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The Lamiaceae Family Plants Ethnobotanical Properties, Ethnopharmacological Uses, Phytochemical Studies and Their Utilization in Public or Current Clinical Practices: A Review

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Abstract: Through ethnobotanical, pharmacological, and phytochemical data of the Lamiaceae family of inflammatory, cardiovascular, diabetes, Alzheimer's disease, cancer, and gastrointestinal disorders, this study aims to gather knowledge on traditional usage. The necessity to guarantee the safety, effectiveness, and purity of herbal medicines is underscored by the long tradition of folk medicine's use for therapeutic purposes. As this need has increased throughout the years, collective attempts have been made to conserve priceless information about therapeutic plants and to archive records of the past. The family Lamiaceae, sometimes known as Labiatae, is well known for its wide variety of medicinal herbs. The leaves, flowers, roots, bark, fruit, twigs, seeds, and other components of Lamiaceae species may be separately utilized for medicinal purposes. A multitude of plants in the Lamiaceae family have been used in traditional medicine to treat a variety of illnesses. The members of the Lamiaceae family are found across the Mediterranean area. Also, some biochemical and pharmacological analyses have been used to investigate the biological activity of Lamiaceae species. Its pharmacological qualities have been confirmed by the thorough study, which has shown that numerous bioactive characteristics of this plants possess wound healing, immunomodulatory, antioxidant, antidiabetic, anti-Alzheimer's disease, enzymes inhibitory, antiviral, antibacterial, anti-inflammatory, anticancer, antihypertensive, and antileishmanial effects. This thorough analysis provides a perceptive synopsis of the Lamiaceae family, clarifies the extraction techniques used to produce therapeutic organic compounds, investigates the phytoconstituents found in Lamiaceae medicinal plant species, and systematically describes the family's diverse range of pharmacological properties.

Keywords Lamiaceae species; antioxidants; phytochemistry; ethnobotany; ethnopharmacology; phenolic compounds.

1. Introduction

Plants are potential natural resources for the development of new products in the cosmetic, food, and pharmaceutical industries [1-3]. Plant-based medications are being used extensively in many healthcare procedures across the world since they are safe, accessible, and successful at preventing and treating a variety of fatal illnesses [4-7]. The therapeutic application of herbal medications is widespread

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in indigenous medicine, Ayurveda, Sidda, Unani, and other alternative medical disciplines. Approximately 80% of people worldwide still rely on traditional herb-based remedies, according to the World Health Organization, since they are inexpensive, easily accessible, and probably have fewer adverse effects than allopathic pharmaceuticals [8]. The knowledge of traditional medicinal techniques for the treatment of illnesses is undoubtedly the primary reason for the use of many of the most potent active medication molecules of plants and their derivatives in traditional medical treatment today [9]. Herbal remedies are widespread because they are inexpensive, easy to obtain, effective, and have little adverse reactions [10].

