

Traditional Persian Medicinal Plants for Neurological Disorders: A Phytochemical and Ethnobotanical Review

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Article Info	ABSTRACT
Article Type Review Article Article History Received: 17 April 2025 Accepted: 26 August 2025 © 2012 Iranian Society of Medicinal Plants. All rights reserved. *Corresponding author F.rabizade@semnan.ac.ir 	Neurological disorders—including Alzheimer’s disease, Parkinson’s disease, anxiety, depression, and insomnia—are among the most challenging global health issues. Due to the limitations and side effects of conventional treatments, there is increasing interest in natural, plant-based alternatives. This review aims to evaluate medicinal plants used in Traditional Iranian Medicine (TIM) for neurological disorders and to assess their phytochemical and pharmacological relevance based on both classical texts and modern scientific literature. A total of 52 plant species belonging to 26 botanical families were identified, with Lamiaceae, Apiaceae, Euphorbiaceae, Pinaceae, Asteraceae, and Fabaceae being the most frequently represented. Phytochemical analyses revealed that compounds such as terpenoids (68%), phenolic compounds (52%), and flavonoids (20%)—alongside glycosides, alkaloids, steroids, amines, and saponins—are key contributors to neuropharmacological activity. These metabolites may exert neuroprotective, antioxidant, anti-inflammatory, anxiolytic, and cognition-enhancing effects through various mechanisms, including neurotransmitter modulation (e.g., serotonin, dopamine, GABA), suppression of neuroinflammation, and oxidative stress reduction. Notable species such as <i>Curcuma longa</i>, <i>Cannabis sativa</i>, <i>Mentha</i> spp., <i>Narcissus jonquilla</i>, and <i>Peucedanum officinale</i> contain well-documented bioactive compounds like curcumin, cannabidiol, linalool, galanthamine, and α-pinene. The phytochemical richness of Apiaceae and Lamiaceae suggests their prominence in traditional neurological care. In conclusion, this review highlights the therapeutic potential of traditional Iranian medicinal plants for neurological disorders and advocates for future bioassay-guided studies, synergistic compound analysis, and formulation standardization to support their integration into evidence-based modern medicine. Keywords: Botanical therapeutics, Ethnomedicine, Herbal neuroprotective, Natural compounds, Neuropharmacology

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INTRODUCTION

Neurological disorders—including neurodegenerative diseases such as Alzheimer's, Parkinson's, and Huntington's disease, as well as mood-related conditions like depression, anxiety, and insomnia—are increasingly prevalent worldwide [1]. These conditions present significant diagnostic and therapeutic challenges, and many conventional pharmacological treatments are associated with limited efficacy and adverse effects [2]. As a result, there is growing global interest in complementary and alternative medicine approaches, particularly those involving natural products [3].

Among these alternatives, Traditional Persian Medicine (TPM), a rich and well-documented system of healing, has long utilized medicinal plants to manage neurological and psychological ailments [4]. These traditional approaches offer insights into therapeutic strategies that are still relevant today and have prompted renewed scientific interest.

The therapeutic properties of medicinal plants are closely linked to their phytochemical constituents [5]. Plants produce a wide range of primary and secondary metabolites; although secondary metabolites are not essential for basic plant survival, they play

critical ecological and pharmacological roles [6]. These compounds—including terpenoids, alkaloids, flavonoids, and phenolic acids—exhibit anti-inflammatory, antioxidant, anxiolytic, and neuroprotective effects, making them promising candidates for treating neurological disorders [7, 8].

This review explores medicinal plants traditionally used in TPM for neurological diseases and highlights the secondary metabolites believed to underlie their therapeutic effects on the nervous system. Notable examples include *Cannabis sativa* L., known for its anticonvulsant and anxiolytic effects [9]; *Curcuma longa* L., with established anti-inflammatory and neuroprotective properties [10]; and *Artemisia* spp. L., which have shown potential against neurodegenerative conditions [11]. A more in-depth understanding of these plants and their bioactive compounds may guide the development of novel herbal-based neurotherapeutics [12].

From ancient times, natural products—particularly those derived from plants—have been integral to traditional medical practices worldwide. While many cultures, including Indian, Egyptian, and Chinese systems, have used herbal remedies, Traditional Persian Medicine (TPM) offers a unique and rich pharmacopeia specifically relevant to neurological disorders [13, 14].

In TPM, numerous plants have been historically employed to manage conditions such as seizures, melancholia, insomnia, and nervous agitation. The efficacy of these treatments is closely tied to their phytochemical composition, particularly secondary metabolites such as alkaloids, flavonoids, terpenoids, and phenolic compounds. These compounds contribute to various therapeutic effects including neuroprotection, antioxidant activity, anti-inflammatory responses, and modulation of neurotransmitters like serotonin and dopamine [15, 16].

This review aims to systematically identify and evaluate medicinal plants used in TPM for neurological disorders, focusing on their phytochemical profiles and mechanisms of action. By bridging ethnobotanical records with contemporary pharmacological data, we seek to provide a scientific basis for the integration of these traditional remedies into modern neurotherapeutic strategies [17-19].

Recent scientific studies have revealed that the powerful therapeutic properties of plants are largely determined by their phytochemical compositions [20]. Consequently, understanding plant chemistry is essential for their medicinal applications [21]. Plants produce two major categories of compounds: primary and secondary metabolites [22]. Secondary metabolites are smaller molecules derived from primary metabolites or act as intermediates in their biosynthetic pathways [23]. These compounds do not directly impact the basic cellular processes necessary for growth and reproduction but play critical ecological roles in helping plants adapt to their environments [24]. Additionally, secondary metabolites are known for their wide range of biological activities, including antifungal, antibiotic, and antiviral properties, making them crucial for plant defense against pathogens and their ability to absorb harmful ultraviolet rays [25].

Recent research has demonstrated that secondary metabolites are beneficial not only for plant protection but also for human health, agricultural production, and the cosmetic industry, significantly contributing to economic growth [26]. These compounds are believed to be responsible for the therapeutic effects of plants, with many secondary metabolites being used in modern medicine to treat conditions like cancer and migraines [27].

Despite the progress in medical research, there are still no approved cures for some infections and diseases, and vaccines are limited to certain viral infections [28]. Furthermore, conventional medications can be expensive and often cause adverse effects [29]. As a result, plant-based pharmacotherapy presents a promising alternative for treating various ailments [30].

Neurological disorders, including conditions like Alzheimer's disease, Parkinson's disease, anxiety, and depression, are increasingly prevalent and present significant challenges in modern medicine [31]. Traditional medicine has utilized plants for centuries to manage these disorders [32]. Phytochemical research has indicated that specific plant-derived compounds exhibit beneficial effects on the nervous system [33]. For instance, antioxidants, anti-inflammatory agents, and neuroprotective substances found in plants have shown promise in protecting the nervous system from damage and improving cognitive functions [34].

Similarly, as with liver diseases, understanding the role of secondary metabolites in treating neurological conditions is crucial [35]. Research has highlighted the potential of these compounds to not only protect neurons but also enhance mental clarity and combat neurodegenerative diseases [36]. Given the limitations of current treatments and their often-debilitating side effects,

exploring natural, plant-based remedies may offer a safer and more sustainable approach for managing neurological health [37].

In conclusion, the use of traditional knowledge from sources like Traditional Persian Medicine (TPM) has long guided the treatment of various disorders [38]. Many herbs, recorded in ancient texts, have demonstrated scientific validity in treating neurological diseases [39]. The present review focuses on identifying these herbs, analyzing their bioactive constituents, and evaluating their potential in treating nervous system disorders based on modern scientific research and traditional Persian medical knowledge [40, 41].

MATERIALS AND METHODS

This review was conducted to document medicinal plants used in Traditional Persian Medicine (TPM) for the treatment of neurological disorders and to examine their phytochemical constituents. The selection of plant species was based on their mention in at least one of three classical TPM texts: *Makhzan al-Advieh*, *The Canon of Medicine (Al-Qanun fi al-Tibb)*, and *Taqwim al-Abdan fi Tadbir al-Insan*. Plants were included if they were explicitly described as treatments for neurological conditions such as anxiety, melancholia, convulsions, insomnia, or other neuropsychological symptoms.

To complement the ethnobotanical data, modern scientific literature was reviewed using online databases including PubMed, Web of Science, Google Scholar, and ScienceDirect. Search terms included combinations of each plant's scientific name with keywords such as “neuroprotective,” “phytochemical,” “antioxidant,” “anti-inflammatory,” and “neurological disorders.” Only those plants for which at least one phytochemical or pharmacological study related to the nervous system was available were included. Species with insufficient modern scientific evidence or unclear therapeutic indications were excluded.

