is another plant with potential anti parasitic properties. Results from an investigation demonstrated the potent protoscolicidal activity of its extract [166]. The essential oil and extracts from *Matricaria chamomila* have shown promising as a therapeutic approach for treating several parasitic diseases. These include leishmaniasis [167], reducing *Ichthyophthirius multifiliis* infections in guppy fish (Poecilia reticulata), as a safe option for enhancing fish health and reducing mortality rates [168], and treating hydatid cysts [169]. *Beta vulgaris* is another plants with antiparasitic properties. According to a study, oral administration of its fresh juice demonstrated strong antimalarial action [170]. It has been suggested that phytochemicals in both the aqueous and ethanol extracts might account for this property [171]. *Mentha pulegium* has also been reported to have anti-parasitic effects. Its extract exhibit anthelmintic properties, particularly against *Haemonchus contortus* [172]. On the other hand, *Thymus vulgaris* was found to have anti-coccidial effect, leading the author to suggest its oil as an effective agent for combating rabbit coccidiosis [173]. Additionally, its extract has shown potential for both in vitro and in vivo trypanocidal effects, which may hold promise for the future treatment of trypanosomosis [174]. *Zingiber officinale* is another plant, and the gingerol compounds extracted from it were successful in preventing fish infection by *Ichthyophthirius multifiliis* [175]. According to another study, its extract is a viable and effective alternative for the treatment of trichinellosis [176]. The antiparasitic potential of *Anethum graveolens* has been well investigated by researchers. It is believed that its essential oil holds promise for preventing sheep gastrointestinal nematodes [177], and is considered a promising hepatoprotective agent against amebic liver abscesses induced by *Entamoeba histolytica* [178]. Furthermore, the ethanol and hexan extracts of *Ocimum basilicum* contain promising bioactive phytocomponents, with anthelminthic activities [179] and exhibit extraordinary effectiveness against both adult and pre-adult stages of malaria vectors [180]. Another plant, *Coriandrum sativum* has been found to have therapeutic potential. Its essential oil can be used to treat some *Trichomonas vaginalis* infections [181], and its aqueous leaf extract has been used to assess the survivability of *Toxoplasma gondii* [182]. On the other hand, the aalcoholic extract of *Verbascum thapsus* has been shown to have antitrichomonal activity and induce apoptosis in *T. vaginalis* [183]. Other researchers found that *Syzygium aromaticum* oil has an anthelmintic effect on adult and muscle larvae of *Trichinella spiralis* [184] and also exhibits an inhibitory effect against *Trypanosoma cruzi* [185]. Scientific studies have established a wide range of biological activities of *Artemisia absinthium*'s constituents, including its use as an alternative treatment for piroplasmosis [186] and its anticoccidial action in both ruminants and poultry [187]. Lastly, *Malva sylvestris* extract was successfully used to treat mice infected with *Trypanosoma brucei*, and the extract significantly reduced the parasite count in both blood and cerebrospinal fluid (CSF) compared to the animals in the negative control group [188].

### 3.5 As anti-diabetic agents

In Kurdistan, numerous plants can be used as anti-diabetic agents. Starting with *Gundelia tournefortii*, studies have demonstrated that both ethanolic and aqueous extracts from various parts of this plant play a significant role in the treatment of diabetes mellitus [189–191]. Another plant with documented bioactive compounds representing anti-diabetic properties is *Lepidium sativum* [192,193]. More precisely, the potent hypoglycemic activity of the aqueous seed extract of *Lepidium sativum* was demonstrated in vivo in streptozotocin-induced diabetic Wistar rats (albino outbred strain) without affecting basal plasma insulin concentrations [194]. Another plant, *Silybum marianum*, has been demonstrated to decrease blood sugar levels in rabbits with diabetes mellitus [195]; specifically, this activity may be attributed to the silymarin flavonolignan in its seeds and fruit extracts [196]. *Matricaria chamomilla* is another common herb used as an anti-diabetic [197], particularly due to its terpenes, such as α-pinene, β-myrcene, α-thujone, and γ-terpinene constituents [31]. As it is well known, the inhibition and suppression of a-glucosidase and a-amylase enzymes are therapeutic strategies in the management of type 2 diabetes mellitus [198]. Furthermore, the following plants have also been documented to possess antidiabetic properties: *Helianthus tuberosus* [35], *Beta vulgaris var. vulgaris* [199], and *Anethum graveolens* extract [200], known for containing significant amounts of compounds such as tannins, terpenoids, steroidal saponins, flavonoids, cardiac glycosides and anthraquinone [201], *Nasturtium officinale* [202,203], *Thymus vulgaris* due to its volatile compounds [204,205], and *Rosa canina* [206,207], particularly its oligosaccharides, which enhance insulin production in the beta-cells of the islets of Langerhans [208].

### 3.6 As antioxidant and anticancer agents

Antioxidants have garnered significant interest from researchers due to their protective activities in food and pharmaceutical goods [209]. Meanwhile, laboratory and animal studies have shown that increased levels of exogenous antioxidants can prevent the types of free radical damage associated with cancer development [210]. Thus, by decreasing free radicals and oxidative stress, antioxidants play a role in ameliorating DNA damage, reducing the rate of abnormal cell division, and decreasing mutagenesis [211].

Several plant SMs have been investigated for their radical scavenging activity and high antioxidant properties. Examples include quinic acid, protocatechuic acid, chlorogenic acid, protocatechuic aldehyde, caffeic acid, and acacetin from *Gundelia tournefortii* [212], glucosinolates from *Lepidium sativum* [213], phenolic compounds and flavonols from *Rosa canina* [214], *Nasturtium officinale's* polyphenols [215] and its flavonoid contents [216], phenolic acids and flavonoids from *Ocimum basilicum* [217], extracts from *Silybum marianum* [19], *Matricaria chamomilla* [218], *Rheum ribes* extracts containing rutin hydrate, kuromanine, procyanidin, and sinapic acid [219], SMs in the extracts of *Beta vulgaris* [220,221], and gallic acid, syringic acid, chlorogenic acid, and quercetin in the extracts of *Alcea kurdica*, which have also been concluded to reduce oxidative stress [101].

Additional plant-derived bioactive compounds reported to have antioxidant properties include catechin and gallic acid from *Zingiber officinale*'s rhizome extracts [222], kaempferol from its leaves [223], isocembrol from *Lactuca serriola* [224], eugenol from *Syzygium aromaticum* [225], camphor, camphene, and a-pinene from *Artemisia absinthium* [226], phytol *from Malva sylvestris* [227], and also its diterpenoids contents such as malvin and coumarin derivatives [228]. In addition, *Coriandrum sativum* has been identified by many researchers as one of the main sources of antioxidant plants due to its contents, especially β-linalool [229], tannins, saponins, polyphenols, and flavonoids [230], as well as linalool, γ-terpinene, and α-pinene [231].

Also, many plant extracts have been used for centuries as anticancer agents. To illustrate; *Gundelia tournefortii* extracts have been shown to exhibit anticancer activity against different cancer cell lines (Skov-3, CaCo-2, and U118) [232] and hepatocellular carcinoma (HCC) in rats [233]. Besides, chlorogenic acid, quercetin, and kaempferol from *Lepidium sativum* [234], caffeoylquinic acid, isoxazolidine, feruloylquinic acid, camphene, and caffeic acid from *Helianthus tuberosus* [35], and phenolic compounds from *Malva sylvestris* flowers [235] have all been shown to have the most cytotoxic activity in both Hela and Hep G2 cell lines. Furthermore, it was found that curcumin from *Rheum ribes* exhibited anti-proliferative activity on the growth of the human colonic epithelial Caco-2 cell line [25]. Additionally, aromadendrene, α-humulene, and viridiflorene from *Thymus vulgaris* [236] and betalains from *Beta vulgaris* [237] have shown strong anticancer activity against breast cancer cell lines. On the other hand, betanin from *Beta vulgaris* has also been shown to inhibit the growth of colorectal cancer cells [238], and thymol and p-cymene from *Thymus vulgaris* demonstrated cytotoxic activity against lung carcinoma and an acute lymphoblastic leukaemia cell line [239].

Further investigations have been conducted on the anticancer activities of several plant phytochemicals as follows : gallic acid, salicylic acid, syringic acid, catechin, and ellagic acid from *Nasturtium officinale* which were found to improve intestinal morphology in mice challenged with colorectal cancer [46]; 6-shogaol, quercetin, and rutin from *Zingiber officinale* displayed cytotoxicity against liver cancer, human lung adenocarcinoma, breast cancer, and colorectal tumor cell lines [240]; gingerol, thymoquinol, heptanol, and hexanol conjugated with nanoparticles which exhibited significant cytotoxicity against breast cancer and colorectal cancer cell lines [241]; L-borneol, farnesol, beta-sesquiphellandrene, alpha-curcumene, and zingiberene, which induced apoptosis in HeLa cells in a more recent study [242]; piperitenone oxide and piperitenone from *Mentha longifolia,* which were found to have anticancer activities on colorectal cancer cell lines [243]; and Naringin, cryptochlorogenic acid, and rosmarinic acid, which exhibited the highest activities against Jurkat, breast, colorectal, and HeLa cell lines [244]. Eugenol from *Syzygium aromaticum* showed growth inhibition against the hepato-carcinoma cell line [245] and also against breast, HeLa, and lung cancer cell lines [246]. *Matricaria chamomilla*'s bisabolol oxide A and (E)-tonghaosu from the flowers and apigenin-7-β-d-glucoside from the stem extracts, showed anticancer effects against Caco-2 colon cancer cells and breast cancer cells [247]. Phenethyl isothiocyanate, phenolics, flavonoids, pigments, and ascorbic acid from *Nasturtium officinale* have shown anticancer activity against human malignant melanoma [248]. Additionally, and later, hexaprenol, phytol, and 18-[(1-oxohexadecyl) oxy]-9-octadecenoic acid from *Spinacia oleracea* exhibited remarkable antiproliferative activity against myeloid leukaemia cells [249].

### 3.7 For promoting system functions in the human body

The use of plant extracts for medical purposes to treat disease and support body functions has existed since the beginning of time. Owing to their higher cultural acceptance, better compatibility with the human body, and fewer side effects [250].

The Kurdistan region is home to a wide variety of herbal plants that are used as promoters for human system functions in a wide range. Some are used to support the nervous system, while others impact systems such as the circulatory, gastrointestinal, integumentary, urinary, respiratory, reproductive, and immune systems. Below is a brief review of the most recently used plants:

As neuroprotective agents, several plants mentioned in this review have such properties, such as *Ocimum basilicum* [251], *Beta vulgaris* [252], mainly due to betalain content [253], Silymarin from the seeds of *Silybum marianum* [254], *Coriandrum sativum* essential oil, known for its analgesic and as anti-Alzheimer properties, especially for migraine relief [255], *Lactuca serriola,* which is rich in flavonoids, phenols, and terpenoids and acts as anxiolytic and anti-epileptogenic agent [256], *Anethum graveolens* due to its phytocomponents (apiol, carvone, and dihydrocarvone) [257], and *Spinacia oleracea*, that contains phytoecdysteroids and flavonoids [258]. In addition, research has shown that the SMs in *Zingiber officinale* extract may help enhance diabetic retinopathy, primarily due to the compounds gingerol and shogaol found in its extracts [259].

Some plants that affect the cardiovascular system have been found useful in treating hypolipidemia hypertension, and hypotension in humans, such as *Beta vulgaris* [260] due to its phenolic and flavonoid contents [261], and *Ocimum basilicum* due to its phenolic compounds such as quercetin [251]. Others have cardioprotective activity, such as inulin obtained from *Helianthus tuberosus* [262], silibinin from the seeds of S*ilybum marianum* [263], *Zingiber officinale's* components such as zingerone, gingerols, and shogaols [264,265], extracts of *Spinacia oleracea* [266], and *Matricaria chamomilla* due to its high flavonoid contents [267].

Several important plants have been shown to affect the gastrointestinal system, mainly for their hepatoprotective activities. Examples include: *Rheum ribes*, as it contains various flavonoids and phenolic compounds [268], *Matrica chamomilla* due to the action of many bioactive compounds in its extracts [269], isothiocyanates and carotenoids as the main components of *Nasturtium officinale* [270], and *Lactuca serriola* extract [271].

Moreover, sseveral plant extracts have been found to improve digestive system function and bowel movement. These include *Alcea kurdica*, due to its flavonoids and phenolic contents [272], *Rheum ribes* extracts [273], *Beta vulgaris* by the action of betalain [274], *Thymus vulgaris* essential oil [275], *Anethum graveolens* [276], and *Ocimum basilicum*, mainly due to its content of phenolic compounds [277].