Because of its ability to support health, provide temporary symptom relief, or have therapeutic purposes, medicinal plants, often referred to as medical herbs, are used in herbal medicine [11-13]. A variety of substances, known as phytoconstituents, are produced by plants and are crucial to their biological processes, including defense against predators including insects, fungi, herbivores, and animals. Utilizing complete plants or plant parts (leaves, flowers, fruits, stems, roots, or rhizomes) to promote a person's overall health is known as herbal medicine or phytotherapy, and it is a long-standing custom that is performed all over the world [14-16]. Recent studies have shown that some active phenolic compounds from natural products including plants. [17-19]. The most abundant and biologically active molecules in plants include hederin [20], caffeic acid [21], tannic acid [22], rosmarinic acid [23-25], p-coumaric acid [26], usnic acid [27], naringin [28,29], lignans [30,31], curcumin [32], hesperidin [33], silymarine [34], chrysin [35], baicalin [36], hamamelitannin [37], isofraxidin [38], magnofluorine [39], secoiridoids [40], spiraeoside [41], resveratrol [42], alkaloids [43], coumestrol [44], eugenol [45-47], olivetol [48] and gingerol [49] obtained from plants are highly biologically active agents. Medicinal and aromatic plants play a crucial role in primary health care, food and cosmetic industries in many developing and developed countries. It has been reported that approximately 400,000 plant taxa have been identified to date and approximately 30,000 of them have been documented and used in traditional medicine [50-53]. Several ailments, including cancer, diabetes, heart disease, and aging, have been linked to consuming natural phytochemicals, according to prior research. Phenolic chemicals have also been shown to be abundant in medicinal plants that exhibit greater levels of antioxidant activity. As a result, these plants have the potential to be a source of antioxidants that can help fight cancer and other illnesses [54-56]. The therapeutic application of herbal medications is widespread in indigenous medicine, Ayurveda, Sidda, Unani, and other alternative medical disciplines. Approximately 80% of people worldwide still rely on traditional herb-based remedies, according to the World Health Organization, since they are inexpensive, easily accessible, and probably have fewer adverse effects than allopathic pharmaceuticals [57]. The knowledge of traditional medicinal techniques for treating illnesses is undoubtedly the primary reason for the use of many of the most potent active medication molecules of plants and their derivatives in traditional medical treatment today [58-60]. It is known that these potent relativities of plants are due to the biological effectiveness of phenolic contents [61]. Phenolic compounds have effective biological activities Herbal remedies are widespread because they are inexpensive, easy to obtain, effective, and have little adverse reactions [61-64].