Information on phytochemical profiles was obtained from peer-reviewed studies involving analytical techniques such as gas chromatography–mass spectrometry (GC-MS), high-performance liquid chromatography (HPLC), and nuclear magnetic resonance (NMR), when available. Where such data were not reported, secondary metabolites were identified based on existing phytochemical reviews or monographs.

All identified species were then listed by their scientific names, botanical families, and major classes of bioactive compounds, as presented in the Results section and summary table.

RESULTS

A total of 52 medicinal plant species from 26 botanical families were identified in classical Traditional Persian Medicine (TPM) sources as being traditionally used for the treatment of neurological disorders. These plants were analyzed for their phytochemical profiles based on available scientific literature, resulting in the identification of over 80 bioactive compounds, primarily belonging to classes such as terpenoids, flavonoids, alkaloids, and phenolic compounds. A comprehensive list of these species, including their botanical families and principal phytochemicals, is presented in Table 1. The frequency distribution of plant families is visualized in Figure 1, which demonstrates the taxonomic richness of the dataset. Among the families, Euphorbiaceae was the most represented with 8 species (14.55%), followed by Lamiaceae and Pinaceae (each with 6 species, 10.91%), Asteraceae (5 species, 9.09%), Fabaceae (4 species, 7.27%), and Apiaceae (3 species, 5.45%). Several families, including Cyperaceae, Tamaricaceae,

and Rhamnaceae, were each represented by two species (3.64%). The remaining 17 families appeared with only one species each. These families not only reflect taxonomic diversity but also highlight significant pharmacological potential. For instance, Lamiaceae is notably rich in essential oils with anxiolytic and sedative properties, while Euphorbiaceae contains several diterpenes and alkaloids with reported neuroactive effects.

Among the most studied bioactive compounds are α -pinene, a monoterpene found in *Pistacia* species shown to enhance cholinergic transmission, and linalool, commonly present in

Lavandula species, which modulates GABAergic activity and has anxiolytic effects. These findings support the traditional neurological uses of these plants as documented in TPM.

Despite these promising results, notable gaps remain in the scientific validation of several species. For many traditionally cited plants, detailed pharmacological or toxicological studies are lacking. Additionally, the mechanisms of action for numerous phytochemicals remain poorly understood. These limitations highlight the need for future *in vitro* and *in vivo* investigations to fully explore the therapeutic potential of these traditional remedies.

Table 1 Medicinal plants used in Traditional Persian Medicine (TPM) for neurological disorders, along with their scientific names, family affiliations, and key bioactive compounds.

No.	Scientific name	Family	Organ	Major phytochemical classes	Key compounds (examples)	Ref
1	<i>Acacia nilotica</i>	Fabaceae	Leaves	Flavonoids, phenolic acids, terpenoids, alkaloids	Kaempferol, gallic acid, cinnamic acid derivatives	42
2	<i>Aquilaria malaccensis</i>	Thymelaeaceae	Leaves	Phenolics, terpenoids	Phenolic derivatives, farnesol	43
3	<i>Artemisia absinthium</i>	Asteraceae	Aerial parts	Terpenoids	Monoterpenes & sesquiterpenes (e.g., α -pinene, camphor)	44
4	<i>Artemisia maritima</i>	Asteraceae	Aerial parts	Terpenoids	Terpenes (e.g., terpinene, thujone)	45
5	<i>Artemisia siversiana</i>	Asteraceae	Aerial parts	Phenylpropanoids, terpenoids	Eugenol, cinnamyl derivatives, limonene	46
6	<i>Asarum europaeum</i>	Aristolochiaceae	Root, aerial parts	Flavonoids, phenolics, terpenoids, sterols	Quercetin, caffeic acid, eugenol, limonene	47
7	<i>Caesalpinia bonduc</i>	Fabaceae	Fruit	Phenolics, terpenoids, alkaloids	Caryophyllene, nitrogen compounds	48
8	<i>Calycotome spinosa</i>	Fabaceae	Flower	Flavonoids, tannins, terpenoids, alkaloids	Quercetin, caffeic acid	49
9	<i>Cannabis sativa</i>	Cannabaceae	Aerial parts	Terpenoids	α -pinene, myrcene, caryophyllene	50–51
10	<i>Chamaemelum nobile</i>	Asteraceae	Aerial parts	Terpenoids	Pinocarvone, α -pinene	52–53
11	<i>Citrus aurantium</i>	Rutaceae	—	Sterols, phenolics, terpenoids	Phytosterols, limonene, curcumin derivatives	54
12	<i>Curcuma longa</i>	Zingiberaceae	Aerial parts	Terpenoids, sterols	Sesquiterpenes, stigmaterol	55
13	<i>Cyperus longus</i>	Cyperaceae	—	Phenolics, terpenoids	Aromatic acids, terpenes	56
14	<i>Cyperus rotundus</i>	Cyperaceae	—	Phenolics, terpenoids	Eugenol derivatives, α -pinene	57
15	<i>Equisetum arvense</i>	Equisetaceae	Aerial parts	Flavonoids, sterols, alkaloids	Quercetin, β -sitosterol	58
16	<i>Euphorbia helioscopia</i>	Euphorbiaceae	Whole plant	Phenolics, terpenoids	Thymol, carvone	59
17	<i>Euphorbia hirta</i>	Euphorbiaceae	Whole plant	Phenolics, terpenoids, alkaloids	Phytol, phenolic derivatives	60
18	<i>Euphorbia lathyris</i>	Euphorbiaceae	Seeds	Glycosides, sterols, terpenoids	Sitosterol, oleanane derivatives	61
19	<i>Euphorbia millii</i>	Euphorbiaceae	Latex, stems	Glycosides, terpenoids, sterols	Lupeol, cembrene	62
20	<i>Euphorbia parviflora</i>	Euphorbiaceae	Whole plant	Phenolics	Extract-based presence	63
21	<i>Euphorbia retusa</i>	Euphorbiaceae	Latex	Glycosides, flavonoids, alkaloids	Caffeoyl derivatives	64
22	<i>Glossostemon bruguieri</i>	Malvaceae	Aerial parts	Flavonoids, sterols, alkaloids	Apigenin, cholesterol	65
23	<i>Glycyrrhiza glabra</i>	Fabaceae	Root	Phenolics, terpenoids, sterols	Linalool, β -caryophyllene	66
24	<i>Laurus nobilis</i>	Lauraceae	Leaves, seeds	Phenolics, terpenoids	Eugenol, cineole	67–68
25	<i>Matricaria chamomilla</i>	Asteraceae	Flowers	Flavonoids, phenolics	Apigenin, caffeic acid	69
26	<i>Mentha piperita</i>	Lamiaceae	Leaves	Terpenoids	Menthol, limonene	70
27	<i>Mentha aquatica</i>	Lamiaceae	Leaves	Terpenoids	Pulegone, germacrene	71
28	<i>Mentha longifolia</i>	Lamiaceae	Leaves	Terpenoids, sterols	Linalool, β -sitosterol	72
29	<i>Mentha pulegium</i>	Lamiaceae	Leaves	Phenolics, terpenoids	Thymol, pulegone	73
30	<i>Momordica charantia</i>	Cucurbitaceae	Leaves, seeds	Saponins, flavonoids	Charantin, catechin	74–75
31	<i>Narcissus jonquilla</i>	Amaryllidaceae	Whole plant	Alkaloids	Galanthamine, lycorine	76–77
32	<i>Nauclea latifolia</i>	Rubiaceae	Leaves	Glycosides, sterols	Campesterol, phytol	78
33	<i>Nerium oleander</i>	Apocynaceae	Leaves	Sterols, terpenoids	Sitosterol, limonene	79
34	<i>Ocimum basilicum</i>	Lamiaceae	Leaves	Flavonoids, phenolics, terpenoids	Rosmarinic acid, linalool	80