Furthermore, some of these plants offer benefits for maintaining gut microflora balance. For example *Rheum ribes* [278], promotes gut health due to its various phenolic compounds in mice infected with enteropathogenic *Escherichia coli* (O157:H7) [279], *Beta vulgaris* due to its betalains, especially betacyanins [280], *Gundelia tournefortii* due to its high total phenolic content [281], *Zingiber officinale,* contributes to gut health through the action of 6-gingerol and 6-shogaol [282]. These plants may also be advantageous for facilitating weight loss and addressing obesity.

Dermatological problems can also be improved by using different plant extracts. Examples include *Helianthus tuberosus* because of inulin content [283], *Silybum marianum* for its silibinin and flavonoids [284], *Nasturtium officinale* due to iits phenolic compounds [285], *Zingiber officinale* due to the presence of 6-shagoal in its extracts [286], and *Thymus vulgaris* extracts, especially for their gallic and ferulic acids, which act as anti-ageing compounds [287].

Equally important, some other plants may act as a protective agent for the urinary system, such as *Rheum ribes* due to emodin, rhein, and aloe-emodin [288], *Zingiber officinale* due to the presence of high levels of polyphenolic (such as gingerol) and flavonoid content [289], and phenolics and flavonoids of *Beta vulgaris* extract [290].

Further studies have shown that some other plants are used for promoting functions of respiratory systems. For instance, *Thymus vulgaris* has been shown to improve coughing and nasal disorders [291]. Also,many plant extracts have been recorded to effects the reproductive system, such as *Zingiber officinale* [292] and *Rosa canina* [293]. More importantly, some of them influence processes like spermatogenesis, sperm development, and increasing fertility, specifically *Zingiber officinale* [294].

Finally, *Silybum marianum* has been recorded as an immunostimulant due to the existence of four primary silymarin flavonolignans (silydianin, silybin, silychristin, and isosilybin) [295].

## Conclusion

The investigations of secondary metabolites (SMs) from various plant species show their significant potential in medical applications, especially as antibacterial, antifungal, antiviral, antiparasitic, antidiabetic, antioxidant/anticancer agents, and human system function promoters. The increasing resistance of bacteria to synthetic antibiotics, their possible adverse effects, and the limited availability of effective medications underscore the urgent need for alternative solutions. Plant-derived SMs hold promise due to their broad range of actions and effectiveness against various health issues. The global study of these compounds demonstrates their potential for developing novel and effective pharmaceuticals. Therefore, identifying and characterizing these bioactive compounds from locally grown plant species is crucial for utilizing their potential in treating diseases and health problems, as well as contributing to sustainable medical practices, especially in regions like Kurdistan.

## References

[1] Figueiredo, A. C., Barroso, J. G., Pedro, L. G. & Scheffer, J. J. C. Factors affecting secondary metabolite production in plants: Volatile components and essential oils. *Flavour Fragr J* **23**, doi:10.1002/ffj.1875 (2008).

[2] Abdulrahman, M. D., Mohammed, F. Z., Hamad, S. W., Hama, H. A. & Lema, A. A. Medicinal Plants Traditionally Used in the Management of COVID-19 in Kurdistan Region of Iraq. *ARO* **10**, doi:10.14500/aro.11042 (2022).

[3] Wink, M. Modes of Action of Herbal Medicines and Plant Secondary Metabolites. *Medicines* **2**, doi:10.3390/medicines2030251 (2015).

[4] Verma, S. & Singh, S. P. Current and future status of herbal medicines. *Vet World* **1** doi:10.5455/vetworld.2008.347-350 (2008).

[5] Manoharan, S. & Kaur, J. Anticancer, antiviral, antidiabetic, antifungal and phytochemical constituents of medicinal plants. *Am J PharmTech Res* **3**, (2013).

[6] Keita, K., Darkoh, C. & Okafor, F. Secondary plant metabolites as potent drug candidates against antimicrobial-resistant pathogens. *SN Appl Sci* **4**, 209, doi:10.1007/s42452-022-05084-y (2022).

[7] Alamgir, A. N. M. Cultivation of herbal drugs, biotechnology, and in vitro production of secondary metabolites, high-value medicinal plants, herbal wealth, and herbal trade. *Prog Drug Res* **73**, doi:10.1007/978-3-319-63862-1_9 (2017).

[8] Ahmed, H. M. Ethnopharmacobotanical study on the medicinal plants used by herbalists in Sulaymaniyah Province, Kurdistan, Iraq. *J Ethnobiol Ethnomed* **12**, doi:10.1186/s13002-016-0081-3 (2016).

[9] Naqishbandi, A. Plants used in Iraqi traditional medicine in Erbil - Kurdistan region. *Zanco J Med Sci* **18**, 811–815, doi:10.15218/zjms.2014.0038 (2014).

[10] Amin, H. I. M., Ibrahim, M. F., Hussain, F. H. S., Sardar, A. S. & Vidari, G. Phytochemistry and ethnopharmacology of some medicinal plants used in the Kurdistan Region of Iraq. *Nat Prod Commun* **11**, doi:10.1177/1934578x1601100306 (2016).

[11] Hooper, D. *Useful Plants and Drugs of Iran and Iraq*. Botanical series IX. Field Museum of Natural History. Chicago, U. S. A. (1937).

[12] Ahmad, S. A. & Askari, A. A. Ethnobotany of the hawraman Region of Kurdistan Iraq. *Harv Pap Bot* **20**, doi: 10.3100/hpib.v20iss1.2015.n8 (2015).

[13] Makalesi, A., Hameed, M. A., Azad Hameed, M., Uzun, A. & Saeed, J. F. Vascular Plant Species of Hujran Basin-Erbil / Iraq. *J Agric Nat Res* **19**, 279–295, (2016).

[14] Kayfi, S. & Abdulrahman, M. D. Ethnopharmacology of plants in Choman, the Kurdistan region of Iraq. *Appl Biol Res* **23**, doi:10.5958/0974-4517.2021.00042.2 (2021).

[15] Abdulrahman, M. D. Plants biodiversity utilisation in Bardarash, Kurdistan Region, Iraq. in *IOP Conf Series: Earth Environ Sci* **1185**, doi:10.1088/1755-1315/1185/1/012034 (2023).

[16] Halabi, S., Battah, A. A., Aburjai, T. & Hudaib, M. Phytochemical and antiplatelet investigation of Gundelia tournifortii. *Pharm Biol* **43**, doi:10.1080/13880200500220268 (2005).

[17] Matthäus, B. & Özcan, M. M. Chemical evaluation of flower bud and oils of tumbleweed (gundelia tourneforti l.) as a new potential nutrition sources. *J Food Biochem* **35**, doi:10.1111/j.1745-4514.2010.00449.x (2011).

[18] Guemari, F., Laouini, S. E., Rebiai, A. & Bouafia, A. Phytochemical screening and Identification of Polyphenols, Evaluation of Antioxidant activity and study of biological properties of extract Silybum marianum (L.). *Asian J Res Biochem* **13**, doi:10.5958/0974-4150.2020.00037.1 (2020).

[19] Javeed, A., Ahmed, M., Sajid, A. R., Sikandar, A., Aslam, M., *et al.* Comparative Assessment of Phytoconstituents, Antioxidant Activity and Chemical Analysis of Different Parts of Milk Thistle Silybum marianum L. *Molecules* **27**, doi:10.3390/molecules27092641 (2022).

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

[21] Hassan, N. E. & Umer, M. I. Potential of local plants as phytoremediator of polluted soil in Kwashe industrial area Duhok province, Kurdistan region. *J Jilin Univ* **42**, doi:10.17605/osf.io/4zghv (2023).

[22] Chatoui, K., Talbaoui, A., Aneb, M., Bakri, Y., Harhar, H. & Tabyaoui, M. Phytochemical screening, antioxidant and antibacterial activity of Lepidium sativum seeds from Morocco. *J Mater Environ Sci* **7**, (2016).

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

[24] Adham, A. & Naqishbandi, A. HPLC analysis and antidiabetic effect of Rheum ribes root in type 2 diabetic patients. *Zanco J Med Sci* **19**, doi:10.15218/zjms.2015.0017 (2015).

[25] Noori, S., Kiasat, A. R., Kolahi, M., Mirzajani, R. & Seyyed Nejad, S. M. Determination of secondary metabolites including curcumin in Rheum ribes L. and surveying of its antioxidant and anticancer activity. *J Saudi Chem Soc* **26**, doi:10.1016/j.jscs.2022.101479 (2022).

[26] Abdulla, K. K., Taha, E. M. & Rahim, S. M. Phenolic profile, antioxidant, and antibacterial effects of ethanol and aqueous extracts of Rheum ribes L. roots. *Pharm Lett* **7**, (2015).

[27] Hassan, H. & Shekha, Y. Detection of Parasitic Contamination of Cress Crop Irrigated with Two Types of Water in Jumka Village, Erbil – Iraq. *Rafidain J Sci* **32**, doi:10.33899/rjs.2023.178570 (2023).

[28] Amin, H. D. M., Lazim, Z. S. & Nashi, T. A. W. Phytochemical Screening of Rheum ribes Root, Leaves and Flowering Stem and Biological Activity of the Root. in *IOP Conf Series: Earth Enviro Sci* **1158**, doi:10.1088/1755-1315/1158/4/042068 (2023).

[29] Abdalla R. M. & Abdelgadir A. E. Antibacterial Activity and Phytochemical Constituents of Cinnamomum verum and Matricaria chamomilla from Sudan. *Bio Bulletin* **2**, 08-12(2016).

[30] Jahan, N., Ali, S. & Asi, M. R. Phenolic acid and flavonol contents of gemmo-modified and native extracts of some indigenous medicinal plants. *Pak J Bot* **45**, 1515–1519, (2013).

[31] Qasem, A., Assaggaf, H., Montesano, D., Khalil, Z., Al-Mijalli, S. H., *et al.* Determination of Chemical Compounds and Investigation of Biological Properties of Matricaria chamomilla Essential Oils, Honey, and Their Mixture. *Molecules* **27**, doi:10.3390/molecules27185850 (2022).

[32] Görmez, G., Battal, A., Dalar, A. & Türker, M. The investigation of the medicinal potential of Alcea Kurdica Alef. In nature and tissue culture. *Farmacia* **70**, doi:10.31925/farmacia.2022.6.23 (2022).

[33] H. Abdulqader, D., AL-Zubaydi, S. & Kadhim, E. Characterization of constituent therapeutic components of Alcea kurdica flowers and leaves using HPLC technique. *Iraqi J Pharm* **0**, doi:10.33899/iphr.2023.139258.1031 (2023).

[34] Qader, S. W. & Awad, H. M. Evaluation of antioxidant, antimicrobial and cytotoxicity of Alcea kurdica Alef. *Jordan J Biol Sci* **7**, doi:10.12816/0008240 (2014).

[35] Mariadoss, A. V. A., Park, S., Saravanakumar, K., Sathiyaseelan, A. & Wang, M. H. 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**, 1–22, doi:10.3390/antiox10010099 (2021).

[36] Kaszás, L., Alshaal, T., El-Ramady, H., Kovács, Z., Koroknai, J., *et al.* Identification of bioactive phytochemicals in leaf protein concentrate of jerusalem artichoke (Helianthus tuberosus l.). *Plants* **9**, doi:10.3390/plants9070889 (2020).

[37] Zia, P., Sunita, M. & Sneha, S. Extraction of Natural Colour from Beet Root (Beta vulgaris) its Phytochemical Analysis and Antibacterial Activity. *EAS J Nutr Food Sci* **1873**, 2663–7308, doi:10.36349/easjnfs.2021.v03i04.002 (2021).

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

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

[40] سەدرەدین نورەدین بەکر. *دەرد و نەخۆشیەلانی ڕووەک Plant Pests and Diseases*. (چاپخانەی کشتوکاڵ, 2003). Kurdistan region of Iraq.

[41] Grigore, A., Paraschiv, I., Colceru-Mihul, S., Bubueanu, C., Draghici, E. & Ichim, M. Chemical composition and antioxidant activity of Thymus vulgaris L. volatile oil obtained by two different methods. *Rom Biotechnol Lett* **15**, (2010).

[42] Al-Asmari, A. K., Athar, M. T., Al-Faraidy, A. A. & Almuhaiza, M. S. Chemical composition of essential oil of Thymus vulgaris collected from Saudi Arabian market. *Asian Pac J Trop Biomed* **7**, doi:10.1016/j.apjtb.2016.11.023 (2017).

[43] Borugă, O., Jianu, C., Mişcă, C., Goleţ, I., Gruia, A. T. & Horhat, F. G. Thymus vulgaris essential oil: chemical composition and antimicrobial activity. *J Med Life* **7**, 56–60, (2014).