Reactive oxygen species (ROS) are highly reactive chemicals and intermediates formed from diatomic oxygen (O_2) which is abundant. When there is inflammation, neutrophils and macrophages create ROS, which can also be formed by other processes, metal-catalyzed reactions, atmospheric contaminants, and mitochondria-catalyzed electron transport reactions. Exposure to UV, X, and gamma radiation also results in their production [65-67]. The synthesis of ROS and their inactivation are balanced by the antioxidant system in living things. When pathogenic conditions arise, an excess of ROS is produced, which leads to oxidative stress. ROS are generated when the body's natural antioxidant defenses are not strong enough. An imbalance in living things results in oxidative alteration of cellular membranes or intracellular molecules [68,69]. Within living cells, ROS accelerates the oxidative degradation of proteins, lipids, and nucleic acids. ROS, sometimes referred to as free radicals, are widely acknowledged to play a significant role in the development of several severe medical disorders, such as cancer, heart disease, and aging [70-72]. The balance between the generation of ROS and their deactivation is maintained by the antioxidants found in living things. Oxidative stress is brought on by an excess of ROS production in pathological circumstances. ROS are produced when antioxidant defenses are insufficient [73,74]. Excessive ROS and reactive nitrogen species (RNS) can cause oxidative and nitrosative stress and damage the neuronal membrane. The metabolic reaction known as "nitrification stress" is brought on by RNS formed from nitric oxide (NO) and ROS. This reaction causes the aromatic rings of residues of amino acids to be hydroxylated, which can cause apoptosis or other harmful consequences in cells [75,76]. A rise in ROS in living things, which are known to have an equilibrium between oxidants and antioxidants, causes oxidative stress. The use of antioxidants from external sources is essential as variables such as stress, air pollution, diabetes, and chronic illnesses damage the antioxidant defense system. Consuming dietary items with antioxidant qualities is therefore crucial to lowering oxidative damage [77]. ROS has been shown to cause numerous pathophysiological conditions, such as diabetes, inflammatory diseases, oxidative stress, malignancies, cardiovascular problems, and arthritis [78]. Although ROS and RNS have a limited lifespan, unchecked redox reactions constantly produce new ROS, and RNS are thought to have a role in common illnesses, like, diabetes, cancer, age-related macular degeneration, and neurodegenerative Parkinson and Alzheimer's diseases [79]. Antioxidant enzymes and substances are part of the immune system's defense mechanism. Numerous biomolecules' oxidation is decreased, stopped, or halted by antioxidant mechanisms. These compounds consist of polyphenols and are potent ROS blockers that effectively mitigate their undesirable and harmful consequences [80,81]. Nevertheless, meals or supplements high in antioxidants can help the body lessen oxidative damage from free radicals and active oxygen [82,83]. Numerous antioxidant chemicals that occur naturally in plant sources have been discovered as either active oxygen scavengers or free radicals. Recently, there has been a lot of focus on finding naturally occurring antioxidants to utilize in foods or pharmaceuticals because synthetic antioxidants are becoming increasingly rare owing to their adverse effects, such as carcinogenesis [84,85]. Antioxidants, however, may delay or decrease oxidative damage, preventing and/or treating diseases brought on by oxidative stress. Enzymatic antioxidants and non-enzymatic antioxidants are two well-known categories into which antioxidants can be classified [86]. However, cells usually have an inherent antioxidant system that may inhibit ROS's oxidative capacity by activating several antioxidant pathways. Because they include phytochemical elements such as phenolics, terpenes, and alkaloids, medicinally significant plants have strong antioxidant enzymatic activity and free radical removal capabilities. These substances can scavenge free radicals, preventing the oxidative damage that leads to progressive illnesses [87]. The oxidative pathways that lead to degenerative disorders are suppressed by antioxidants such as flavonoids, phenolic acids, tannins, and phenolic diterpenes because they scavenge free radicals like lipid peroxyl, hydroperoxide, and peroxide [88]. Strong defenses against free radical attacks, which are the primary cause of serious health issues, can be found in antioxidant compounds. Therefore, finding novel sources of antioxidants is essential to curing the degenerative diseases listed above. Certain chemicals, like butylated hydroxyanisole (BHA), and butylated hydroxytoluene (BHT), were chemically manufactured and utilized in the chemical industry; nevertheless, their possible hepatotoxicity and carcinogenic effects on humans have raised public concerns about their use [88-90]. Therefore, there has been a lot of research done on plants to investigate whether they possess any antioxidant properties. For this purpose, a lot of study has been done on both raw herbal extracts and purified compounds. For use in food and medicine, there is a rising need for more secure natural antioxidants derived from plants [91]. Medical plants are one of the most important herbal sources of antioxidants. There are a lot of phenols in medicinal plants. The primary natural antioxidants found in the human diet are found in cereals, vegetables, and fruits [92]. Secondary metabolites found in plants called phenolic molecules contribute to avoiding progressive illnesses such as arteriosclerosis, diabetes, rheumatoid arthritis, cancer, cataracts, and cardiovascular disease [93]. Thus, consuming them prevents the antioxidative balance from being upset, which in turn reduces the risk of developing numerous illnesses, such as cancer, heart disease, diabetes, and neurological disorders [94]. Multiple in-vitro and in-vivo studies have suggested that plant extracts, fruits, and their secondary metabolites may help avoid diabetes and neurological problems [95].