No.	Scientific name	Family	Organ	Major phytochemical classes	Key compounds (examples)	Ref
35	<i>Opopanax chironium</i>	Apiaceae	Gum	Coumarins	Psoralen derivatives	81
36	<i>Pastinaca sativa</i>	Apiaceae	Aerial parts	Coumarins, terpenoids	Bergaptene, α -pinene	82
37	<i>Peucedanum officinale</i>	Apiaceae	Fruits	Coumarins, terpenoids	Carvacrol, pinene	83
38	<i>Picea orientalis</i>	Pinaceae	Cone	Terpenoids	Camphor, limonene	84
39	<i>Pinus cembra</i>	Pinaceae	Wood	Flavonoids, terpenoids	Chrysin, α -pinene	85
40	<i>Pinus eldarica</i>	Pinaceae	Needles	Terpenoids	Camphene, caryophyllene	86
41	<i>Pinus nigra</i>	Pinaceae	Wood	Terpenoids	Limonene, humulene	87
42	<i>Pinus sylvestris</i>	Pinaceae	Bark	Phenolics, terpenoids	Naringenin, pinene	88–89
43	<i>Piper nigrum</i>	Piperaceae	Seeds	Alkaloids	Piperine	90
44	<i>Plantago ovata</i>	Plantaginaceae	Seeds	Flavonoids, saponins	Luteolin, amyrrin	91
45	<i>Rosa canina</i>	Rosaceae	Fruit	Flavonoids, phenolics	Rutin, caffeic acid	92–93
46	<i>Saccharum officinarum</i>	Poaceae	Stem	Flavonoids, phenolics	Quercetin, ferulic acid	94
47	<i>Tamarix gallica</i>	Tamaricaceae	Leaves	Tannins, flavonoids	Ellagic acid	95
48	<i>Tamarix nilotica</i>	Tamaricaceae	Leaves	Flavonoids, phenolics	Kaempferol, gallic acid	96
49	<i>Vitis vinifera</i>	Vitaceae	Peel	Phenolics, tannins	Resveratrol, phenols	97–98
50	<i>Ziziphus spina-christi</i>	Rhamnaceae	Leaves	Sterols, flavonoids	β -sitosterol, quercetin	99–100
51	<i>Ziziphus lotus</i>	Rhamnaceae	Fruit	Flavonoids, tannins, sterols	Rutin, saponins	101

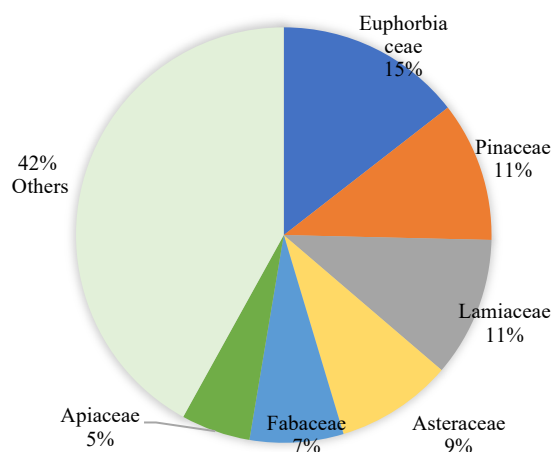


Fig. 1 Relative Abundance of Medicinal Plant Families Used in Traditional Persian Medicine for Neurological Disorders.

Phytochemical Profile of Medicinal Plants Used for Neurological Disorders

Further analysis of the 51 medicinal plant species revealed a wide array of secondary metabolites implicated in neurological health. Terpenoids emerged as the most prevalent phytochemical class, present in approximately 68% of the species. These compounds, especially monoterpenes such as α -pinene, are recognized for their neuroprotective, anti-inflammatory, and antioxidant properties. They play a critical role in preventing neurodegeneration by enhancing cholinergic neurotransmission and mitigating oxidative stress and inflammation.

Phenolic compounds, identified in 52% of the plants, are potent free radical scavengers that protect neurons from oxidative damage. Their neuroprotective activity is linked to improved cognitive function and modulation of cellular signaling pathways related to neuronal survival.

Flavonoids were found in 20% of the species and are known to enhance synaptic plasticity, regulate neuroinflammatory responses, and improve learning and memory processes. These compounds contribute to the restoration of neuronal function under stress conditions.

In addition, several other classes of secondary metabolites were identified:

- Glycosides (16%): Exhibit anti-inflammatory and analgesic effects, beneficial for conditions like neuropathic pain.
- Alkaloids (15%): Possess diverse neurological activities, including anticonvulsant and neuroprotective effects, often mediated through neurotransmitter modulation.
- Steroids (12%), amines (10%), and saponins (8%): Provide complementary roles such as hormonal balancing, neurotransmitter regulation, and immune modulation—factors essential for maintaining nervous system equilibrium.

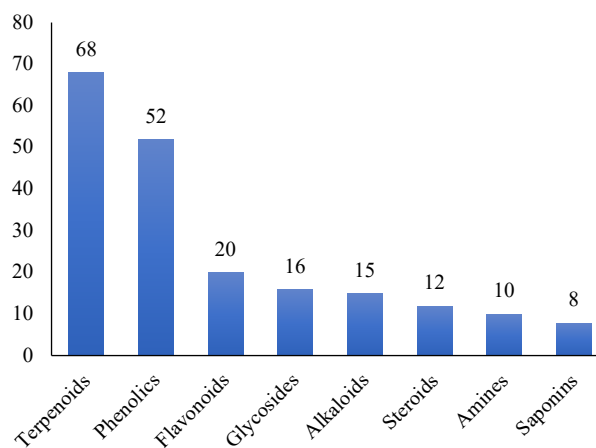


Fig. 2 Percentage of occurrence of main bioactive compounds, including terpenoids, phenolic compounds, flavonoids, glycosides, alkaloids, steroids, amines, and saponins in medicinal plants used for treating neurological disorders based on traditional medicine sources and phytochemical findings. Terpenoids, with 68%, show the highest frequency, followed by phenolic compounds and flavonoids at 52% and 20%, respectively.

Taken together, these findings underscore the synergistic potential of multiple phytochemical classes in TPM-based medicinal plants. The predominance of terpenoids, phenolic compounds, and flavonoids suggests that these metabolites are key contributors not only to direct neuroprotection but also to the regulation of complex molecular pathways implicated in neurodegenerative and neuropsychiatric disorders.

Nevertheless, it is important to note that for many of these compounds, the exact mechanisms of action remain incompletely understood, and further experimental validation is necessary. Future research should aim to isolate and characterize individual constituents, assess their interactions, and evaluate their efficacy through bioassay-guided in vivo and clinical studies.

Additionally, to visually support the botanical diversity of the most frequently cited neuroactive plants in Traditional Persian Medicine, a composite illustration (Figure 3) was included. This figure presents four key species—*Lavandula angustifolia* Mill., *Curcuma longa*, *Glycyrrhiza glabra* L., and *Mentha × piperita* L.—that are frequently used for their neuroprotective, anxiolytic, and cognitive-enhancing properties.

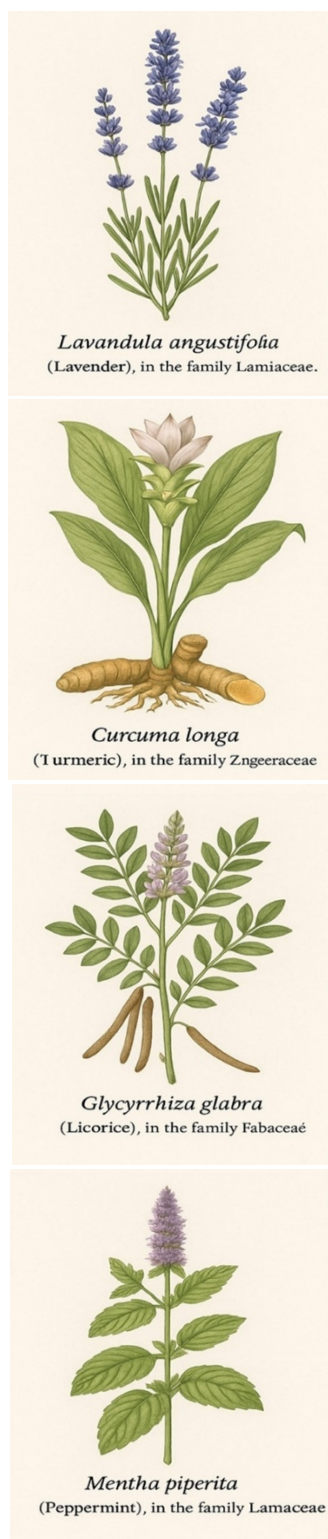


Fig. 3 Representative medicinal plants commonly used in Traditional Persian Medicine for neurological disorders. Clockwise from top left: *Lavandula angustifolia* (Lamiaceae) – anxiolytic and sleep-inducing properties; *Curcuma longa* (Zingiberaceae) – anti-inflammatory and neuroprotective effects; *Mentha × piperita* (Lamiaceae) – stress-reducing and cognitive-enhancing effects; *Glycyrrhiza glabra* (Fabaceae) – mood-regulating and antioxidant activities. All illustrations are based on public-domain botanical references.