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

[45] Boligon, A. A., Janovik, V., Boligon, A. A., Pivetta, C. R., Pereira, R. P., Rocha, J. B. T. Da & Athayde, M. L. HPLC analysis of polyphenolic compounds and antioxidant activity in nasturtium officinale. *Int J Food Prop* **16**, doi:10.1080/10942912.2010.528111 (2013).

[46] Taghavinia, F., Teymouri, F., Farokhrouz, F., Bagherabad, E. H., Farjami, S., Karimi, E., Oskoueian, E., Le, H. H. & Shakeri, M. Nanoliposome-Loaded Phenolics from Nasturtium officinale Improves Health Parameters in a Colorectal Cancer Mouse Model. *Animals* **12**, doi:10.3390/ani12243492 (2022).

[47] Quezada-Lázaro, R., Fernández-Zuñiga, E. A., García, A., Garza-González, E., Alvarez, L. & Camacho-Corona, M. del R. Antimycobacterial compounds from Nasturtium officinale. *Afr J Tradit Complement Altern Med* **13**, doi:10.4314/ajtcam.v13i2.3 (2016).

[48] Ercan, L. & Dogru, M. Determination of Antimicrobial Activity of Nasturtium officinale and Its Content of Volatile Organic Compounds and Fatty Acids. *J Agric Nat* **25**, doi:10.18016/ksutarimdoga.vi.1001837 (2022).

[49] Osabor, V., Bassey, F. & Umoh, U. Phytochemical Screening and Quantitative Evaluation of Nutritional Values of Zingiber officinale (Ginger). *Am Chem Sci* **8**, doi:10.9734/acsj/2015/16915 (2015).

[50] Yousfi, F., Abrigach, F., Petrovic, J. D., Sokovic, M. & Ramdani, M. Phytochemical screening and evaluation of the antioxidant and antibacterial potential of Zingiber officinale extracts. *S Afr J Bot* **142**, doi:10.1016/j.sajb.2021.07.010 (2021).

[51] Bhargava, S., Dhabhai, K., Batra, A., Sharma, A. & Malhotra, B. Zingiber Officinale : Chemical and Phytochemical Screening and Evaluation of Its Antimicrobial Activities. *J Chem Pharm Res* **4**, (2012).

[52] Ullah, M. I., Anwar, R., Kamran, S., Gul, B., Elhady, S. S. & Youssef, F. S. 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**, doi:10.3390/antiox11112232 (2022).

[53] N. Shukurlu, E. Chemical Content of L. Serriola: Fatty Acid Esters and Triterpene Compounds from the Roots. *Plant Fung Res* **1**, 61–65, doi:10.29228/plantfungalres.70 (2020).

[54] Doğan, A. & Servi, H. Chemical Composition of Essential Oil from Aerial Parts of Lactuca serriola L. *Aurum J Health Sci* **2**, 83–90, (2020).

[55] Rasul, N. Growth Performance and Microflora in Growing Quail Fed Diet Supplemented with Lactuca serriola Powder. *Mesopotamia J Agri* **48**, doi:10.33899/magrj.2020.128996.1094 (2020).

[56] Jana, S. & Shekhawat, G. S. Phytochemical analysis and antibacterial screening of in vivo and in vitro extracts of indian medicinal herb: Anethum graveolens. *Res J Med Plant* **4**, doi:10.3923/rjmp.2010.206.212 (2010).

[57] Sharopov, F. S., Wink, M., Gulmurodov, I. S., Isupov, S. J., Zhang, H. & Setzer, W. N. Composition and bioactivity of the essential oil of Anethum graveolens L. from Tajikistan. *Int J Med Aromat Plants* **3**, (2013).

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

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

[60] Sanni, S., Onyeyili, P. A. & Sanni, F. S. Phytochemical Analysis, Elemental Determination and Some in vitro Antibacterial Activity of Ocimum basilicum L. Leaf Extracts. *Res J Phytochem* **2**, doi:10.3923/rjphyto.2008.77.83 (2008).

[61] Sajjadi, S. E. Analysis of the essential oils of two cultivated basil (Ocimum basilicum L.) from Iran. *Daru* **14**, (2006).

[62] Özcan, M. & Chalchat, J.-C. Essential oil composition of Ocimum basilicum L. and Ocimum minimum L. in Turkey. *Czech J Food Sci* **20**, doi:10.17221/3536-cjfs (2002).

[63] Abdullah, A. M. Contamination of fresh vegetables with protozoan parasites, in duhok city, kurdistan region of iraq. *Med J Babylon* **18**, 416–420, doi:10.4103/mjbl.mjbl_69_21 (2021).

[64] Hosni, K., Kerkenni, A., Medfei, W., Ben Brahim, N. & Sebei, H. Volatile Oil Constituents of Rosa canina L.: Quality as Affected by the Distillation Method. *Org Chem Int* **2010**, doi:10.1155/2010/621967 (2010).

[65] Nadeem, A., Ahmed, B., Shahzad, H., Craker, L. E. & Muntean, T. Verbascum thapsus (mullein) versatile polarity extracts: GC-MS analysis, phytochemical profiling, anti-bacterial potential and anti-oxidant activity. *Pharmaco J* **13**, doi:10.5530/pj.2021.13.189 (2021).

[66] Soto, K. M., Luzardo-Ocampo, I., López-Romero, J. M., Mendoza, S., Loarca-Piña, G., Rivera-Muñoz, E. M. & Manzano-Ramírez, A. 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**, doi:10.3390/pharmaceutics14102069 (2022).

[67] Al-Mathidy, A., Al-Doskey, Z. A. S. & Shehab, M. O. M. Numerical Taxonomy of the Genus Rosa L. (Rosaceae) Grown in the Kurdistan Region of Iraq. *SABRAO J Breed Genet* **55**, doi:10.54910/sabrao2023.55.2.16 (2023).

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

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

[70] Al-Rubaye, A. F., Kaizal, A. F. & Hameed, I. H. Phytochemical Screening of Methanolic Leaves Extract of Malva sylvestris. *Int J Pharmacogn Phyto Res* **9**, doi:10.25258/phyto.v9i4.8127 (2017).

[71] Prod, J. N., Resour, P., Zohra, S. F., Meriem, B., Samira, S. & S, A. M. M. Phytochemical Screening and identification of some compounds from Mallow. *J Nat Prod Plant Reso* **2**, 512–516, (2012).

[72] DellaGreca, M., Cutillo, F., D'Abrosca, B., Fiorentino, A., Pacifico, S. & Zarrelli, A. Antioxidant and radical scavenging properties of Malva sylvestris. *Nat Prod Commun* **4**, doi:10.1177/1934578x0900400702 (2009).

[73] Ali, R. A., Muhammad, K. A. & Qadir, O. K. A survey of Nitrate and Nitrite Contents in Vegetables to Assess the Potential Health Risks in Kurdistan, Iraq. in *IOP Conf Series: Earth Environ Sci* **910**, doi:10.1088/1755-1315/910/1/012065 (2021).

[74] Tabassum, B., Babu, S. R. & Raja, A. Preliminary Phytochemical Screening of Spinacia Oleracea L. *World J Pharm Pharm Sci* **4**, (2015).

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

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

[77] Sasi Kumar, R., Balasubramanian, P., Govindaraj, P., Krishnaveni, T. & Kumar, R. S. Preliminary studies on phytochemicals and antimicrobial activity of solvent extracts of Coriandrum sativum L. roots (Coriander). *J Pharmaco Phytochem* **2**, (2014).

[78] Ahmed, E. H., Mohammed, A. M., Sudan Correspondence Abdelhafeez Mohammed, N. M., Sudan, N. & Abadi, R. S. Phytochemical screening, chemical composition and antioxidant activity of seeds essential oil of Coriandrum sativum L. from the Sudan. *Int J Herb Med* **6**, (2018).

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

[80] Shahwar, M. K., El-Ghorab, A. H., Anjum, F. M., Butt, M. S., Hussain, S. & Nadeem, M. Characterization of coriander (Coriandrum sativum L.) seeds and leaves: Volatile and non volatile extracts. *Int J Food Prop* **15**, doi:10.1080/10942912.2010.500068 (2012).

[81] Politeo, O., Bektašević, M., Carev, I., Jurin, M. & Roje, M. Phytochemical Composition, Antioxidant Potential and Cholinesterase Inhibition

Potential of Extracts from Mentha pulegium L. *Chem Biodivers* **15**, doi:10.1002/cbdv.201800374 (2018).

[82] Zekri, N., Amalich, S., Boughdad, A., El Belghiti, M. A. & Zair, T. Phytochemical study and insecticidal activity of Mentha pulegium L. oils from Morocco against Sitophilus Oryzae. *Mediterranean J Chem* **2**, doi:10.13171/mjc.2.4.2013.08.11.23 (2013).

[83] Dharsono, H. D. A., Putri, S. A., Kurnia, D., Dudi, D. & Satari, M. H. Ocimum Species: A Review on Chemical Constituents and Antibacterial Activity. *Molecules* **27**, doi:10.3390/molecules27196350 (2022).

[84] Okan, K., Aydin, S., Apaydın, E. & Sevindik, E. Antimicrobial Activity of Essential Oils from Juglans regia L.(Juglandaceae) Leaves Grown in the West Anatolian Area. *ProEnvironment* **11**, 32–36, (2018).

[85] Hu, W., Li, C., Dai, J., Cui, H. & Lin, L. Antibacterial activity and mechanism of Litsea cubeba essential oil against methicillin-resistant Staphylococcus aureus (MRSA). *Ind Crops Prod* **130**, doi:10.1016/j.indcrop.2018.12.078 (2019).

[86] Chassagne, F., Samarakoon, T., Porras, G., Lyles, J. T., Dettweiler, M., *et al.* A Systematic Review of Plants with Antibacterial Activities: A Taxonomic and Phylogenetic Perspective. *Front Pharmaco* **11** doi:10.3389/fphar.2020.586548 (2021).

[87] Wu, S. C., Yang, Z. Q., Liu, F., Peng, W. J., Qu, S. Q., Li, Q., Song, X. Bin, Zhu, K. & Shen, J. Z. Antibacterial Effect and Mode of Action of Flavonoids from Licorice Against Methicillin-Resistant Staphylococcus aureus. *Front Microbiol* **10**, doi:10.3389/fmicb.2019.02489 (2019).

[88] Alkandahri, M. Y., Kusumati, A. H. & Fikayuniar, L. Antibacterial Activity of Zingiber officinale Rhizome. *Inter J Psycho Reh* **24**, (2020).

[89] Selamoglu, Z., Sevindik, M., Bal, C., Ozaltun, B., Sen, İ. & Pasdaran, A. Antioxidant, antimicrobial and DNA protection activities of phenolic content of Tricholoma virgatum (Fr.) P. Kumm. *Biointerface Res Appl Chem* **10**, doi:10.33263/briac103.500506 (2020).

[90] Al-Rajhi, A. M. H., Qanash, H., Almuhayawi, M. S., Al Jaouni, S. K., Bakri, M. M., Ganash, M., Salama, H. M., Selim, S. & Abdelghany, T. M. Molecular Interaction Studies and Phytochemical Characterization of Mentha pulegium L. Constituents with Multiple Biological Utilities as Antioxidant, Antimicrobial, Anticancer and Anti-Hemolytic Agents. *Molecules* **27**, doi:10.3390/molecules27154824 (2022).

[91] Sevindik, M., Rasul, A., Hussain, G., Anwar, H., Zahoor, M. K., *et al.* Determination of anti-oxidative, anti-microbial activity and heavy metal contents of Leucoagaricus leucothites. *Pak J Pharm Sci* **31**, (2018).

[92] Saridogan, B. G. O., Islek, C., Baba, H., Akata, I. & Sevindik, M. Antioxidant antimicrobial oxidant and elements contents ofxylaria polymorpha and x hypoxylon (xylariaceae). *Fresenius Environ Bull* **30**, (2021).

[93] Ordaz, G., D'Armas, H., Yáñez, D., Hernández, J. & Camacho, A. Metabolitos secundarios, letalidad y actividad antimicrobiana de los extractos de tres corales y tres moluscos marinos de Sucre, Venezuela. *Rev Biol Trop* **58**, 677–688, (2010).

[94] Jubair, N., Rajagopal, M., Chinnappan, S., Abdullah, N. B. & Fatima, A. Review on the Antibacterial Mechanism of Plant-Derived Compounds against Multidrug-Resistant Bacteria (MDR). *J Evid Based Complement Altern Med* **2021**, doi:10.1155/2021/3663315 (2021).

[95] Rempe, C. S., Burris, K. P., Lenaghan, S. C. & Stewart, C. N. The potential of systems biology to discover antibacterial mechanisms of plant phenolics. *Front Microbiol* **8**, doi:10.3389/fmicb.2017.00422 (2017).