The Lamiaceae (Labiatae) is a very diverse and common family of plants, especially when it comes to its ethnomedical applications. The substantial quantity of volatile oils in plants has been proposed to be responsible for the strength of their therapeutic effects [96]. Several species have strong scents, making the Lamiaceae botanical clans one of the largest dicotyledon families. These plants have glandular structures on the outside that produce volatile oils, which are responsible for their scents [97]. Numerous businesses, including medicines, flavoring, insecticides, scent, perfumery, and cosmetics, rely heavily on this specific oil. Mints are a collection of taxonomically different flowering plants that belong to the Lamiaceae family. It has been acknowledged throughout history that they share an intimate kinship with the Verbenaceae family [98]. Although the Lamiaceae family is distributed all over the world, the Mediterranean area is the location it is most prevalent [99]. One of the most significant flowering plant families with a global distribution is the Lamiaceae, which contains the genus Otostegia and is often known as the mint family [100]. There are approximately 6,900–7,200 species in the families around 236 genera. The majority of plants in the Lamiaceae family are fragrant. Ajuga, Coleus, and Salvia are among the species of this family that are grown for their aesthetic qualities [101]. Numerous plants in this family have biological and therapeutic uses as well. The most well-known plants in this family include fragrant spices like hyssop, lemon balm, savory, self-healing, mint, thyme, sage, oregano, basil, rosemary, and others with a broader range of applications [102]. Both annual and perennial herbaceous plants make up the Lamiaceae family. The species tend to be shrubs or herbs. Due to the existence of essential oils, several species are fragrant. On the square stems, the leaves are seated in opposition to one another. Plants in the Lamiaceae family have many glandular trichomes on their aerial portions. One finds the verticillaster inflorescence, which is made up of two condensed dichasial cymes. Adventitious roots are seldom produced by some species; instead, roots are often composed of branching tap roots. The fruits are seldom drupaceous and are composed of achenes, schizocarpic carcerulus, or nutlets [103]. The Lamiaceae family, particularly members of the Lavandula genus like *Lavandula angustifolia* [104] and *Lavandula stoechas* [105] is perhaps one of the most significant in the production of essential oils [104]. The genus Salvia is a standout among the diverse Lamiaceae family, having an astounding 900 species. Other noteworthy genera that add to the enormous diversity of this botanical family include Scutellaria, Coleus, Plectranthus, Hyptis, Teucrium, Thymus, and Nepeta. Each of these genera has 200–360 species [98]. Through its worldwide distribution and diverse range of natural habitats, the Lamiaceae family is incredibly diverse and varied. The strong demand for particular species' food and medicinal has led to the cultivation of several species of the family, including thyme, lavender, basil, mint, and oregano [106]. Throughout Europe, northern and eastern Africa, the Mediterranean, southwest Asia, Arabia, western Iran, and India, there are 41 species of fragrant blooming plants known as lavender [107]. In addition to examining the traditional botanical knowledge of the local population and how they utilize plants for various purposes, ethnobotany explains the full link between humans and plants [108]. Ethnobotanists are increasingly concentrating on the use of various quantitative and statistical techniques to comprehend and gather information on valuable plants in particular communities. Ethnobotanical studies highlight the dynamic relationships between botanical diversity and social and cultural systems [109]. The Lamiaceae family is widely recognized for its medicinal properties because it produces a large number of secondary metabolites, including alkaloids, flavonoids, and phenolics. For example, in traditional folk medicine, *Mentha spicata* is used to treat intestinal, cold, muscular, and stomach issues. The antioxidant capacity of *M. spicata* is associated with the presence of phenolics in its leaves [110]. A perennial plant indigenous to the Mediterranean region, *R. officinalis*, sometimes referred to as rosemary, is a member of the Lamiaceae family. But today, most people know *R. officinalis* as *S. rosmarinus.* Because of its therapeutic and nutritional qualities, it is grown all over the World [111]. The Lamiaceae family includes the well-known therapeutic herb *M. officinalis*, usually referred to as lemon balm. The aromatic leaves of this plant have been used extensively in cooking for over 2,000 years to enhance culinary flavors. Additionally, the plant has been used as a memory enhancer, heart tonic, antidepressant, sleeping aid, antidote, and to cure a variety of malignancies, psychological and central nervous system disorders, cardiovascular and respiratory issues, and other illnesses [112]. Environmental factors and genetic variations can affect the quality and yields of phytochemicals, which result in a variety of pharmacological activity in medicinal plants [113].

Therefore, the purpose of the study is to provide up-to-date information on the pharmacological characteristics, phytochemical components, traditional uses, and overall security characteristics of plants in the Lamiaceae family. The review offers phytochemical and pharmacological data that may be used to fill up knowledge gaps, explore viable treatment options, and create promising prevention strategies. This study is suggested to bolster the necessity for more investigation into the development of innovative dietary supplements and diets.