DISCUSSION

Overview of Phytochemical Classes and Their Neurological Roles

In this study, medicinal plants used in Traditional Iranian Medicine (TIM) for neurological disorders were analyzed for their

phytochemical composition. The main bioactive classes identified include flavonoids, terpenoids, alkaloids, glycosides, phenolic acids, and volatile compounds, all of which are known for their diverse pharmacological activities on the central nervous system.

Terpenoids and Mood Regulation

Terpenoids such as glabridin from *Glycyrrhiza glabra* and citrulline from *Jasminum sambac* (L.) Aiton modulate neurotransmitters serotonin and dopamine, exerting notable antidepressant and anxiolytic effects [102]. Volatile terpenoids, like linalool and linalyl acetate from *Lavandula angustifolia*, and α -pinene from *Rosmarinus officinalis* L., improve sleep quality and reduce anxiety via central nervous system modulation [103, 104].

Alkaloids in Neurodegeneration

Alkaloids such as huperzine A from *Huperzia serrata* (Thunb. ex Murray) Trevis. and quinine from *Cinchona officinalis* L. act by inhibiting enzymes like acetylcholinesterase or modulating dopamine pathways, thereby alleviating symptoms of Alzheimer's and Parkinson's diseases [105, 106]. Another key alkaloid, galanthamine from *Narcissus jonquilla* L., is clinically approved for Alzheimer's treatment, demonstrating the empirical efficacy of TIM [107].

Flavonoids and Alzheimer's Disease

Flavonoids, like quercetin found in *Allium cepa* L. and *Malus domestica* Borkh., and EGCG from *Camellia sinensis* (L.) Kuntze, inhibit amyloid plaque formation and oxidative stress, protecting neurons from degeneration [108, 109]. Species such as *Asarum europaeum* L. are rich in flavonoids (kaempferol, quercetin, luteolin) with potent antioxidant and anti-inflammatory effects, contributing to neuroprotection and cognitive support [110].

Glycosides and Anti-inflammatory Effects

Glycosides, such as senoside A from *Senna alexandrina* Mill., display strong anti-inflammatory properties essential for mitigating neurodegenerative inflammation [126]. Other secondary metabolites, like steroids and saponins, also contribute to reducing neuroinflammation and supporting neuronal health [111, 112].

Volatile Compounds in Stress and Sleep Regulation

Compounds such as linalool, linalyl acetate from *Lavandula angustifolia*, and α -pinene from *Rosmarinus officinalis* L. enhance sleep and alleviate anxiety by modulating neurotransmitter systems in the brain [103, 104]. Plants like *Mentha × piperita* and *Ocimum basilicum* L. contain menthol and rosmarinic acid, which help regulate mood and reduce stress [113].

Phytochemical Diversity and Plant Families in TIM

The therapeutic potential of TIM plants arises from the complex mixture of bioactive compounds. Notably, families such as Apiaceae, Asteraceae, Lamiaceae, Fabaceae, and Euphorbiaceae dominate the pharmacopeia for neurological disorders.

- In Apiaceae, species like *Opopanax chironium* (W.D.J. Koch) G. Karrer and *Peucedanum officinale* L. are rich in coumarins and volatile terpenoids that may act through calcium channel inhibition and GABA receptor modulation, effective for seizures and nervous tension relief [114].
- The Asteraceae family includes *Matricaria chamomilla* L. and *Artemisia absinthium* L., which contain apigenin, luteolin, and eucalyptol with anxiolytic and anti-inflammatory properties [115].

- Lamiaceae species such as *Mentha × piperita* and *Ocimum basilicum* provide linalool, menthol, and rosmarinic acid, which aid in stress reduction and sleep improvement [116].
- Families Fabaceae and Euphorbiaceae, including *Glycyrrhiza glabra* and *Euphorbia ipecacuanha* L., offer flavonoids, alkaloids, and saponins that contribute to mood regulation and neuroprotection. Although several species of the Euphorbiaceae family are well known for their dermatological applications and contain diterpenes with recognized toxic potential, some of these plants—such as *Euphorbia ipecacuanha*—have also been traditionally prescribed in Persian Medicine for neurological conditions. Their inclusion in this review is based on combined ethnobotanical evidence and the presence of neuroactive phytochemicals. Nevertheless, the potentially toxic nature of diterpenes warrants further toxicological validation before therapeutic use [117, 118].

Future research should aim to isolate and characterize active constituents through bioassay-guided methods, investigate compound synergies, and conduct controlled clinical trials. Integrating traditional knowledge with rigorous pharmacological research may lead to novel, effective, and safer neurotherapeutic agents derived from medicinal plants [119].

In our previous phytochemical investigations on medicinal plants traditionally used for liver and kidney disorders in Persian Medicine, we identified several bioactive compounds—such as flavonoids, terpenoids, and phenolic acids—with proven antioxidant and anti-inflammatory effects [120, 121]. These classes of compounds, frequently found in plants like *Scrophularia striata* Boiss., *Berberis integerrima* Bunge., and *Rheum ribes* L., have shown significant potential in modulating oxidative stress and immune responses. Given the shared pathophysiological mechanisms between hepatic/renal inflammation and neuroinflammation, these findings further support the potential role of such phytochemicals in neurological protection. Thus, integrating knowledge from phytochemical studies on liver and kidney therapeutics may offer new insights into neuropharmacological applications of Persian medicinal plants.

CONCLUSION

This study underscores that Traditional Iranian Medicine (TIM), with its centuries-long empirical knowledge, has identified numerous plant species now validated by modern phytochemical research for their promising therapeutic potential in neurological disorders. The frequent presence of bioactive compounds such as flavonoids, volatile terpenoids, coumarins, and alkaloids in these plants highlights their significant role as sources of neuroprotective agents.

These phytochemicals act via multiple mechanisms—including modulation of neurotransmitter systems, antioxidative effects, and anti-inflammatory actions—offering potential benefits for conditions such as Alzheimer's disease, Parkinson's disease, anxiety, and depression. The growing evidence supports integrating these natural compounds as complementary options alongside conventional treatments.

The fusion of traditional ethnobotanical knowledge with contemporary phytochemical research creates a fertile ground for discovering and developing safe, natural, and effective neuropharmacological agents. However, to fully realize this potential, focused and multidisciplinary efforts are urgently needed.

We strongly encourage future research to:

Employ bioassay-guided isolation and characterization of active constituents, especially from species within the Apiaceae and Lamiaceae families.

Investigate synergistic and antagonistic interactions among plant compounds to better understand combined effects.

Conduct rigorous in vitro and in vivo neuropharmacological evaluations, including standardized clinical trials, to validate efficacy and safety.

Explore chemical variability within species (intraspecific diversity) and standardize herbal formulations for reproducible therapeutic outcomes.

Integrate traditional knowledge with modern pharmacology and toxicology to innovate novel, effective, and safer neurotherapeutics.

By prioritizing these research directions, the scientific community can accelerate the development of novel neuroprotective agents derived from medicinal plants, ultimately improving treatment options for neurological disorders worldwide

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REFERENCES

1. World Health Organization. Neurological disorders: public health challenges. Geneva: WHO; 2006.
2. Cummings J.L. Biomarkers in Alzheimer's disease drug development. *Alzheimer's & Dementia: The Journal of the Alzheimer's Association*. 2011;7(3): e13-e44. DOI: 10.1016/j.jalz.2010.06.004.
3. Debas H.T., Laxminarayan R., Straus S.E. Complementary and alternative medicine. Washington (DC): The World Bank; 2011.
4. Moeini R., Memariani Z., Enayati A., Gorji N., Kolangi F. Nephrotonic and nephroprotective medicinal herbs in traditional Persian medicine: review and assessment of scientific evidence. *Current Traditional Medicine*. 2022;8(3):11-25. DOI: 10.2174/221508380766621118145406.
5. Wink M. Modes of action of herbal medicines and plant secondary metabolites. *Medicines*. 2015;2(3):251-286. DOI: 10.3390/medicines2030251.
6. Dewick P.M. Medicinal natural products: a biosynthetic approach. 2nd ed. Chichester: John Wiley & Sons; 2002.
7. Ahmed T., Gilani A.H. Therapeutic potential of turmeric in Alzheimer's disease: curcumin or curcuminoids? *Phytotherapy Research*. 2014;28(4):517-525. DOI: 10.1002/ptr.5030.
8. Panickar K.S. Anti-inflammatory properties of botanical extracts contribute to their protective effects in brain edema in cerebral ischemia. In: Watson R.R., Preedy V.R., editors. *Bioactive nutraceuticals and dietary supplements in neurological and brain disease*. San Diego (CA): Academic Press; 2015. p. 3-15.
9. Fernández-Ruiz J., Sagredo O., Pazos M.R., García C., Pertwee R., Mechoulam R., Martínez-Orgado, J. Cannabidiol for neurodegenerative disorders: important new clinical applications for this phytocannabinoid? *British Journal of Clinical Pharmacology*. 2013;75(2):323-333. DOI: 10.1111/j.1365-2125.2012.04341. x.
10. Hewlings S.J., Kalman D.S. Curcumin: a review of its effects on human health. *Foods*. 2017;6(10):92. DOI: 10.3390/foods6100092.
11. Zafar S., Saeed R., Fatima S., Jahan S. Neuroprotective potential of *Artemisia* species: a review on ethnopharmacology, phytochemistry, and pharmacological activities. *Phytotherapy Research*. 2021;35(1):13-35. doi:10.1002/ptr.6802.