[96] Srivastava, J., Chandra, H., Nautiyal, A. R. & Kalra, S. J. S. Antimicrobial resistance (AMR) and plant-derived antimicrobials (PDAms) as an alternative drug line to control infections. *3 Biotech* **4**, 451, doi:10.1007/s13205-013-0180-y (2014).

[97] Khameneh, B., Iranshahy, M., Soheili, V. & Fazly Bazzaz, B. S. Review on plant antimicrobials: a mechanistic viewpoint. *Antimicrob Resist Infect Control* **8**, doi:10.1186/s13756-019-0559-6 (2019).

[98] Bouarab-Chibane, L., Forquet, V., Lantéri, P., Clément, Y., Léonard-Akkari, L., Oulahal, N., Degraeve, P. & Bordes, C. Antibacterial Properties of Polyphenols: Characterization and QSAR (Quantitative Structure–Activity Relationship) Models. *Front Microbiol* **10**, 829, doi:10.3389/fmicb.2019.00829 (2019).

[99] Balogun, S., Stephenson, C., … A. O.-J. of C. & 2017, U. Antipseudomonal activity of aqueous and methanolic leaf extracts of Lactuca serriola Linn. (Astereceae). *Int J Adv Pharm, Biol Chem* **6**, (2017).

[100] Keshavarzi, Z., Shakeri, F., Maghool, F., Jamialahmadi, T., Johnston, T. P. & Sahebkar, A. A Review on the Phytochemistry, Pharmacology, and Therapeutic Effects of Rheum ribes. *Adv Exp Med Biol* **1328** doi:10.1007/978-3-030-73234-9_30 (2021).

[101] Mohammed, F. S., Sevindik, M., Uysal, I., Sevindik, E. & Akgül, H. A Natural Material for Suppressing the Effects of Oxidative Stress: Biological Activities of Alcea kurdica. *Biol Bullet* **49**, doi:10.1134/s1062359022140102 (2022).

[102] Masoody, I. H. Al, Alarkwazi, R. K. & Yasssiry, A. S. Al. Pharmaceutical and Biological Properties of Dill: A Review. in *IOP Conf Series: Earth Environ Sci* **1158**, doi:10.1088/1755-1315/1158/6/062005 (2023).

[103] Azizkhani, M., Jafari Kiasari, F., Tooryan, F., Shahavi, M. H. & Partovi, R. Preparation and evaluation of food-grade nanoemulsion of tarragon (Artemisia dracunculus L.) essential oil: antioxidant and antibacterial properties. *J Food Sci Technol* **58**, 1341–1348, doi:10.1007/s13197-020-04645-6 (2021).

[104] Ali Esmail Al-Snafi & Lawahidh Fali Hasham. Bioactive constituents and pharmacological importance of Matricaria chamomilla: A recent review. *GSC biol pharm sci* **22**, doi:10.30574/gscbps.2023.22.2.0477 (2023).

[105] Evren, E. & Yurtcu, E. In vitro effects on biofilm viability and antibacterial and antiadherent activities of silymarin. *Folia Microbiol* **60**, 351–356, doi:10.1007/s12223-015-0399-6 (2015).

[106] Shabih, S., Hajdari, A., Mustafa, B. & Quave, C. L. Medicinal plants in the Balkans with antimicrobial properties. in *Medicinal Plants as Anti-infectives: Curr Know New Persp,* 103-138, doi:10.1016/b978-0-323-90999-0.00013-6 (2022).

[107] El-Mesallamy, A. M. D., El-Latif, A. E. S. A., El-Azim, M. H. A., Mahdi, M. G. M. & Hussein, S. A. M. Chemical composition and biological activities of red beetroot (Beta Vulgaris Linnaeus) roots. *Egypt J Chem* **63**, doi:10.21608/ejchem.2019.17977.2092 (2020).

[108] Tabesh, M., Sh, Me., Etemadi, M., Naddaf, F., Heidari, F. & Alizargar, J. The antibacterial activity of nasturtium officinale extract on common oral pathogenic bacteria. *Niger J Clin Pract* **25**, doi:10.4103/njcp.njcp_1887_21 (2022).

[109] Alkufeidy, R. M., Al Farraj, D. A., Aljowaie, R. M., Ali, M. A. & Elshikh, M. S. Chemical composition of Thymus vulgaris extracts and antibacterial activity against pathogenic multidrug resistance bacteria. *Physiol Mol Plant Pathol* **117**, doi:10.1016/j.pmpp.2021.101745 (2022).

[110] Tian, J., Ban, X., Zeng, H., Huang, B., He, J. & Wang, Y. In vitro and in vivo activity of essential oil from dill (Anethum graveolens L.) against fungal spoilage of cherry tomatoes. *Food Control* **22**, doi:10.1016/j.foodcont.2011.05.018 (2011).

[111] Namik, S., Novruz, A. & Farrukh, B. Antifungal Effect of Lactuca tatarica and Lactuca Aerriola Plant Extracts to some Phytopathogenic Fungi. *Scientific News* **4**, 75–82, doi:10.5281/zenodo.7520096 (2022).

[112] Zhaleh, M., Zangeneh, A., Goorani, S., Seydi, N., Zangeneh, M. M., Tahvilian, R. & Pirabbasi, E. In vitro and in vivo evaluation of cytotoxicity, antioxidant, antibacterial, antifungal, and cutaneous wound healing properties of gold nanoparticles produced via a green chemistry synthesis using Gundelia tournefortii L. as a capping and reducing agent. *Appl Organomet Chem* **33**, doi:10.1002/aoc.5015 (2019).

[113] Janeczko, M. & Kochanowicz, E. Silymarin, a popular dietary supplement shows anti–Candida activity. *Antibiotics* **8**, doi:10.3390/antibiotics8040206 (2019).

[114] Mohammed, F. S., Pehlivan, M. & Sevindik, M. Antioxidant, Antibacterial and Antifungal Activities of Different Extracts of Silybum marianum Collected from Duhok (Iraq). *Int J Sec Met* **6**, doi:10.21448/ijsm.581500 (2020).

[115] Yaldiz, G. Effects of potassium sulfate [K2SO4] on the element contents, polyphenol content, antioxidant and antimicrobial activities of milk thistle [Silybum marianum]. *Pharmacogn Mag* **13**, doi:10.4103/0973-1296.197641 (2017).

[116] Mustafa Mahdi Auda, Hajir Ali Shareef & Bari Lateef Mohammed. Green synthesis of Silver Nanoparticles using the extract of Rheum ribes and evaluating their antifungal activity against some of Candida sp. *Tikrit J Pure Sci* **26**, doi:10.25130/tjps.v26i2.119 (2022).

[117] Höferl, M., Wanner, J., Tabanca, N., Ali, A., Gochev, V., Schmidt, E., Kaul, V. K., Singh, V. & Jirovetz, L. Biological Activity of Matricaria chamomilla Essential Oils of Various Chemotypes. *Planta Medica Int Open* **07**, e114–e121, doi:10.1055/a-1186-2400 (2020).

[118] Abdullah, A., Jafar, F., Proceedings, A. S.-A. C. & 2022, U. Evaluation study of Matricaria chamomilla extract toward pathogenic isolates of