2. Materials and Methods

This review's data was gathered from relevant papers on plants in the Lamiaceae family. Web of Science, Scopus, Elsevier-Science Direct, Google Scholar, PubMed, Google, Springer, Wiley, and other online libraries were used to gather the literature.

3. Phytochemical Constituents

Phytochemicals may be extracted from plants using a variety of techniques, such as steam distillation, maceration, Soxhlet extraction, supercritical fluid extraction, and ultrasound-assisted extraction [114-116]. The plant substance employed, the particular chemicals of concern, and the intended application of the natural extract are only a few of the numerous variables that affect the extraction process. Understanding the secondary metabolites in plants that give rise to various medical applications is crucial. New chemicals and their related function in pharmacological activity are discovered by researchers. Despite the widespread usage of many plant species to treat illnesses, little is known about the substances that cause these effects [117,118]. Nonnutritive plant substances with preventive and antibacterial properties are called phytochemicals. Studies have demonstrated that these chemicals can be useful in actively curing human ailments, despite the fact that they are mostly generated by plants as a self-defense strategy [119-121]. An important and new addition to the world pharmacopeia is phytomedicine. As a result of study and analysis, our understanding of their biological potential is continuously expanding, perhaps making them a safer alternative to allopathic medication. These days, the growing need for novel and improved medications derived from plants has rekindled interest in phytomedicine [122,123]. The current widespread belief that "green medicine" is inexpensive, environmentally friendly, and potentially safer than synthetic drugs-which are more expensive and have several negative side effects largely responsible for the renewed interest in plant-based medications [124]. The structure-activity correlations of secondary metabolites and nutraceuticals with potential pharmacological efficacy are therefore gaining more attention [125]. The link between the phytochemical makeup of plants and their botanical and pharmacological capabilities is also being studied by a large number of researchers from across the World [126,127]. The botanical classification of the Lamiaceae plants is given in Table 1.

Table 1. The botanical classification of the Lamiaceae plants given in this study.

Kingdom	**Plantae**
Subkingdom	*Tracheobionta*
Super division	*Spermatophyta*
Division	*Magnoliophyta*
Class	*Magnoliopsida*
Subclass	*Asteridae*
Order	*Lamiales*
Family	Lamiaceae
Genus	Nearly 236 genera
Species	Almost 7200 species