12. Khazdair M.R., Kianmehr M., Anaiegoudari A. Effects of medicinal plants and flavonoids on Parkinson's disease: a review on basic and clinical evidences. *Advanced Pharmaceutical Bulletin*. 2020;11(2):224-231. DOI: 10.34172/apb.2021.026.
13. Cragg G.M., Newman D.J. Natural products: a continuing source of novel drug leads. *Biochimica et Biophysica Acta (BBA) - General Subjects*. 2013;1830(6):3670-3695. DOI: 10.1016/j.bbagen.2013.02.008.
14. Etkin N.L., Ticktin T. Integrating ethnographic and ecological perspectives for ethnopharmacology field research. In: Etkin N.L., editor. *Eating on the wild side: the pharmacologic, ecologic, and social implications of using noncultigens*. Tucson (AZ): University of Arizona Press; 2005. p. 187-206.
15. Fabricant D.S., Farnsworth N.R. The value of plants used in traditional medicine for drug discovery. *Environmental Health Perspectives*. 2001;109(Suppl 1):69-75. DOI: 10.1289/ehp.01109s169.
16. Barnes J., Anderson L.A., Phillipson J.D., Heinrich M. *Fundamentals of pharmacognosy and phytotherapy*. London: Churchill Livingstone; 2004.
17. Alamgir A.N.M. Origin, definition, scope and area, subject matter, importance, and history of development of pharmacognosy. In: Alamgir A.N.M., editor. *Therapeutic Use of Medicinal Plants and Their Extracts. Volume 1: Pharmacognosy*. Cham: Springer; 2017. p. 19-60.
18. Balick M.J., Cox P.A. *Plants, people, and culture: the science of ethnobotany*. 2nd ed. Boca Raton (FL): CRC Press; 2020.
19. Gurib-Fakim A. Medicinal plants: traditions of yesterday and drugs of tomorrow. *Molecular Aspects of Medicine*. 2006;27(1):1-93. DOI: 10.1016/j.mam.2005.07.008.
20. Hongratanaworakit T. Simultaneous aromatherapy massage with rosemary oil on humans. *Scientia Pharmaceutica*. 2009;77(2):375-388. DOI: 10.3797/scipharm.090312.
21. Kadi A., Öner S., Yuca H., Arslan M.E., Atila A., İncekara Ü., Karakaya S. Integrative study of *Plantago lanceolata* L.: Phytochemical properties and therapeutic effects on cancer, diabetes, and Alzheimer's disease. *Natural Product Research*. 2025;1-11. DOI:10.1080/14786419.2025.2469311.
22. Wink M. *Annual Plant Reviews, Functions and Biotechnology of Plant Secondary Metabolites*. Chichester: John Wiley & Sons; 2010.
23. Khosravi M.S., Heidari R., Jamei R., Kouhi S.M.M., Moudi M. Comparative growth and physiological responses of tetraploid and hexaploid species of wheat to flooding stress. *Acta Agriculturae Slovenica*. 2018;111(2):285-292.
24. Harborne J.B. *Introduction to Ecological Biochemistry*. 4th ed. London: Academic Press/Elsevier; 2014.
25. Gershenzon J., Dudareva N. The function of terpene natural products in the natural world. *Nature Chemical Biology*. 2007;3(7):408-414. DOI: 10.1038/nchembio0707-408.
26. Isman M.B. Plant essential oils for pest and disease management. *Crop Protection*. 2000;19(8-10):603-608.
27. Raut J.S., Karuppaiyl S.M. A status review on the medicinal properties of essential oils. *Industrial Crops and Products*. 2014; 62:250-264. DOI: 10.1016/j.indcrop.2014.09.091.
28. Zhang X., Wei X., Shi L., Jiang H., Ma F., Li Y., Li C., Ma Y. The latest research progress: active components of Traditional Chinese medicine as promising candidates for ovarian cancer therapy. *Journal of Ethnopharmacology*. 2024;118811. DOI: 10.1016/j.jep.2023.118811.
29. Fauci A.S., Morens D.M. The perpetual challenge of infectious diseases. *The New England Journal of Medicine*. 2012;366(5):454-461. DOI: 10.1056/NEJMr1108296.
30. Cullen P. Mental illness in the oldest-old. In: *Advanced Age Geriatric Care: A Comprehensive Guide*. Cham: Springer International Publishing; 2018. p. 145-157.
31. Patwardhan B., Vaidya A.D., Chorghade M. Ayurveda and natural products drug discovery. *Current Science*. 2004; 78:789-799.
32. Prince M., Ali G.C., Guerchet M., Yu-Tzu W., Prina M. The global prevalence of dementia. *World Alzheimer Report*. 2009; 25:45.
33. Sarris J., Panossian A., Schweitzer I., Stough C., Scholey A. Herbal medicine for depression, anxiety and insomnia: a review of psychopharmacology and clinical evidence. *European Neuropsychopharmacology*. 2011;21(12):841-860. DOI: 10.1016/j.euroneuro.2011.07.004.
34. Pandey S. Phytochemicals: Recent trends pertaining to beneficial effects on neurological disorders. *Neuro Phytomedicine*. 2024; 1:1-20.
35. Butterfield D.A., Castegna A., Pocernich C.B., Drake J., Scapagnini G., Calabrese V. Nutritional approaches to combat oxidative stress in Alzheimer's disease. *Journal of Nutritional Biochemistry*. 2002;13(8):444-461. DOI: 10.1016/S0955-2863(02)00111-X.
36. Singh S., Chib S., Akhtar M.J., Kumar B., Chawla P.A., Bhatia R. Paradigms and success stories of natural products in drug discovery against neurodegenerative disorders (NDDs). *Current Neuropharmacology*. 2024;22(6):992-1015. DOI: 10.2174/1570159X22666240617124417.
37. Alzobaidi N., Quasimi H., Emad N.A., Alhalmi A., Naqvi M. Bioactive compounds and traditional herbal medicine: promising approaches for the treatment of dementia. *Degenerative Neurological and Neuromuscular Disease*. 2021; 11:1-14. DOI: 10.2147/DNND.S287723.
38. Howes M.J.R., Perry N.S., Houghton P.J. Plants with traditional uses and activities, relevant to the management of Alzheimer's disease and other cognitive disorders. *Phytotherapy Research*. 2003;17(1):1-18. DOI: 10.1002/ptr.1114.
39. Nimrouzi M., Zarshenas M.M. Anorexia: highlights in Traditional Persian medicine and conventional medicine. *Avicenna Journal of Phytomedicine*. 2018;8(1):1-9. DOI: 10.22038/AJP.2017.26625.1884.
40. Moradi S.Z., Momtaz S., Bayrami Z., Farzaei M.H., Abdollahi M. Nanoformulations of herbal extracts in treatment of neurodegenerative disorders. *Frontiers in Bioengineering and Biotechnology*. 2020; 8:238. DOI: 10.3389/fbioe.2020.00238.
41. Sadeghi H.S., Rezaei Tavirani M., Mokaberinejad R., Poormohammadi M. Medicinal plants used to relieve toothache in Iranian traditional medicine. *Research Journal of Pharmacognosy*. 2025;12(1):63-78.
42. Gamel R.M.E., Haroun S.A., Alkhateeb O.A., Soliman E.A., Tanash A.B., Sherief A.D.A., Abdel-Mogib M., Abdou A.H., Ali H.S.A.M., Al-Harbi N.A., Abdelaal, K. Role of biotransformation of *Acacia nilotica* metabolites by *Aspergillus subolivaceus* in boosting Lupinus termis yield: a promising approach to sustainable agriculture. *Sustainability*. 2023; 15:9509. DOI: 10.3390/su15129509.
43. Batubara R., Hanum T.I., Affandi O. GC-MS analysis of young and mature wild agarwood leaves (*Aquilaria malaccensis* Lamk) and its antioxidant potential. *IOP Conference Series: Earth and Environmental Science*. 2021; 912:012003.
44. Aati H.Y., Attia H.A., Alanazi A.S., Al Tamran L.K., Wanner J.K. Phytochemical characterization utilizing HS-SPME/GC-MS: exploration of the antioxidant and enzyme inhibition properties of essential oil from Saudi *Artemisia absinthium* L. *Pharmaceuticals*. 2024; 17:1460. DOI: 10.3390/ph17101460.
45. Shah A.J., Gilani A.H., Abbas K., Rasheed M., Ahmed A., Ahmad V.U. Studies on the chemical composition and possible mechanisms underlying the antispasmodic and bronchodilatory activities of the essential oil of *Artemisia maritima* L. *Archives of Pharmacol Research*. 2011;34(8):1227-1238. DOI: 10.1007/s12272-011-0806-9.
46. Zhigzhitzhapova S.V., Popov D.V., Pintaeva E.T., Radnaeva L.D., Chimittsyrenova L.I., Randalova T. Essential oil from *Artemisia sieversiana* Willd. and development of related oil-in-water emulsions. *Pharmaceutical Chemistry Journal*. 2017; 51:388-390. DOI: 10.1007/s11094-017-1634-0.
47. Antsyshkina A.M., Ars Yu.V., Bokov D.O., Pozdnyakova N.A., Prostodusheva T.V., Zaichikova S.G. The genus *Asarum* L.: a phytochemical and ethnopharmacological review. *Systematic Reviews in Pharmacy*. 2020;11(5):472-502.
48. Watekar R., Patil S., Pawar S., Jadhav V., Kadam V. Phytochemical screening of oil extracted from two categories of fruit of *Semecarpus anacardium* Linn. using traditional Indian method. *International Journal of Botany Studies*. 2020;5(4):236-248.
49. Mustafa H.H., Al-Khafaji Z.S., Al-Khafaji A.A., Al-Khafaji A.H., Al-Khafaji H.A. Extraction and identification of effective compounds from natural plants. *Journal of Composites Science*. 2022;6(5):149. DOI: 10.3390/jcs6050149.