Candida. *The 9th Int Conf Appl Sci Technol (ICAST 2021)* **2547**, doi:10.1063/5.0121876 (2022).
[119] EL-Hefny, M., Abo Elgat, W. A. A., Al-Huqail, A. A. & Ali, H. M. Essential and recovery oils from Matricaria chamomilla flowers as environmentally friendly fungicides against four fungi isolated from cultural heritage objects. *Processes* **7**, doi:10.3390/pr7110809 (2019).
[120] Malm, A., Grzegorczyk, A., Biernasiuk, A., Baj, T., Rój, E., *et al.* Could supercritical extracts from the aerial parts of helianthus salicifolius a. Dietr. and helianthus tuberosus L. be regarded as potential raw materials for biocidal purposes? *Agriculture* **11**, doi:10.3390/agriculture11010010 (2021).
[121] Chen, F. J., Long, X. H. & Li, E. Z. Evaluation of antifungal phenolics from Helianthus tuberosus L. leaves against Phytophthora capsici leonian by chemometric analysis. *Molecules* **24**, doi:10.3390/molecules24234300 (2019).
[122] Piras, A., Porcedda, S., Falconieri, D., Maxia, A., Gonçalves, M., Cavaleiro, C. & Salgueiro, L. Antifungal activity of essential oil from Mentha spicata L. and Mentha pulegium L. growing wild in Sardinia island (Italy). *Nat Prod Res* **35**, doi:10.1080/14786419.2019.1610755 (2021).
[123] Rizwana, H. & Alwhibi, M. S. Biosynthesis of silver nanoparticles using leaves of Mentha pulegium, their characterization, and antifungal properties. *Green Process Synth* **10**, doi:10.1515/gps-2021-0079 (2021).
[124] Alves, M., Gonçalves, M. J., Zuzarte, M., Alves-Silva, J. M., Cavaleiro, C., Cruz, M. T. & Salgueiro, L. Unveiling the antifungal potential of two iberian thyme essential oils: Effect on C. albicans germ tube and preformed biofilms. *Front Pharmacol* **10**, doi:10.3389/fphar.2019.00446 (2019).
[125] Moazeni, M., Davari, A., Shabanzadeh, S., Akhtari, J., Saeedi, M., *et al.* In vitro antifungal activity of Thymus vulgaris essential oil nanoemulsion. *J Herb Med* **28**, doi:10.1016/j.hermed.2021.100452 (2021).
[126] Ahmad, K., Khalil, A. talha & Somayya, R. Antifungal, phytotoxic and hemagglutination activity of methanolic extracts of Ocimum basilicum. *J Tradit Chin Med* **36**, doi:10.1016/s0254-6272(17)30017-1 (2016).
[127] Elsherbiny, E. A., Safwat, N. A. & Elaasser, M. M. Fungitoxicity of organic extracts of Ocimum basilicum on growth and morphogenesis of Bipolaris species (teleomorph Cochliobolus). *J Appl Microbiol* **123**, doi:10.1111/jam.13543 (2017).
[128] Gulbagca, F., Ozdemir, S., Gulcan, M. & Sen, F. Synthesis and characterization of Rosa canina-mediated biogenic silver nanoparticles for anti-oxidant, antibacterial, antifungal, and DNA cleavage activities. *Heliyon* **5**, doi:10.1016/j.heliyon.2019.e02980 (2019).
[129] Gayoso, C. W., Lima, E. O., Oliveira, V. T., Pereira, F. O., Souza, E. L., Lima, I. O. & Navarro, D. F. Sensitivity of fungi isolated from onychomycosis to Eugenia cariophyllata essential oil and eugenol. *Fitoterapia* **76**, doi:10.1016/j.fitote.2004.12.005 (2005).
[130] Viuda-Martos, M., Ruiz-Navajas, Y., Fernández-López, J. & Pérez-Álvarez, J. A. Antifungal activities of thyme, clove and oregano essential oils. *J Food Saf* **27**, 91–101, doi:10.1111/j.1745-4565.2007.00063.x (2007).
[131] Bansal, V., Gupta, M., Bhaduri, T., Shaikh, S. A., Sayed, F. R., Bansal V., Agrawal, A. Assessment of antimicrobial effectiveness of neem and clove extract against Streptococcus mutans and Candida albicans: an in vitro study. *Nigerian Med J* **60**, doi: 10.4103/nmj.NMJ_20_19 (2020).
[132] Ribeiro, A., Barros, L., Calhelha, R. C., Carocho, M., Ćirić, A., *et al.* Tarragon phenolic extract as a functional ingredient for pizza dough: Comparative performance with ascorbic acid (E300). *J Funct Foods* **26**, doi:10.1016/j.jff.2016.08.019 (2016).
[133] Al-Otibi, F., Perveen, K., Al-Saif, N. A., Alharbi, R. I., Bokhari, N. A., Albasher, G., Al-Otaibi, R. M. & Al-Mosa, M. A. Biosynthesis of silver nanoparticles using Malva parviflora and their antifungal activity. *Saudi J Biol Sci* **28**, doi:10.1016/j.sjbs.2021.01.012 (2021).
[134] Mejri, S., Siah, A., Coutte, F., Magnin-Robert, M., Randoux, B., *et al.* Biocontrol of the wheat pathogen Zymoseptoria tritici using cyclic lipopeptides from Bacillus subtilis. *Environ Sci Pollut Res* **25**, doi:10.1007/s11356-017-9241-9 (2018).
[135] Hellin, P., King, R., Urban, M., Hammond-Kosack, K. E. & Legrève, A. The adaptation of Fusarium culmorum to DMI fungicides is mediated by major transcriptome modifications in response to azole fungicide, including the overexpression of a PDR transporter (FcABC1). *Front Microbiol* **9**, doi:10.3389/fmicb.2018.01385 (2018).
[136] Raveau, R., Fontaine, J., Soltani, A., Jemâa, J. M. Ben, Laruelle, F. & Sahraoui, A. L. H. In Vitro Potential of Clary Sage and Coriander Essential Oils as Crop Protection and Post-Harvest Decay Control Products. *Foods* **11**, doi:10.3390/foods11030312 (2022).
[137] Pereira, A. A., de Oliveira Andrade, A., de Andrade Palis, A., Cabral, A. M., Barreto, C. G. L., *et al.* Non-pharmacological treatments for COVID-19: current status and consensus. *Res Biomed Eng* **38**, 193–208, doi:10.1007/s42600-020-00116-1/tables/2 (2022).
[138] Habibzadeh, S. & Zohalinezhad, M. E. Antiviral activity of Matricaria chamomilla in the treatment of COVID-19: Molecular Docking study. *Eur J Integr Med* **48**, doi:10.1016/j.eujim.2021.101975 (2021).
[139] Ćavar Zeljković, S., Schadich, E., Džubák, P., Hajdúch, M. & Tarkowski, P. Antiviral Activity of Selected Lamiaceae Essential Oils and Their Monoterpenes Against SARS-Cov-2. *Front Pharmacol* **13**, doi:10.3389/fphar.2022.893634 (2022).
[140] Catella, C., Camero, M., Lucente, M. S., Fracchiolla, G., Sblano, S., Tempesta, M., Martella, V., Buonavoglia, C. & Lanave, G. Virucidal and antiviral effects of Thymus vulgaris essential oil on feline coronavirus. *Res Vet Sci* **137**, doi:10.1016/j.rvsc.2021.04.024 (2021).
[141] Kurnia, D., Putri, S. A., Tumilaar, S. G., Zainuddin, A., Dharsono, H. D. A. & Amin, M. F. In silico Study of Antiviral Activity of Polyphenol Compounds from Ocimum basilicum by Molecular Docking, ADMET, and Drug-Likeness Analysis. *Adv Appl Bioinforma Chem* **16**, doi:10.2147/aabc.s403175 (2023).
[142] Rathinavel, T., Palanisamy, M., Palanisamy, S., Subramanian, A. & Thangaswamy, S. Phytochemical 6-Gingerol-A promising Drug of choice for COVID-19. *Int J Adv Sci Eng* **6**, 1482, doi:10.29294/ijase.6.4.2020.1482-1489 (2020).
[143] Pandit, M. In silico studies reveal potential antiviral activity of phytochemicals from medicinal plants for the treatment of COVID-19 infection. *Res Sq* (2020).
[144] Okasha, Y. M., Fathy, F. I., Soliman, F. M. & Fayek, N. M. The untargeted phytochemical profile of Verbascum thapsus L. with potent antiviral, antibacterial and anticancer activities. *S Afr J Bot* **156**, doi:10.1016/j.sajb.2023.03.035 (2023).
[145] Batiha, G. E. S., Olatunde, A., El-mleeh, A., Hetta, H. F., Al-rejaie, S., *et al.* Bioactive compounds, pharmacological actions, and pharmacokinetics of wormwood (Artemisia absinthium). *Antibiotics* **9** doi:10.3390/antibiotics9060353 (2020).
[146] Cui, X., Wang, Y., Kokudo, N., Fang, D. & Tang, W. Traditional Chinese medicine and related active compounds against hepatitis B virus infection. *Biosci Trends* **4**, 39–47, (2010).
[147] Munir, A., Jahan, S., Saleem, F. & Raza, H. An in silico molecular docking study to evaluate the inhibitory potential of Cichorium intybus, Saussurea lappa, Trigonella foenum-graecum, Glycin max. Lepidium sativum andNigella sativa against NS5B of HCV to treat hepatitis C. *Journal of Xi'an Shiyou University, Nat Sci Ed* **19**, (2023).
[148] Gamage, K., Dissanayake, C., Angoda, W., Chandrasiri Waliwita, L. & Liyanage, R. P. A Review on Medicinal Uses of Zingiber Officinale (Ginger). *Int J Health Sci Res* **10**, (2020).
[149] Batiha, G. E. S., Alkazmi, L. M., Wasef, L. G., Beshbishy, A. M., Nadwa, E. H. & Rashwan, E. K. Syzygium aromaticum l. (myrtaceae): Traditional uses, bioactive chemical constituents, pharmacological and toxicological activities. *Biomolecules* **10**, doi:10.3390/biom10020202 (2020).
[150] Valdiviezo-Campos, J., Aredo, C. & Ruiz-Reyes, S. In Silico Potential Antiviral Activity of Polyphenols from Plants Used in Traditional Medicine in La Libertad Región, Peru. *Plant Sci*, doi:10.20944/preprints202305.1669.v1 (2023).
[151] Payer, B. A., Reiberger, T., Rutter, K., Beinhardt, S., Staettermayer, A. F., Peck-Radosavljevic, M. & Ferenci, P. Successful HCV eradication and inhibition of HIV replication by intravenous silibinin in an HIV-HCV coinfected patient. *J Clin Virol* **49**, doi:10.1016/j.jcv.2010.07.006 (2010).
[152] Neumann, U. P., Biermer, M., Eurich, D., Neuhaus, P. & Berg, T. Successful prevention of hepatitis C virus (HCV) liver graft reinfection by silibinin mono-therapy. *J Hepat* **52** doi:10.1016/j.jhep.2010.02.002 (2010).
[153] Xu, X., Zhang, Y. & Li, Q. Characteristics of herpes simplex virus infection and pathogenesis suggest a strategy for vaccine development. *Rev Med Virol* **29**, doi:10.1002/rmv.2054 (2019).
[154] Batiha, G. E. S., Alkazmi, L. M., Wasef, L. G., Beshbishy, A. M., Nadwa, E. H. & Rashwan, E. K. Syzygium aromaticum l. (myrtaceae): Traditional uses, bioactive chemical constituents, pharmacological and toxicological activities. *Biomolecules* **10**, doi:10.3390/biom10020202 (2020).

[155] Abdel-Hady, H., Hamed, M. M., Nasr, S. M., El-Wakil, E. A. & Morsi, E. A. Comparative Study of Alpinia officinarum and Zingiber officinale Root Extracts for Chemical Composition, Antioxidant Potential and Cell Mediated Blocking of HSV-II Activities. *Egypt J Chem* **67**, 127–137, doi:10.21608/ejchem.2024.267627.9283 (2024).

[156] de Lima Cavalcanti, T. Y. V., Pereira, M. R., de Paula, S. O. & Franca, R. F. de O. A Review on Chikungunya Virus Epidemiology, Pathogenesis and Current Vaccine Development. *Viruses* **14**, doi:10.3390/v14050969 (2022).

[157] Camini, F. C., da Silva, T. F., da Silva Caetano, C. C., Almeida, L. T., Ferraz, A. C., *et al.* Antiviral activity of silymarin against Mayaro virus and protective effect in virus-induced oxidative stress. *Antiviral Res* **158**, doi:10.1016/j.antiviral.2018.07.023 (2018).

[158] Hayati, R. F., Better, C. D., Denis, D., Komarudin, A. G., Bowolaksono, A., Yohan, B. & Sasmono, R. T. [6]-Gingerol Inhibits Chikungunya Virus Infection by Suppressing Viral Replication. *Biomed Res Int* **2021**, 6623400, doi:10.1155/2021/6623400 (2021).

[159] Habeballa, R. S., Ibrahim, E. A., Awad, N. S. & Abdein, M. A. In vitro antiviral activity of Illicium verum and Zingiber officinale ethanolic extracts. *Med Sci* **24**, (2020).

[160] Kurćubić, V., Mašković, P., Petrović, T., Lazić, S. & Đukić, D. Antiviral activity in vitro of five selected indigenous plants against bovine herpes virus-1 (BHV-1) and bovine viral diarrhoea virus (BVDV). *J Immunol Immunopathol* **13**, 30-37, (2019).

[161] Valdiviezo-Campos, J., Aredo, C. & Ruiz-Reyes, S. In Silico Potential Antiviral Activity of Polyphenols from Plants Used in Traditional Medicine in La Libertad Región, Peru. *Plant Sci*, doi:10.20944/preprints202305.1669.v1 (2023).

[162] Raoof, G. F. A. & Mohamed, A. W. L. Exploring the antiparasitic activity of medicinal plants. *Univ J Pharma* **5,** 71-75, *Res* doi:10.22270/ujpr.v5i4.442 (2020).

[163] Al-Otaibi, M. S. A., Al-Quraishy, S., Al-Malki, E. S. & Abdel-Baki, A. S. Therapeutic potential of the methanolic extract of Lepidium sativum seeds on mice infected with Trypanosoma evansi. *Saudi J Biol Sci* **26**, doi:10.1016/j.sjbs.2018.08.031 (2019).

[164] Emiru, A. Y., Makonnen, E., Regassa, F., Regassa, F. & Tufa, T. B. Antitrypanosomal activity of hydromethanol extract of leaves of Cymbopogon citratus and seeds of Lepidium sativum: in-vivo mice model. *BMC Complement Med Ther* **21**, doi:10.1186/s12906-021-03449-1 (2021).

[165] Jasim, A. H. Effect of the garden cress, lepidium sativum l. leaf extract on protoscolices of echinococcus granulosus of sheep origin in in vitro conditions. *Plant Arch* **20**, (2020).

[166] Mahmoudvand, H., Saki, M., Kiani, A. A., Taban, T. & Shahmoradi, M. K. In vitro and Ex vivo Antiparasitic Effect of Rheum ribes L. Extract Against the Hydatid Cyst Protoscoleces. *Infect Disord Drug Targets* **21**, doi:10.2174/1871526520666201116094851 (2020).

[167] Karam, T. K., Ortega, S., Ueda Nakamura, T., Auzély-Velty, R. & Nakamura, C. V. Development of chitosan nanocapsules containing essential oil of Matricaria chamomilla L. for the treatment of cutaneous leishmaniasis. *Int J Biol Macromol* **162**, doi:10.1016/j.ijbiomac.2020.06.149 (2020).

[168] Sahandi, J., Bagherzadeh Lakani, F., Zorriehzahra, M. J. & Shohreh, P. Effects of garlic (Allium sativum) and chamomile (Matricaria chamomilla) extracts on Ichthyophthirius multifiliis parasite in guppy fish (Poecilia reticulata). *J Surv Fish Sci* **10**, (2023).

[169] Gharakhani Deh Sorkhi, S. & Taqipour Dehkordi, M. The effect of hydroalcoholic Matricaria chamomilla on the survival of protoscolices of sheep hydatid cyst. *Research in Cell and Tissue* **2**, 26–31, doi:10.30495/rkctc.2022.66639.1037 (2021).

[170] Albohiri, H. H., Al-Zanbagi, N. A., Alzahrani, M. S., Albohairi, S. H., Alsulami, M. N., Abdel-Gaber, R., Al-Quraishy, S. & Yehia, R. S. Evaluation of antiplasmodial potential of Beta vulgaris juice in Plasmodium berghei infected mice. *J King Saud Univ Sci* **34**, doi:10.1016/j.jksus.2022.101844 (2022).

[171] Oghogho U. I., Ekugum, E., Ogbeide, O. K., Idagan, M., Uadia, J. O. & Falodun, A. Phytochemical Assessment, Anti-inflammatory and Antimalarial Activities of Beta vulgaris (Chenopodiaceae) Root Extract. *Trop J Phytochem Pharmc Sci* **1**, doi:10.26538/tjpps/v1i1.3 (2022).

[172] Sebai, E., Serairi, R., Saratsi, K., Abidi, A., Sendi, N., Darghouth, M. A., Wilson, M. S., Sotiraki, S. & Akkari, H. Hydro-Ethanolic Extract of Mentha pulegium Exhibit Anthelmintic and Antioxidant Proprieties in Vitro and In Vivo. *Acta Parasitol* **65**, doi:10.2478/s11686-020-00169-3 (2020).

[173] Abu El Ezz, Aboelsoued, D., Hassan, S. E., Abdel Megeed, K. N. & El-Metenawy, T. M. Therapeutic effect of moringa oleifera and thymus vulgaris oils against hepatic coccidiosis in experimentally infected rabbits. *Trop Biomed* **37**, doi:10.47665/tb.37.4.1018 (2020).

[174] Farrag, H. M. M., Yones, D. A., Hassanin, E. S. A., Ibraheim, Z. Z. & Huseein, E. A. E. H. M. Thymus vulgaris, Mentha piperita and Elettaria cardamomum against Trypanosoma evansi in vitro and in an animal model with new insights for the treatment of trypanosomosis. *Ann Parasitol* **67**, doi:10.17420/ap6701.308 (2021).