During the course of their regular metabolic activities, plants produce phytochemicals. Alkaloids, coumarins, flavonoids, glycosides, gums, phenols, polysaccharides, tannins, terpenes, and glycosides are only a few of the numerous chemical types that are referred to as secondary metabolites in plants. The chemical substances found in plants are not the only ones. They may be employed as adjuvants to lessen undesirable side effects of the active components or to help absorb them. The 12,000 of the almost limitless variety of aromatic chemicals that plants can synthesize have been discovered [128]. Among the many bioactive chemical substances found in *O. basilicum* are trans-α-bergamotene, geraniol, methyl eugenol, 1,8-cineole, p-allylanisole, and methyl chavicol [129]. *O. basilicum* contains a wide range of bioactive metabolites. Nonetheless, the majority of research has demonstrated that the primary constituents, in differing amounts, are bergamotene, 1,8-cineole, eucalyptol, methyl chavicol, eugenol, estragole, and linalool [130]. Caffeic acid and its byproducts, rosmarinic acid and chlorogenic acid, are thought to be abundant in Mentha species [131]. Pulegone, cis-isopulegone, cineol, thymol, αand β-pinen, piperitenone, terpenoids, and flavonoids are among the chemical constituents of this plant species [132]. Terpenoids, flavonoids, phenolic acids, anthraquinones, hydrocarbons, polysaccharides, and other phytochemicals are the main components of *Mentha haplocalyx*, according to a thorough investigation. The main bioactive components of these are known to be volatile substances such as terpenoids, among which menthol and menthone are especially noteworthy [133]. Monoterpene phenol (thymol), monoterpene phenol derivative (thymol methyl ether), monoterpene phenol precursors (p-cymene and γ-terpinene), oxygenated monoterpenes (α-terpineol, cis-sabinene hydrate, borneol, camphor, and thymoquinone), monoterpene hydrocarbons (α-pinene, β-myrcene, camphene, and terpinolene), monoterpene hydrocarbons (α-pinene, β-myrcene, camphene, and thymoquinone), and sesquiterpenes (β-bisabolene and β-caryophyllene) make up the majority of the aroma components of Thymus species [134]. Researchers have been searching for new pharmacologically active molecules with unique scaffolds because of the broad range of Salvia plants and their phytochemical abundance. Most importantly, while mono-, sesqui-, di-(abietanes, clerodanes, labdanes, pimaranes, and ent-kauranes), sester-, tri- (oleananes, ursanes, and lupanes) terpenoids, phenylpropanoids, phenolic acids, and flavonoids have been documented in large quantities, only a few rare terpenoid metabolites have been identified from Salvia species up to this point [135]. Diterpenoids, phenolic acids, triterpenoids, flavonoids, and saccharides are the main phytochemical components of Salvia species. While phenolic acids and diterpenoids are mostly found in the roots of plants, flavonoids, triterpenoids, and monoterpenes are primarily found in the aerial sections of the plants, especially in the flowers and leaves [136]. By using GC-MS analysis, several chemical species have been identified in *Clerodendrum infortunatum*, including limonene, phytol, catechol, hexadecanoic acid, squalene, dodecanoic acid, vitamin E, hydroxymethylfurfural, stigmasterol, cinnamic acid, guaiacol, eugenol, and vanillic acid [137]. Based on its flavonoids (quercetin, rhamnocitrin, and luteolin), phenolic acids (rosmarinic and caffeic acid), and volatile chemicals (geranial, citronellal, and geraniol), *Melissa officinalis* (Lamiaceae) is used to treat age-related macular degeneration (AMD). Having strong antioxidant qualities and functioning as radical scavengers, these phytochemicals can lower oxidative damage and apoptosis [138].

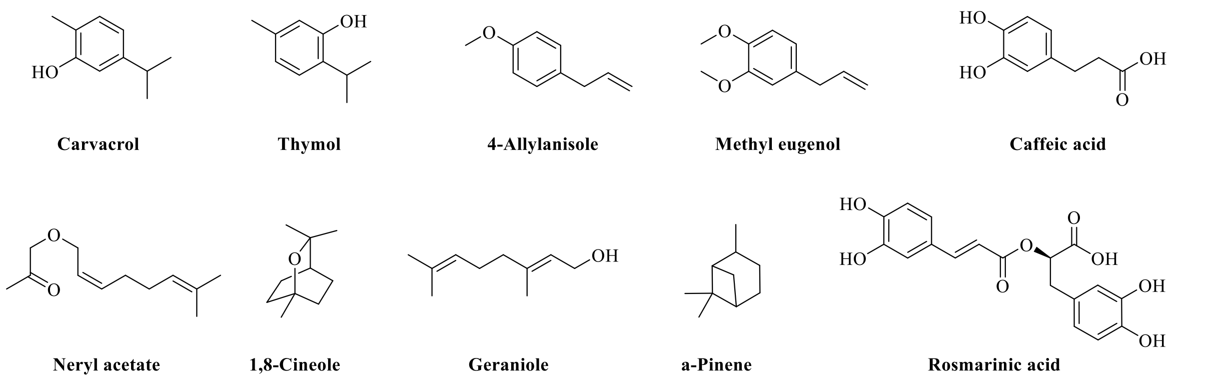

Figure 1. Chemical structure of some phytochemical compounds in Lamiaceae family plants