50. Fernández N., Lanosa D.A., Janezic N.S., Quiroga P.N. Development and validation of a GC-MS method for quantification of terpenes in *Cannabis sativa* L. oil: application to commercially available preparations in Argentina. *Journal of Applied Research on Medicinal and Aromatic Plants*. 2023; 35:100466. DOI: 10.1016/j.jarmap.2023.100466.
51. Kianasab M.R., Asghari G., Mahdavi M.A. GC/MS analysis of the hydrodistilled essential oils and volatiles from the aerial parts of *Cannabis sativa* L. *Natural Product Research*. 2023; 37:1–5. doi:10.1080/14786419.2023.2241845.
52. Umezu T., Sano T., Hayashi J., Yoshikawa Y., Shibata Y. Identification of isobutyl angelate, isoamyl angelate, and 2-methylbutyl isobutyrate as active constituents in Roman chamomile essential oil that promotes mouse ambulation. *Flavour and Fragrance Journal*. 2017; 32:1–7. doi:10.1002/ffj.3356.
53. Wang M., Avula B., Wang Y.H., Zhao J., Avonto C., Parcher J.F., Khan I.A., Willmann J.T. An integrated approach utilising chemometrics and GC/MS for classification of chamomile flowers, essential oils, and commercial products. *Food Chemistry*. 2014; 152:391–398. doi: 10.1016/j.foodchem.2013.11.114.
54. Cui Q., Zhang X., Liu T., Li F., Zhang L. Metabolomic profiles of *Citrus aurantium* pericarp during development. *Food Chemistry: X*. 2024; 23:101631. doi: 10.1016/j.fochx.2024.101631.
55. Fahmy N.M., Fayed S., Uba A.I., Shariati M.A., Aljohani A.S.M., El-Ashmawy I.M., Batiha G.E.S., Eldahshan O.A., Singab A.N.B., Zengin G. Comparative GC-MS analysis of fresh and dried *Curcuma* essential oils with insights into their antioxidant and enzyme inhibitory activities. *Plants*. 2023; 12:1785. doi:10.3390/plants12101785.
56. Memariani T., Shaterian B., Esfandiari M. Evaluation of the cytotoxic effects of *Cyperus longus* extract, fractions, and its essential oil on the PC3 and MCF7 cancer cell lines. *Oncology Letters*. 2016;11(2):1353–1360. doi:10.3892/ol.2016.4097.
57. Abo-Altmen R.A., Al-Shammari A.M., Shawkat M.S., Al-Marzouqi A.S. GC-MS analysis and chemical composition identification of *Cyperus rotundus* L. from Iraq. *Energy Procedia*. 2019; 157:1462–1474. doi: 10.1016/j.egypro.2018.11.325.
58. Dormousoglou M., Tzima E., Papadopoulou V., Antonopoulou E., Tsatsakis K. Investigation of the genotoxic, antigenotoxic, and antioxidant profile of different extracts from *Equisetum arvense* L. *Antioxidants*. 2022; 11:1393. doi:10.3390/antiox11071393.
59. Zhu Q., Li H., Xu F., Wei S., Zhang C. Chemical composition and antimicrobial activity of essential oil from *Euphorbia helioscopia* L. *Natural Product Communications*. 2020;15(9):1934578X20953249. doi:10.1177/1934578X20953249.
60. Karki S., Raut P., Rai M., Shrestha B., Joshi R. Phytochemical screening and GC-MS analysis of *Euphorbia hirta*. *Journal of Pharmacognosy and Phytochemistry*. 2020;9(1):1883–1889.
61. Sosa A.A., Bagi S.H., Hameed I.H. Analysis of bioactive chemical compounds of *Euphorbia lathyris* using gas chromatography-mass spectrometry and Fourier-transform infrared spectroscopy. *Journal of Pharmacognosy and Phytotherapy*. 2016;8(5):109–126.
62. Rautela I., Singh S., Singh A., Singh R., Singh S. Comparative GC-MS analysis of *Euphorbia hirta* and *Euphorbia milii* for therapeutic potential utilities. *Plant Archives*. 2020;20(2):3515–3522.
63. Adil M., Filimban F.Z., Ambrin, Qudooos A., Sher A.A., Naseer M. Phytochemical screening, HPLC analysis, antimicrobial and antioxidant effect of *Euphorbia parviflora* L. (Euphorbiaceae Juss.). *Scientific Reports*. 2024;14(1):5627. doi:10.1038/s41598-024-55905-w.
64. El-Amier Y.A., Al-Hadithy O.N., Fahmy A.A., El-Eraky T.E., El-Sayed A.I., El-Banna O.M., El-Shahat Z.A. *Euphorbia retusa* (Forssk.): A promising source for bioactive compounds in biomedical and agriculture applications. *Plant Archives*. 2021;21(1):23–31.
65. Darweesh K.F., Ahmed K.M. Anatomical and phytochemical study of *Glossostemon bruguieri* (Desf.) Sterculiaceae in Kurdistan Region of Iraq. *Diyala Journal for Pure Science*. 2017;13(1):23–41. doi:10.24237/djps.1301.115B.
66. Asadi M. Chemical structure of *Glycyrrhiza glabra* L. and *Salvia officinalis* L. essential oils collected from Kermanshah Province in west of Iran. *Journal of Medicinal Herbs*. 2021;12(4):33–42. doi:10.22092/medherb.2021.687756.
67. Semiz N., Deveci M.Z.Y. Effects of common centaury (*Centaureum erythraea*) oil and laurel (*Laurus nobilis*) seed oil on full-thickness excisional skin wound healing in rats. *Ankara Üniversitesi Veteriner Fakültesi Dergisi*. 2024;71(4):487–496. doi:10.33988/auvfd.1085562.
68. Kıvrak Ş., Göktürk T., Kıvrak İ. Assessment of volatile oil composition, phenolics and antioxidant activity of bay (*Laurus nobilis*) leaf and usage in cosmetic applications. *International Journal of Secondary Metabolite*. 2017;4(2):148–161. doi:10.21448/ijsm.323800.
69. Saeedi M., Khanavi M., Shahsavari K., Manayi A. *Matricaria chamomilla*: An updated review on biological activities of the plant and constituents. *Research Journal of Pharmacognosy*. 2024;11(1):109–136.
70. El Omari N., Benaissa A., El Ghouizi A., Aazza S., Aouinty B., Gseyra N., Tamsouri N., Naceiri Mrabti H., Cherrah Y., Alaoui K., El Mzibri M. GC-MS-MS analysis and biological properties determination of *Mentha piperita* L. essential oils. *Biochemical Systematics and Ecology*. 2024; 116:104875. doi: 10.1016/j.bse.2024.104875.
71. Karami H., Rasekh M., Darvishi Y., Khaledi R. Effect of drying temperature and air velocity on the essential oil content of *Mentha aquatica* L. *Journal of Essential Oil-Bearing Plants*. 2017;20(4):1131–1136.
72. Al-Taie S., Al-Kenane N. Study biochemistry of *Mentha longifolia* (L.) Huds. A review. *Herbs and Spices*. 2020; 27:1–8.
73. El Maimouni M.A., Bencheikh N., Zair T., Hassikou R., El Azhary K., Lahrichi A., Ouahhoud S., Bendaoud H. Chemical composition, antioxidant activity, and multivariate analysis of four Moroccan essential oils: *Mentha piperita*, *Mentha pulegium*, *Thymus serpyllum*, and *Thymus zygis*. *The Scientific World Journal*. 2024; 2024:5552496. DOI: 2024/5552496.
74. Choudhury P.P.N., Choudhury S. GC-MS profiling and bioactivity prediction of compounds from *Momordica charantia* L. extract. *Bioinformation*. 2022;18(10):1009. DOI: 973206300181009.
75. Ferreira Almeida N., dos Santos Niculau E., Cordeiro Toledo Lima P., Ferreira da Silva W. Determination of the volatile chemical profile of *Momordica charantia* (bitter melon) leaf and fruit by GC-MS. *Natural Product Research*. 2024;1–8. DOI: 14786419.2024.2325595.
76. Gotti R., Bertucci C., Cavrini V., Andrisano V. Analysis of Amaryllidaceae alkaloids from *Narcissus* by GC-MS and capillary electrophoresis. *Journal of Pharmaceutical and Biomedical Analysis*. 2006;42(1):17–24. DOI: j. jpbpa.2006.01.003.
77. Tallini L.R., Manfredini G., Rodríguez-Escobar M.L., Ríos S., Martínez-Francés V., Feresin G.E., Borges W.S., Bastida J., Viladomat F., Torras-Claveria L. The anti-cholinesterase potential of fifteen different species of *Narcissus* L. (Amaryllidaceae) collected in Spain. *Life*. 2024;14(4):536. DOI: life14040536.
78. Mgbeje B.I.A., Abu C. Chemical fingerprinting of *Nauclea latifolia*, an antidiabetic plant, using GC-MS. *Journal of Complementary and Alternative Medical Research*. 2020;9(4):25–34. DOI: jocamr/2020/v9i430148.
79. Zaid R., Smaili A., Abouraicha E., Ghaout S., Elbouzidi A., El Bouhali B., Taourite M., Haddiou A. Phytochemical analyses and toxicity of *Nerium oleander* (Apocynaceae) leaf extracts against *Chaitophorus leucomelas* Koch, 1854 (Homoptera: Aphididae). *Journal of the Saudi Society of Agricultural Sciences*. 2022;21(5):310–317.
80. Ababutain I.M. Antimicrobial activity and gas chromatography-mass spectrometry (GC-MS) analysis of Saudi Arabian *Ocimum basilicum* leaves extracts. *Journal of Pure and Applied Microbiology*. 2019;13(2):823–833. DOI: JPAM.13.2.17.
81. Önder A., Nahar L., Nath S., Sarker S.D. Phytochemistry, traditional uses and pharmacological properties of the genus *Opopanax* W.D.J. Koch: A mini-review. *Pharmaceutical Sciences*. 2020;26(2):99–106.
82. Kenari H.M., Kordafshari G., Moghimi M., Eghbalian F., TaherKhani D. Review of pharmacological properties and chemical constituents of *Pastinaca sativa*. *Journal of Pharmacopuncture*. 2021;24(1):14. DOI: jopc.2021.24.1.14.
83. Ušjak L., Niketić M., Petrović S. Composition of essential oils from fruits of *Peucedanum longifolium* and *Rhizomatophora aegopodioides*