[175] Fu, Y. W., Wang, B., Zhang, Q. Z., Xu, D. H., Liu, Y. M., Hou, T. L. & Guo, S. Q. Efficacy and antiparasitic mechanism of 10-gingerol isolated from ginger Zingiber officinale against Ichthyophthirius multifiliis in grass carp. *Vet Parasitol* **265**, doi:10.1016/j.vetpar.2018.11.011 (2019).

[176] Salama, M., El sayed Mostafa, N., Abd El-Aal, N. F., Moawad, H., Ahmed Mohamed Salama, M., *et al.* Efficacy of Zingiber officinale and Cinnamomum zeylanicum extracts against experimental Trichinella spiralis infection. *J Parasit Dis* **46**, 24–36, doi:10.1007/s12639-021-01412-y (2022).

[177] Castro, L. M., Pinto, N. B., Moura, M. Q., Villela, M. M., Capella, G. A., Freitag, R. A. & Berne, M. E. A. Antihelminthic action of the anethum graveolens essential oil on haemonchus contortus eggs and larvae. *Braz J Biol* **81**, doi:10.1590/1519-6984.225856 (2021).

[178] Abas, A. S. M. & Elagib, S. M. Antiparasitic activity of aqueous extract of Anethum graveolens against Entamoeba histolytica: In vitro and in vivo study. *Biocatal Agric Biotechnol* **34**, doi:10.1016/j.bcab.2021.102026 (2021).

[179] Osei Akoto, C., Acheampong, A., Boakye, Y. D., Naazo, A. A. & Adomah, D. H. Anti-Inflammatory, Antioxidant, and Anthelmintic Activities of Ocimum basilicum (Sweet Basil) Fruits. *J Chem* **2020**, doi:10.1155/2020/2153534 (2020).

[180] Ileke, K. D. & Adesina, J. M. Toxicity of ocimum basilicum and ocimum gratissimum extracts against main malaria vector, anopheles gambiae (Diptera: Culicidae) in Nigeria. *J Arthropod Borne Dis* **13**, doi:10.18502/jad.v13i4.2232 (2019).

[181] Chalechale, A., Zangeneh, M. M., Zangeneh, A., Hamzavi, Y. & Valadkhani, Z. Chemical characterization and anti-parasitic property of essential oil of Coriandrum sativum leaf against Trichomonas vaginalis. *J Pharmaco Therap* **17**, 1–7, (2019).

[182] Ismail, R. M. The role of Coriandrum sativum in treatment of kidney lesions that induced by Toxoplasma gondii in male rats. *Texas J Agr Biol Sci* **14**, (2023).

[183] Fakhrieh-Kashan, Z., Arbabi, M., Delavari, M., Mohebali, M. & Hooshyar, H. Induction of apoptosis by alcoholic extract of combination verbascum thapsus and ginger officinale on Iranian isolate of trichomonas vaginalis. *Iran J Parasitol* **13**, (2018).

[184] Fahmy, A., Zalat, R. & Rabei, A. In vitro evaluation of the antiparasitic activity of Syzygium aromaticum against adult and larval stages of Trichinella spiralis. *Sci Parasitol* **21**, (2020).

[185] Teles, A., Silva-Silva, J., … J. F.-E.-B. & 2021, U. GC-MS characterization of antibacterial, antioxidant, and antitrypanosomal activity of Syzygium aromaticum essential oil and eugenol. *J Evid Based Complement Altern Med* **2021**, doi.org/10.1155/2021/6663255 (2021).

[186] E-S Batiha, G., Beshbishy, A. M., Tayebwa, D. S., Adeyemi, O. S., Yokoyama, N. & Igarashi, I. Anti-piroplasmic potential of the methanolic Peganum harmala seeds and ethanolic Artemisia absinthium leaf extracts. *J Protozool Res* **29**, (2019).

[187] Habibi, H., Firouzi, S., Nili, H., Razavi, M., Asadi, S. L. & Daneshi, S. Anticoccidial effects of herbal extracts on Eimeria tenella infection in broiler chickens: in vitro and in vivo study. *J Paras Dis* **40**, doi:10.1007/s12639-014-0517-4 (2016).

[188] Ding, Y. B., Chen, J., Huang, L. X., Gong, Y. L., Yuan, F. H. & Tu, J. W. Anti-trypanosomal effect of Malva sylvestris (Malvaceae) extract on a Trypanosoma brucei brucei-infected mouse model of sleeping sickness. *Trop J Pharm Res* **16**, doi:10.4314/tjpr.v16i10.9 (2017).

[189] Konak, M., Ates, M. & Şahan, Y. Evaluation of Antioxidant Properties of Gundelia tournefortii: A Wild Edible Plant. *J Agri Faculty Uludag Univ* **31**, 101–108, (2017).

[190] Farhang, H. R., Vahabi, M. R. & Allafchian, A. R. Chemical compositions of the essential oil of Gundelia tournefortii L. (Asteraceae) from Central Zagros, Iran Hamid. *J Herb Drug* **6**, (2016).

[191] Keskin, M., Kaya, G. & Keskin, Ş. Gundelia Tournefortii L. (Kenger): Determination of in vitro Antidiabetic Activities. *Prog Nutr* **23**, doi:10.23751/pn.v23i4.11079 (2021).

[192] Painuli, S., Quispe, C., Herrera-Bravo, J., Semwal, P., Martorell, M., *et al.* Nutraceutical Profiling, Bioactive Composition, and Biological Applications of Lepidium sativum L. *Oxid Med Cell Longev* **2022** doi:10.1155/2022/2910411 (2022).

[193] AL-Snafi, A. E. Chemical Constituents and Pharmacological Effects of Lepidium sativum-a Review. *Int J Curr Pharm Res* **11**, doi:10.22159/ijcpr.2019v11i6.36338 (2019).

[194] Shukla, A., Bigoniya, P. & Srivastava, B. Hypoglycemic activity of lepidium sativum linn seed total alkaloid on alloxan induced diabetic rats. *Res J Medic Plant* **6**, doi:10.3923/rjmp.2012.587.596 (2012).

[195] Arshad, A., Pervaiz, S., Errum, A., Mahmood, A., Asghar, H., Maqsood, S. & Shamim, S. Evaluation of Antidiabetic Effect of Silybum marianum and Cichorium intybus extracts. *Pak J Med Health Sci* **16**, doi:10.53350/pjmhs22161820 (2022).

[196] Wang, X., Zhang, Z. & Wu, S. C. Health Benefits of Silybum marianum: Phytochemistry, Pharmacology, and Applications. *J Agric Food Chem* **68**, doi:10.1021/acs.jafc.0c04791 (2020).

[197] Hajizadeh-Sharafabad, F., Varshosaz, P., Jafari-Vayghan, H., Alizadeh, M. & Maleki, V. Chamomile (Matricaria recutita L.) and diabetes mellitus, current knowledge and the way forward: A systematic review. *Complement Ther Med* **48**, doi:10.1016/j.ctim.2019.102284 (2020).

[198] Mechchate, H., Es-Safi, I., Louba, A., Alqahtani, A. S., Nasr, F. A., *et al.* In vitro alpha-amylase and alpha-glucosidase inhibitory activity and in vivo antidiabetic activity of withania frutescens l. Foliar extract. *Molecules* **26**, doi:10.3390/molecules26020293 (2021).

[199] Mohammed, H. S., Abdel-Aziz, M. M., Abu-Baker, M. S., Saad, A. M., Mohamed, M. A. & Ghareeb, M. A. Antibacterial and Potential Antidiabetic Activities of Flavone C-glycosides Isolated from Beta vulgaris Subspecies cicla L. var. Flavescens (Amaranthaceae) Cultivated in Egypt. *Curr Pharm Biotechnol* **20**, doi:10.2174/1389201020666190613161212 (2019).

[200] Mashraqi, A. Induction role of chitosan nanoparticles to Anethum graveolens extract against food-borne bacteria, oxidant, and diabetic activities in vitro. *Front Microbiol* **14**, doi:10.3389/fmicb.2023.1209524 (2023).

[201] Manea, H. C., Predut, D., Popovici, R. A., Draghici, G., Dolghi, A. & Poenaru, M. Evaluation of the antimicrobial and cytotoxic activity of an aqueous extract of Anethum graveolens L. seeds. *J Agroaliment Process Technol* **26**, 406–409, (2020).

[202] Navarro, B. F., Martínez, M. B., Castro, B. B., Castillo, O. l., Lopez-Rodrgiues M., Padilla Arellanes S. & Vazquez H. A. Antioxidant and Hypoglycemic Effects of Watercress (Nasturtium Officinale) Extracts in Diabetic Rats. *Afr J Tradit Complement Altern Med* **15**, doi:10.21010/ajtcam.v15i2.9 (2018).

[203] Al-Snafi, A. E. A review on Nasturtium officinale: A potential medicinal plant IOSR Journals A review on Nasturtium officinale: A potential medicinal plant. *IOSR J Pharm* **10**, (2020).

[204] Aljarah, A. K. & Hameed, I. H. In vitro anti-diabetic properties of methanolic extract of thymus vulgaris using α-glucosidase and α-amylase inhibition assay and determination of its bioactive chemical compounds. *Indian J Public Health Res Dev* **9**, doi:10.5958/0976-5506.2018.00241.3 (2018).

[205] Dessalegn, E., Bultosa, G., Haki, G. D. & Rupasinghe, H. P. V. Evaluation of In vitro Antidiabetic Potential of Thymus schimperi R. and Thymus vulgaris L. *J Health, Med Nurs* **69**, doi:10.7176/jhmn/69-02 (2019).

[206] Fattahi, A., Niyazi, F., Shahbazi, B., Farzaei, M. H. & Bahrami, G. Antidiabetic Mechanisms of Rosa canina Fruits: An in Vitro Evaluation. *J Evid Based Complementary Altern Med* **22**, doi:10.1177/2156587216655263 (2017).

[207] Bahrami, G., Izadi, B., Miraghaee, S. S., Mohammadi, B., Hatami, R., Sajadimajd, S. & Batooie, N. Antidiabetic potential of the isolated fractions from the plants of Rosaceae family in streptozotocin-induced diabetic rats. *Res Pharm Sci* **16**, doi:10.4103/1735-5362.323917 (2021).

[208] Bahrami, G., Miraghaee, S. S., Mohammadi, B., Bahrami, M. T., Taheripak, G., Keshavarzi, S., Babaei, A., Sajadimajd, S. & Hatami, R. Molecular mechanism of the anti-diabetic activity of an identified oligosaccharide from Rosa canina. *Res Pharm Sci* **15**, doi:10.4103/1735-5362.278713 (2020).

[209] Gulcin, İ. Antioxidants and antioxidant methods: an updated overview. *Arch Toxicol* **94** doi:10.1007/s00204-020-02689-3 (2020).

[210] Patterson, R. E., White, E., Kristal, A. R., Neuhouser, M. L. & Potter, J. D. Vitamin supplements and cancer risk: the epidemiologic evidence. *Cancer Causes & Control* **8**, 786–802, (1997).

[211] Shigenaga, M. K. & Ames, B. N. Oxidants and mitogenesis as causes of mutation and cancer: the influence of diet. *Antimutagenesis and anticarcinogenesis mechanisms III*. *Basic Life Sci* **61**, 419–436, doi: 10.1007/978-1-4615-2984-2_37 (1993).

[212] Tarhan, A., Firat, M. & Topal, G. Comprehensive study of all Gundelia L. taxa exists in the globe: An insight on LC-MS/MS based phytochemical investigation and bioactivity potential of 22 species. *Biochem Syst Ecol* **109**, 104672, (2023).

[213] Getahun, T., Sharma, V. & Gupta, N. Chemical composition, antibacterial and antioxidant activities of oils obtained by different extraction methods from Lepidium sativum L. seeds. *Ind Crops Prod* **156**, doi:10.1016/j.indcrop.2020.112876 (2020).

[214] Peña, F., Valencia, S., Tereucán, G., Nahuelcura, J., Jiménez-Aspee, F., Cornejo, P. & Ruiz, A. Bioactive Compounds and Antioxidant Activity in the Fruit of Rosehip (Rosa canina L. and Rosa rubiginosa L.). *Molecules* **28**, doi:10.3390/molecules28083544 (2023).

[215] Zaman, S., Ahmad, R., Binobead, M. A., Gawwad, M. R. A., Elshikh, M. S., Gafforov, Y. & Abbasi, A. M. Polyphenolic contents and antioxidant potential in Nasturtium officinale. *J King Saud Univ Sci* **36**, 103223, (2024).