- (Apiaceae) with regard to other related taxa—A chemometric approach. *Separations*. 2024;11(1):14. DOI: separations11010014.
84. Wajs-Bonikowska A., Stachurska M., Kula J., Kuźma Ł., Zawirska-Wojtasiak R., Krajewska U. Composition and biological activity of *Picea pungens* and *Picea orientalis* seed and cone essential oils. *Chemistry & Biodiversity*. 2017;14(3): e1600264. DOI: chem.201600264.
 85. Alperth F., Schneebauer A., Kunert O., Bucar F. Phytochemical analysis of *Pinus cembra* heartwood—UHPLC-DAD-ESI-MSn with focus on flavonoids, stilbenes, bibenzyls and improved HPLC separation. *Plants*. 2023;12(19):3388. DOI: plants12193388.
 86. Ghaffari T., Kafil H.S., Asnaashari S., Farajnia S., Delazar A., Baek S.C., Kim K.H. Chemical composition and antimicrobial activity of essential oils from the aerial parts of *Pinus eldarica* grown in Northwestern Iran. *Molecules*. 2019;24(17):3203. DOI: molecules24173203.
 87. Amri I., Hanana M., Jamoussi B., Hamrouni L. Essential oils of *Pinus nigra* J.F. Arnold subsp. *laricio* Maire: Chemical composition and study of their herbicidal potential. *Arabian Journal of Chemistry*. 2017;10: S3877–S3882. DOI: j. arabjc.2017.05.019.
 88. Salem M.Z.M., Zeidler A., Böhm M., Mohamed M.E.A., Ali H.M. GC/MS analysis of oil extractives from wood and bark of *Pinus sylvestris*, *Abies alba*, *Picea abies*, and *Larix decidua*. *BioResources*. 2015;10(4):7725–7737. doi:10.15376/biores.10.4.7725-7737.
 89. Jordan I.N., Halub B., Shakya A.K., Elagbar Z.A., Naik R.R. GC-MS analysis and biological activity of essential oil of fruits, needles and bark of *Pinus pinea* grown wildy in Jordan. *Acta Poloniae Pharmaceutica – Drug Research*. 2019;76(6):1137–1146. DOI: 10.32383/appdr/110548.
 90. Arsana I.N., Suprpta D.N., Putra D.P., Mardika I.W., Ardiansyah H., Lestari D.R. GC-MS analysis of the active compound in ethanol extracts of white pepper (*Piper nigrum* L.) and pharmacological effects. *Cellular and Molecular Biomedical Reports*. 2022;2(3):151–161. DOI: cmbmr.2022.151161.
 91. El-Feky A.M., El-Deek S.E.M., Abou-Elkhair R., Taha R.A., El-Baz F.K., Abdelaziz A.Z. A therapeutic insight of carbohydrate and fixed oil from *Plantago ovata* L. seeds against ketoprofen-induced hepatorenal toxicity in rats. *Bulletin of the national research Centre*. 2018; 42:1–16. DOI: s42269-018-0036-1.
 92. Sadeghi H., Ahmadian-Attari M.M., Nezhad Z.K., Hosseini A., Sadat-Hoseini A.S., Amanlou M. Protective effects of hydroalcoholic extract of *Rosa canina* fruit on vancomycin-induced nephrotoxicity in rats. *Journal of Toxicology*. 2021; 2021:5525714. DOI: 2021/5525714.
 93. Öz M., Deniz I., Okan O.T., Baltaci C., Karatas S.M. Determination of the chemical composition, antioxidant and antimicrobial activities of different parts of *Rosa canina* L. and *Rosa pimpinellifolia* L. essential oils. *Journal of Essential Oil-Bearing Plants*. 2021;24(3):519–537. DOI: 0972060X.2021.1923250.
 94. Kumar M., Upadhyay S.N., Mishra P.K. Pyrolysis of sugarcane (*Saccharum officinarum* L.) leaves and characterization of products. *ACS Omega*. 2022;7(32):28052–28064. DOI: acsomega.2c03524.
 95. Sánchez-Hernández E., González-García V., Correa-Guimarães A., Casanova-Gascón J., Martín-Gil J., Martín-Ramos P. Phytochemical profile and activity against *Fusarium* species of *Tamarix gallica* bark aqueous ammonia extract. *Agronomy*. 2023;13(2):496. DOI: agronomy13020496.
 96. Fayed M.A.A., Abou El-Kassem L.T., Soliman W.E., Fayed Y.H., Rabeh M.A., Abdelhafez O.H. Chemical profiling and cytotoxic potential of the n-butanol fraction of *Tamarix nilotica* flowers. *BMC Complementary Medicine and Therapies*. 2023; 23:169. DOI: s12906-023-04082-0.
 97. Uraku A.J., Uraku O.H., Nwalo F.N., Obasi O., Okorie I.I., Nzubechukwu E., Nwamaka E.N. Phytochemical and GC-MS evaluation of bioactive principle of *Vitis vinifera* peels. *Asian Journal of Applied Sciences*. 2018; 11:192–198. DOI: 10.3923/ajaps.2018.192.198.
 98. Roy C.L., Das S., Das N., Maity P., Datta K., Dey D. GCMS and FTIR analysis on the methanolic extract of red *Vitis vinifera* peel. *World Journal of Pharmaceutical Sciences*. 2018;7(8):1110–1123.
 99. Mahmoud A.E.D., Mahmoud A.E., Elsharkawy M.M., Ghareeb M.A., Elshamy A.M., Refaat M.M., Elnaggar M.H. Biogenic synthesis of reduced graphene oxide from *Ziziphus spina-christi* (Christ's thorn jujube) extracts for catalytic, antimicrobial, and antioxidant potentialities. *Environmental Science and Pollution Research International*. 2022; 29:89772–89787. DOI: s11356-022-21763-5. https://doi.org/10.1007/s11356-022-21871-x.
 100. Ads E.N., Soliman A.M., Zalat E.M., Tammam A.M., Ghazal A.A., Khalil K.F. Phytochemical screening of different organic crude extracts from the stem bark of *Ziziphus spina-christi* (L.). *Biomedical Research*. 2018;29(8):1645–1652. DOI:10.4066/biomedicalresearch.29-17-1668.
 101. Cadi H.E., Bouzidi H.E., Selama G., Cadi A.E., Ramdan B., Oulad El Majdoub Y., Alibrando F., Dugo P., Mondello L., Fakhri Lanjri A., Brigui J., Cacciola F. Physico-chemical and phytochemical characterization of Moroccan wild jujube "*Zizyphus lotus* (L.)" fruit crude extract and fractions. *Molecules*. 2020;25(22):5237. DOI: molecules25225237.
 102. Fiore C., Eisenhut M., Krausse R., Ragazzi E., Pellati D., Armanini D., Bielenberg J. Antiviral effects of *Glycyrrhiza* species. *Phytotherapy Research*. 2008;22(2):141–148. DOI: 10.1002/ptr.2295
 103. Koulivand P.H., Khaleghi Ghadiri M., Gorji A. Lavender and the nervous system. *Evidence-Based Complementary and Alternative Medicine*. 2013; 2013:681304. DOI:10.1155/2013/681304
 104. Yang H., Woo J., Pae A.N., Um M.Y., Cho N.C., Park K.D., Yoon M., Kim J., Lee C.J., Cho S. α -Pinene, a major constituent of pine tree oils, enhances non-rapid eye movement sleep in mice through GABAA-benzodiazepine receptors. *Molecular Pharmacology*. 2016;90(5):530–539. DOI: 10.1124/mol.116.105080.
 105. Cheng Y., Feng Z., Zhang Q.Z., Zhang J.T. Beneficial effects of melatonin in experimental models of Alzheimer disease. *Acta Pharmacologica Sinica*. 2006;27(2):129–139. DOI: aps06212.
 106. Dubey A., Singh Y. Medicinal properties of *Cinchona* alkaloids—a brief review. *Journal of Medicinal Plants Studies*. 2021; 9(3):1–6.
 107. Zierau O., Geis R.B., Tischer S., Schwab P., Metz P., Vollmer G. Uterine effects of the phytoestrogen 6-(1,1-dimethylallyl) naringenin in rats. *Planta Medica*. 2004;70(7):590–593. DOI: s-2004-815515.
 108. Boubakri A., Leri M., Bucciantini M., Najjaa H., Ben Arfa A., Stefani M., Neffati M. *Allium roseum* L. extract inhibits amyloid beta aggregation and toxicity involved in Alzheimer's disease. *PLoS One*. 2020;15(9): e0223815. DOI: journal. pone. 0223815.
 109. Mandel S., Amit T., Reznichenko L., Weinreb O., Youdim M.B. Green tea catechins as brain-permeable, natural iron chelators-antioxidants for the treatment of neurodegenerative disorders. *Molecular Nutrition & Food Research*. 2006;50(2):229–234. DOI: mnfr.200500167.
 110. Saeedi M., Vahedi-Mazdabadi Y., Rastegari A., Soleimani M., Eftekhari M., Akbarzadeh T. Evaluation of *Asarum europaeum* L. rhizome for the biological activities related to Alzheimer's disease. *Research Journal of Pharmacognosy*. 2020;7(3):25–33.
 111. Le J., Ji H., Zhou X., Wei X., Chen Y., Fu Y., Ma Y., Han Q., Sun Y., Gao Y., Wu H. Pharmacology, toxicology, and metabolism of sennoside A, a medicinal plant-derived natural compound. *Frontiers in Pharmacology*. 2021; 12:714586. DOI: fphar.2021.714586.
 112. Zhang R., Zeng M., Zhang X., Zheng Y., Lv N., Wang L., Gan J., Li Y., Jiang X., Yang L. Therapeutic candidates for Alzheimer's disease: saponins. *International Journal of Molecular Sciences*. 2023;24(13):10505. DOI: ijms241310505.
 113. Kennedy D., Okello E., Chazot P., Howes M.J., Ohiomokhare S., Jackson P., Haskell-Ramsay C., Khan J., Forster J., Wightman E. Volatile terpenes and brain function: investigation of the cognitive and mood effects of *Mentha × piperita* L. essential oil with in vitro properties relevant to central nervous system function. *Nutrients*. 2018;10(8):1029. DOI: nu10081029.
 114. Sarkhail P. Traditional uses, phytochemistry and pharmacological properties of the genus *Peucedanum*: A review. *Journal of Ethnopharmacology*. 2014; 156:235–270. DOI: j.jep.2014.08.041.
 115. Viola H., Wasowski C., De Stein M.L., Wolfman C., Silveira R., Dajas F., Medina J.H., Paladini A.C. Apigenin, a component of *Matricaria recutita* flowers, is a central benzodiazepine receptors-ligand with anxiolytic effects. *Planta Medica*. 1995;61(3):213–216. DOI: s-2006-958027.

- 116.Hadi A., Hossein N., Shirin P., Najmeh N., Abolfazl M. Anti-inflammatory and analgesic activities of *Artemisia absinthium* and chemical composition of its essential oil. International Journal of Pharmaceutical Sciences and Review Research. 2014; 38:237–244.
- 117.Zulfugarova P., Zivari-Ghader T., Maharramova S., Ahmadian E., Eftekhari A., Khalilov R., Turksoy V.A., Rosić G., Selakovic D. A mechanistic review of pharmacological activities of homeopathic medicine licorice against neural diseases. Frontiers in Neuroscience. 2023; 17:1148258. DOI: fnins.2023.1148258.
- 118.Kemboi D., Peter X., Langat M., Tembu J. A review of the ethnomedicinal uses, biological activities, and triterpenoids of *Euphorbia* species. Molecules. 2020;25(17):4019. DOI: molecules25174019.
- 119.Shoaib S., Ansari M.A., Fatease A.A., Safhi A.Y., Hani U., Jahan R., Alomary M.N., Ansari M.N., Ahmed N., Wahab S., Ahmad W. Plant-derived bioactive compounds in the management of neurodegenerative disorders: challenges, future directions and molecular mechanisms involved in neuroprotection. Pharmaceutics. 2023;15(3):749. DOI: pharmaceutics15030749.
- 120.Rabizadeh F., Mirian M.S., Doosti R., Kiani-Anbouhi R., Eftekhari E. Phytochemical classification of medicinal plants used in the treatment of kidney disease based on traditional Persian medicine. Evidence-Based Complementary and Alternative Medicine. 2022; 2022:8022599. DOI: 2022/8022599.
- 121.Rabizadeh F., Mirian M.S. The classification of medicinal plants used in traditional Persian medicine for the treatment of liver disease based on phytochemical properties. Journal of Medicinal Plants By-products. 2024;13(2):257–284. 10.22034/jmpb.2023.363981.1623.