[216] Ercan, L. & Doğru, M. The Investigation on Antioxidant Activities of Nasturtium Officinale Extracts and Its Mineral Content. *Dicle Üniversitesi Fen Bilimleri Enstitüsü Dergisi* **10**, 197–208, (2021).

[217] Mahmoud, E., Starowicz, M., Ciska, E., Topolska, J. & Farouk, A. Determination of volatiles, antioxidant activity, and polyphenol content in the postharvest waste of Ocimum basilicum L. *Food Chem* **375**, 131692, (2022).

[218] Sotiropoulou, N., Megremi, S., Sciences, P. T.-A. & 2020, undefined. Evaluation of Antioxidant Activity, Toxicity, and Phenolic Profile of Aqueous Extracts of Chamomile (Matricaria chamomilla L.) and Sage (Salvia officinalis L.). *Appl Sci* **10**, 2270, doi:10.3390/app10072270 (2020).

[219] Idris Yolbas. Phenolic Compound Content and Antioxidant Activity of Rheum ribes Shells. *J Chem* **8**, (2024).

[220] Coimbra, P. P. S., Silva-e-Silva, A. C. A. G. da, Antonio, A. da S., Pereira, H. M. G., Veiga-Junior, V. F. da, Felzenszwalb, I., Araujo-Lima, C. F. & Teodoro, A. J. Antioxidant Capacity, Antitumor Activity and Metabolomic Profile of a Beetroot Peel Flour. *Metabolites* **13**, doi:10.3390/metabo13020277 (2023).

[221] Flores-Mancha, M. A., Ruíz-Gutiérrez, M. G., Sánchez-Vega, R., Santellano-Estrada, E. & Chávez-Martínez, A. Effect of encapsulated beet extracts (Beta vulgaris) added to yogurt on the physicochemical characteristics and antioxidant activity. *Molecules* **26**, 4768, (2021).

[222] Ghafoor, K., Al Juhaimi, F., Özcan, M. M., Uslu, N., Babiker, E. E. & Mohamed Ahmed, I. A. Total phenolics, total carotenoids, individual phenolics and antioxidant activity of ginger (Zingiber officinale) rhizome as affected by drying methods. *LWT* **126**, doi:10.1016/j.lwt.2020.109354 (2020).

[223] Nam, D.-G., Kim, M., Choi, A.-J. & Choe, J.-S. Health Benefits of Antioxidant Bioactive Compounds in Ginger (Zingiber officinale) Leaves by Network Pharmacology Analysis Combined with Experimental Validation. *Antioxidants* **13**, 652, (2024).

[224] Abd-ElGawad, A. M., Elshamy, A. I., El-Nasser El Gendy, A., Al-Rowaily, S. L. & Assaeed, A. M. Preponderance of Oxygenated Sesquiterpenes and Diterpenes in the Volatile Oil Constituents of Lactuca serriola L. Revealed Antioxidant and Allelopathic Activity. *Chem Biodivers* **16**, doi:10.1002/cbdv.201900278 (2019).

[225] Selles, S. M. A., Kouidri, M., Belhamiti, B. T. & Ait Amrane, A. Chemical composition, in-vitro antibacterial and antioxidant activities of Syzygium aromaticum essential oil. *J Food Meas Charac* **14**, doi:10.1007/s11694-020-00482-5 (2020).

[226] Abdel-Gwad, N. M., Mahmoud, E. A. M., Al-Askalany, S. A. & Hanafy, E. A. Antioxidant, antibacterial and cytotoxic effect of Cymbopogon

citratus, Mentha longifolia, and Artemisia absinthium essential oils. *Egypt J Chem* **65**, doi:10.21608/ejchem.2021.86171.4174 (2022).

[227] Dowek, S., Fallah, S., Basheer-Salimia, R., Jazzar, M. & Qawasmeh, A. Antibacterial, antioxidant and phytochemical screening of palestinian mallow, Malva sylvestris L. *Int J Pharm Pharm Sci* **12**, 12–16, (2020).

[228] Areesanan, A., Nicolay, S., Keller, M., Zimmermann-Klemd, A. M., Potterat, O. & Gründemann, C. Potential benefits of Malva sylvestris in dry-eye disease pathology in vitro based on antioxidant, wound-healing and anti-inflammatory properties. *Biomed Pharmacother* **168**, 115782, (2023).

[229] Kačániová, M., Galovičová, L., Ivanišová, E., Vukovic, N. L., Štefániková, J., *et al.* Antioxidant, Antimicrobial and Antibiofilm Activity of Coriander (Coriandrum sativum L.) Essential Oil for Its Application in Foods. *Foods* **9**, doi:10.3390/foods9030282 (2020).

[230] Nhut, P., Quyen, N., Truc, T., Minh, L., An, T. & Anh, N. Preliminary study on phytochemical, phenolic content, flavonoids and antioxidant activity of Coriandrum Sativum l. originating in Vietnam. IOP Conf Series: *Mater Sci Eng*, 991, (2020).

[231] Nouioura, G., El Fadili, M., El Hachlafi, N., Maache, S., Mssillou, I., A. Abuelizz, H., others & Derwich, E. Coriandrum sativum L., essential oil as a promising source of bioactive compounds with GC/MS, antioxidant, antimicrobial activities: in vitro and in silico predictions. *Front Chem* **12**, (2024).

[232] Keskin, C., Baran, A., Baran, M. F., Hatipoğlu, A., Adican, M. T., *et al.* Green Synthesis, Characterization of Gold Nanomaterials using Gundelia tournefortii Leaf Extract, and Determination of Their Nanomedicinal (Antibacterial, Antifungal, and Cytotoxic) Potential. *J Nanomater* **2022**, doi:10.1155/2022/7211066 (2022).

[233] Amer, J., Salhab, A., Jaradat, N., Abdallah, S., Aburas, H., Hattab, S., Ghanim, M. & Alqub, M. Gundelia tournefortii inhibits hepatocellular carcinoma progression by lowering gene expression of the cell cycle and hepatocyte proliferation in immunodeficient mice. *Biomed Pharmacot* **156**, doi:10.1016/j.biopha.2022.113885 (2022).

[234] Meer, B., Andleeb, A., Iqbal, J., Ashraf, H., Meer, K., *et al.* Bio-Assisted Synthesis and Characterization of Zinc Oxide Nanoparticles from Lepidium sativum and Their Potent Antioxidant, Antibacterial and Anticancer Activities. *Biomolecules* **12**, doi:10.3390/biom12060855 (2022).

[235] Selen İlgun, Polat, D. Ç. & Karatoprak, G. Ş. Phytochemical composition, antioxidant, enzyme inhibitory and cytotoxic activities of flowers and leaves of Malva Sylvestris l. *Studia Ubb Chemia* **69**, 69-83, 10.24193/subbchem.2024.1.05 (2024).

[236] Alotaibi, N. M., Alotaibi, M. O., Alshammari, N., Adnan, M. & Patel, M. Network Pharmacology Combined with Molecular Docking, Molecular Dynamics, and in Vitro Experimental Validation Reveals the Therapeutic Potential of Thymus vulgaris L. Essential Oil (Thyme Oil) against Human Breast Cancer. *ACS Omega* **8**, 48344–48359, (2023).

[237] Amin, O.-H. A., Rasmy, N. M., Nabieh, N. M. & Ahmed, E. A. Phytochemical and Physicochemical properties of betalains extracted from red beetroot (Beta vulgaris L.). *Egypt J Chem* **67**, 283–295, (2024).

[238] Saber, A., Abedimanesh, N., Somi, M.-H., Khosroushahi, A. Y. & Moradi, S. Anticancer properties of red beetroot hydro-alcoholic extract and its main constituent; betanin on colorectal cancer cell lines. *BMC Complement Med Ther* **23**, 246, (2023).

[239] Niksic, H., Becic, F., Koric, E., Gusic, I., Omeragic, E., Muratovic, S., others & Duric, K. Cytotoxicity screening of Thymus vulgaris L. essential oil in brine shrimp nauplii and cancer cell lines. *Sci Rep* **11**, 13178, (2021).

[240] Nguyen, T.-N., Nguyen, K.-A. T., Le, T.-V. N., Nguyen, C.-K., Nguyen, N.-T. T., Kuo, P.-C., others & Nguyen, N.-T. Research on chemical constituents, anti-bacterial and anti-cancer effects of components isolated from Zingiber officinale Roscoe from Vietnam. *Plant Sci Today* **11**, 156–165, (2024).

[241] Alkhathlan, A. H., Al-Abdulkarim, H. A., Khan, M., Khan, M., Alkholief, M., Alshamsan, A., others & Siddiqui, M. R. H. Evaluation of the anticancer activity of phytomolecules conjugated gold nanoparticles synthesized by aqueous extracts of Zingiber officinale (ginger) and Nigella sativa L. seeds (black cumin). *Materials* **14**, 3368, (2021).

[242] Nurani, L. H., Rofida, S., Utami, D., Edityaningrum, C. A. & Guntarti, A. The apoptosis induction of Zingiber oficinale ethanolic Extracts-Treated HeLa (Human Cervical Cancer) cells and active compound profiling using Gas Chromatography/ Mass Spectrometry. *Medical Sains: Jurnal Ilmiah Kefarmasian* **9**, 235–244, (2024).

[243] Beheshtian, N., Karimi, E., Asili, J., Beheshtin, N., Le, H. H. & Shakeri, M. Mentha longifolia L. inhibits colorectal cancer cell proliferation and induces apoptosis via caspase regulation. *Int J Trans Med* **3**, 416–425, (2023).

[244] Elansary, H. O., Szopa, A., Kubica, P., Ekiert, H., Klimek-Szczykutowicz, M., El-Ansary, D. O. & Mahmoud, E. A. Polyphenol profile and antimicrobial and cytotoxic activities of natural Mentha× piperita and Mentha longifolia populations in Northern Saudi Arabia. *Processes* **8**, 479, (2020).

[245] Mekky, A. E., Emam, A. E., Selim, M. N., Abdelmouty, E. S. & Khedr, M. *Antibacterial and Antineoplastic MCF-7* and HePG-2 Characteristics of the Methanolic (80) clove (Syzygium aromaticum L.) extract. *Biomass Convers* **14**, 16787–16798, doi.org/10.1007/s13399-023-03862-1 (2024).

[246] Begum, S., Ali, S. N., Farooq, A. D., Siddiqui, F., Siddiqui, B. S., Ayub, A. & Fatima, M. Volatile constituents and in vitro activity of Syzygium aromaticum flower buds (clove) against human cancer cell lines. *Pak J Pharm Sci* **33**, (2020).

[247] Shaaban, M., El-Hagrassi, A. M., Osman, A. F. & Soltan, M. M. Bioactive compounds from Matricaria chamomilla: structure identification, in vitro antiproliferative, antimigratory, antiangiogenic, and antiadenoviral activities. *Zeitschrift für Naturforschung C* **77**, 85–94, (2022).

[248] Kyriakou, S., Tragkola, V., Alghol, H., Anestopoulos, I., Amery, T., Stewart, K., others & Pappa, A. Evaluation of bioactive properties of lipophilic fractions of edible and non-edible parts of Nasturtium officinale (Watercress) in a model of human malignant melanoma cells. *Pharmaceuticals* **15**, 141, (2022).

[249] Abdelgawad, S. M., Hetta, M. H., Ibrahim, M. A., Balachandran, P., Zhang, J., Wang, M., others & Ross, S. A. Phytochemical Investigation of Egyptian Spinach Leaves, a Potential Source for Antileukemic Metabolites. *Rev Bras Farmacogn* **32**, 774–785, (2022).

[250] Sam, S. Importance and effectiveness of herbal medicines. *J Pharmacogn Phytochem* **8**, (2019).

[251] Qamar, F., Sana, A., Naveed, S. & Faizi, S. Phytochemical characterization, antioxidant activity and antihypertensive evaluation of Ocimum basilicum L. in L-NAME induced hypertensive rats and its correlation analysis. *Heliyon* **9**, doi:10.1016/j.heliyon.2023.e14644 (2023).

[252] Gopalan, M. & Jadhav, A. S. Neuroprotective Activity of Beetroot (Beta Vulgaris) Extract on H2O2-Induced Damage in IMR32 and SHSY5Y Cell Lines. *S Asian J Exp Biol* **11**, doi.org/10.38150/sajeb.11(1).p36-45 (2021).

[253] Ali Alafify, A. S. & Essawy, A. S. Possible Neuroprotective Effect of Red Beetroot Extract on Visual Cortex Injury Induced by Cerebral Ischemic/Reperfusion Injury in Albino Rats. *Egyp J Histol* **46**, 308–318, (2023).

[254] Haddadi, R., Shahidi, Z. & Eyvari-Brooshghalan, S. Silymarin and neurodegenerative diseases: Therapeutic potential and basic molecular mechanisms. *Phytomedicine* **79**, 153320, (2020).

[255] Hajlaoui, H., Arraouadi, S., Noumi, E., Aouadi, K., Adnan, M., Khan, M. A., Kadri, A. & Snoussi, M. Antimicrobial, antioxidant, anti-acetylcholinesterase, antidiabetic, and pharmacokinetic properties of carum carvi l. And coriandrum sativum l. essential oils alone and in combination. *Molecules* **26**, doi:10.3390/molecules26123625 (2021).

[256] Ullah, M. I., Anwar, R., Kamran, S., Gul, B., Elhady, S. S. & Youssef, F. S. 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**, doi:10.3390/antiox11112232 (2022).

[257] Sharma, H., Yang, H., Sharma, N. & An, S. S. A. Neuroprotection by Anethum graveolens (Dill) Seeds and Its Phytocompounds in SH-SY5Y Neuroblastoma Cell Lines and Acellular Assays. *Int J Mol Sci* **25**, 7104, (2024).

[258] Bokov, D. O., Sidorova, Y. S., Mazo, V. K. & Bessonov, V. V. Prospects for the Use of Spinach (Spinacia oleracea L.) Containing Phytoecdysteroids and Polyphenols. *Pharmacog J* **12**, doi:10.5530/pj.2020.12.38 (2020).

[259] Amer, A. A., Mohammed, R. S., Hussein, Y., Ali, A. S. & Khalil, A. A. Development of lepidium sativum extracts/PVA electrospun nanofibers as wound healing dressing. *ACS Omega* **7**, 20683–20695, (2022).

[260] El-Hakim, A., Sunarti, S., Hidayati, L. & Widiyanto, S. Anti-hypercholesterolemia, Anti-atherogenic, and Anti-hypertension Effects of Red Beetroot (Beta vulgaris L.) in Rats Induced by High Fat and Fructose Diet. *J Trop Biodivers Biotechnol* **8**, 75914, (2023).

[261] Edziri, H., Jaziri, R., Haddad, O., Anthonissen, R., Aouni, M., Mastouri, M. & Verschaeve, L. Phytochemical analysis, antioxidant, anticoagulant and in vitro toxicity and genotoxicity testing of methanolic and juice extracts of Beta vulgaris L. *S Afr J Bot* **126**, 170–175, doi:10.1016/j.sajb.2019.01.017 (2019).

[262] Sawicka, B., Skiba, D., Pszczółkowski, P., Aslan, I., Sharifi-Rad, J. & Krochmal-Marczak, B. Jerusalem artichoke (Helianthus tuberosus L.) as a medicinal plant and its natural products. *Cell Mol Biol* **66** doi:10.14715/cmb/2020.66.4.20 (2020).

[263] Chen, Y.-H., Lin, H., Wang, Q., Hou, J.-W., Mao, Z.-J. & Li, Y.-G. Protective role of silibinin against myocardial ischemia/reperfusion injury-induced cardiac dysfunction. *Int J Biol Sci* **16**, 1972, (2020).

[264] Roudsari, N. M., Lashgari, N. A., Momtaz, S., Roufogalis, B., Abdolghaffari, A. H. & Sahebkar, A. Ginger: A complementary approach for management of cardiovascular diseases. *Biofactors* **47**, 933–951, (2021).

[265] Cerdá, B., Marhuenda, J., Arcusa, R., Villaño, D., Ballester, P., & Zafrilla, P. Ginger in the Prevention of Cardiovascular Diseases. *Cur Top Func Food*, doi:10.5772/intechopen.103970 (2022).

[266] Panda, V., Bhandare, N., Mistry, K. & Dande, P. Cardioprotective potential of Spinacia oleracea (Spinach) against isoproterenol-induced myocardial infarction in rats. *Arch Physiol Biochem* **128**, 101–110, (2022).

[267] Nargesi, S., Moayeri, A., Ghorbani, A., Seifinejad, Y., Shirzadpour, E. & Amraei, M. The effects of Matricaria chamomilla L. hydroalcoholic extract on atherosclerotic plaques, antioxidant activity, lipid profile and inflammatory indicators in rats. *Biomed Res Ther* **5**, 2752–2761, (2018).

[268] Asgharian, S., Lorigooini, Z., Bijad, E., Hosseinkhani, H., Abbasian, Z. & Rafieian-Kopaei, M. Protective effect of Rheum ribes extract against lead-induced hepatotoxicity in male rats. *Braz J Pharma Sci* **58**, (2023).

[269] Shebbo, S., El Joumaa, M., Kawach, R. & Borjac, J. Hepatoprotective effect of Matricaria chamomilla aqueous extract against 1, 2-Dimethylhydrazine-induced carcinogenic hepatic damage in mice. *Heliyon* **6**, (2020).

[270] Azarmehr, N., Afshar, P., Moradi, M., Sadeghi, H., Sadeghi, H., Alipoor, B., others & Doustimotlagh, A. H. Hepatoprotective and antioxidant activity of watercress extract on acetaminophen-induced hepatotoxicity in rats. *Heliyon* **5**, (2019).

[271] Awan, A. F., Akhtar, M. S., Anjum, I., Mushtaq, M. N., Fatima, A., Mannan, A. & Ali, I. Anti-oxidant and hepatoprotective effects of Lactuca serriola and its phytochemical screening by HPLC and FTIR analysis. *Pak J Pharm Sci* **33**, (2020).

[272] Jabbar, A. A. Gastroprotective and Immuno-Supportive Role of Alcea kurdica against Stress Induced Lesion in Japanese Quails. *Bag Sci J* **19**, doi:10.21123/bsj.2022.19.4.0716 (2022).

[273] Gao, C., Li, G., Wang, T., Gao, L., … F. W.-B. & & 2021, undefined. Rhubarb extract relieves constipation by stimulating mucus production in the colon and altering the intestinal flora. *Biomed Pharmacother* **138**, 111479, doi: 10.1016/j.biopha.2021.111479 (2021).

[274] Saad, F., Al-Shaikh, T. M., Zouidi, F., Taher, M. A., Saidi, S. A. & Hamden, K. Betalain Enriched Beetroots Exhibit Antiulcer and Anti Inflammatory Potentials. *J Food Process Preserv* **2023**, 9522830, (2023).

[275] Shosha, N. N. H., Fahmy, N. M., Singab, A. N. B. & Mohamed, R. W. Anti-ulcer effects of cumin (Cuminum cyminum L.), thyme (Thymus vulgaris L.), and caraway (Carum carvi L.) essential oils on peptic ulcer and ulcerative colitis models in rats. *J Herb Med Pharmaco* **11**, doi:10.34172/jhp.2022.45 (2022).

[276] Singletary, K. W. Dill: Potential health benefits. *Nutr Today* **58**, 128–136, doi:10.1097/nt.0000000000000604 (2023).

[277] Abdelhamid, O. M., Said, A. M. & Hussein, R. S. Biochemical effects of basil and marjoram on ulcerative gastritis induced experimentally in rats. *World J Pharm Pharm Sci* **9**, 424–435, (2019).

[278] Gao, H., He, C., Hua, R., Liang, C., Wang, B., *et al.* Underlying beneficial effects of Rhubarb on constipation-induced inflammation, disorder of gut microbiome and metabolism. *Front Pharmacol* **13**, doi:10.3389/fphar.2022.1048134/full (2022).

[279] Shamansoori, M. T., Karimi, E. & Oskoueian, E. Rheum ribes extract loaded nanoliposome as a novel phytogenic antibiotic alternative in mice challenged by Escherichia coli (O157: H7). *Biotechnol Appl Biochem* **69**, 2540–2549, (2022).

[280] Wang, Y., Do, T., Marshall, L. J. & Boesch, C. Effect of two-week red beetroot juice consumption on modulation of gut microbiota in healthy human volunteers a pilot study. *Food Chem* **406**, 134989, (2023).

[281] Bati, B., Celik, I., Vuran, N. E., Turan, A., Alkan, E. & Zirek, A. Effects of Gundelia tournefortii L. on biochemical parameters, antioxidant activities and DNA damage in a rat model of experimental obesity. *Braz J Biol* **83**, (2021).

[282] Park, S.-H., Jung, S.-J., Choi, E.-K., Ha, K.-C., Baek, H.-I., Park, Y.-K., others & Cha, Y.-S. The effects of steamed ginger ethanolic extract on weight and body fat loss: a randomized, double-blind, placebo-controlled clinical trial. *Food Sci Biotechnol* **29**, 265–273, (2020).

[283] Nizioł-Łukaszewska, Z., Bujak, T., Wasilewski, T. & Szmuc, E. Inulin as an effectiveness and safe ingredient in cosmetics. *Polish J Chem Tech* **21**, doi:10.2478/pjct-2019-0008 (2019).

[284] Erdoğan, Ü., Gökçe, E. H., Muhammed, M. T., Önem, E., Ayten Asena Erten & Süleymanoğlu, B. Milk thistle extracts could enhance the UV-protection efficiency and stability of mineral filters in sunscreen formulations. *J Photochem Photobiol A Chem* **450**, 115460, (2024).

[285] Camponogara, C., Silva, C. R., Brusco, I., Piana, M., Faccin, H., de Carvalho, L. M., Schuch, A., Trevisan, G. & Oliveira, S. M. Nasturtium officinale R. Br. effectively reduces the skin inflammation induced by croton oil via glucocorticoid receptor-dependent and NF-κB pathways without causing toxicological effects in mice. *J Ethnopharmacol* **229**, doi:10.1016/j.jep.2018.10.011 (2019).

[286] Chen, F., Tang, Y., Sun, Y., Veeraraghavan, V. P., Mohan, S. K. & Cui, C. 6-shogaol, an active constiuents of ginger prevents UVB radiation mediated inflammation and oxidative stress through modulating NrF2 signaling in human epidermal keratinocytes (HaCaT cells). *J Photochem Photobiol B* **197**, 111518, (2019).

[287] Costa, E. F., Magalhães, W. V. & Di Stasi, L. C. Recent Advances in Herbal-Derived Products with Skin Anti-Aging Properties and Cosmetic Applications. *Molecules* **27,** doi:10.3390/molecules27217518 (2022).

[288] Wang, Y., Yu, F., Li, A., He, Z., Qu, C., He, C., others & Zhan, H. The progress and prospect of natural components in rhubarb (Rheum ribes L.) in the treatment of renal fibrosis. *Front Pharmacol* **13**, 919967, (2022).

[289] Gabr, S. A., Alghadir, A. H. & Ghoniem, G. A. Biological activities of ginger against cadmium-induced renal toxicity. *Saudi J Biol Sci* **26**, 382–389, (2019).

[290] Albasher, G., Almeer, R., Alarifi, S., Alkhtani, S., Farhood, M., Al-Otibi, F. O., others & Rizwana, H. Nephroprotective Role of Beta vulgaris L. Root Extract against Chlorpyrifos Induced Renal Injury in Rats. *J Evid Based Complement Altern Med* **2019**, 3595761, (2019).

[291] Ghahremani-Chabok, A., Bagheri-Nesami, M., Shorofi, S., Mousavinasab, S., Gholipour-Baradari, A. & Saeedi, M. The effects of Thymus vulgaris inhalation therapy on airway status and oxygen saturation of patients under mechanical ventilation: A randomized clinical trial. *Adv Integr Med* **8**, 92–100, (2021).

[292] Li, N., Xing, Y., Sultan, A. H., Raeeszadeh, M., Akbari, A. & Liu, H. Ginger (zingiber officinale roscoe) improves ethanol-induced reproductive dysfunction by enhancing steroidogenesis and inhibiting oxidative stress and inflammation. *Braz Arch Biol Technol* **64**, (2021).

[293] Nowrouzi, F., Azadbakht, M., Kalehoei, E. & Modarresi, M. Protective effect of Rosa Canina extract against doxorubicin-induced testicular toxicity in mice. *Braz Arch Biol Technol* **62**, (2019).

[294] Akbari, A., Nasiri, K., Heydari, M., Mosavat, S. H. & Iraji, A. The protective effect of hydroalcoholic extract of Zingiber officinale Roscoe (Ginger) on ethanol-induced reproductive toxicity in male rats. *J Evid Based Complement Altern Med* **22**, 609–617, (2017).

[295] Abdel-Latif, H. M. R., Shukry, M., Noreldin, A. E., Ahmed, H. A., El-Bahrawy, A., Ghetas, H. A. & Khalifa, E. Milk thistle (Silybum marianum) extract improves growth, immunity, serum biochemical indices, antioxidant state, hepatic histoarchitecture, and intestinal histomorphometry of striped catfish, Pangasianodon hypophthalmus. *Aquaculture* **562**, doi:10.1016/j.aquaculture.2022.738761 (2023).