4. Ethnobotanical Properties and Medicinal Uses

One of the most well-known families of flowering plants is Lamiaceae, which has around 7756 species, 1059 (13.7%) of which are medicinal [139]. Numerous scientists have concluded that the phytochemistry of Lamiaceae is complicated. The Lamiaceae include six primary secondary metabolites: Lignans, flavonoids, iridoids, non-volatile terpenoids, phenylethanoid glycosides, caffeoylquinic and other phenolic acids, and others. The Lamiaceae family's species include several secondary metabolites, which have a variety of biological functions [140]. The past several decades have seen a rise in research on medicinal plants and their traditional uses in medicine around the globe. In order to conserve and use biodiversity, it is critical to record traditional indigenous knowledge through ethnobotanical research. Thus, it is accepted that plants can be utilized in either their developed or original form. According to ethnobotanical knowledge and licensed medications derived from medicinal plants, a variety of physiologically active compounds are known to contain medicinal plants that have been separated from plants and used [141]. Many species of the Lamiaceae family are used in medicine and cooking, and most of them are fragrant. Among these species is *Ballota nigra*, which is native to Europe and Asia and has naturalized in North America. It is said to help with nausea, heart palpitations, persistent coughing, sedatives, nervous system diseases, and, most importantly, mild insomnia in children and adults alike [142].

Figure 2. Major Lamiaceae plants species mentioned in this review. A) *Salvia officinalis*, B) *Salvia fruticosa*, C) *Thmus vulgaris*, D) *Lavandula angustifolia*, E) *Mentha piperita*, F) *Ocimum basilicum*, G) *Rosmarinus officinalis*, H) *Melissa officinalis*, I) *Origanum vulgare*

The Lamiaceae plant *C. infortunatum* is used extensively in traditional medicine to treat a variety of illnesses. *C. infortunatum*'s leaves, roots, and blossoms are cooked into paste, juice, and ash and used as medicine. Assam, India, uses roots to cure asthma and bronchitis. Seeds are used as a snakebite remedy, while leaves and blossoms are utilized as a scorpion sting remedy. *Origanum vulgare* in Greece, Turkey and generally in the Mediterranean region in the near future is important, as it constitutes a plant species with high medical, economic and environmental value.

Most essential oils of the family Lamiaceae consist of monoterpenes and sesquiterpenes. The primary components of oregano, *p*-cymene and γ-terpinene, are found in conjunction with carvacrol and thymol, which are responsible for their action [143]. *R. officinalis*'s wide range of chemical components, referred to as plant secondary metabolites, are responsible for its therapeutic use. Flavonoids (e.g., homoplantaginin, cirsimaritin, genkwanin, gallocatechin, nepitrin, hesperidin, and luteolin derivatives) and phenolic acid derivatives (e.g., rosmarinic acid) are examples of polyphenolic compounds, as are essential oils like 1,8-cineole, α-pinene, camphene, α-terpineol, and borneol [144]. Danish traditional medicine uses herbs like *L. angustifolia* and *R. officinalis* to address memory problems. Rosmarinic acid, an active compound against amyloid fibrillation, is present in both species [145]. Some of the well-known Lamiaceae species were given in review.

5. Pharmacological Activities

5.1. General Overview of Pharmacological Activities

Petroleum ether, butanol, *n*-hexane, ethanol, ethyl acetate, hexane, methanol, and in certain situations, fractionated chloroform, were the extraction chemicals utilized in Lamiaceae plant's chemical constituents. Diterpenoids, flavonoids, phenylpropanoids, and other phenolic chemicals are implicated in a variety of pharmacological effects of Lamiaceae plants.

Lamiaceae species have long been utilized for their preventative and therapeutic qualities. The production of many secondary metabolites with antibacterial, antioxidant, anti-inflammatory, antimicrobial, antiviral, and anticancer qualities accounts for their significance. Flavonoids and phenolic acids, particularly caffeic and rosmarinic acids, are the two primary families of phenolic chemicals that have been found. These antioxidant capabilities support the upkeep and health of the eyes [138]. Remarkably, phylogenetic analysis of ethnobotanically significant plant species may identify pharmacologically vital plant families, revealing various civilizations using diverse species similarly, indicating a trend of cultural convergence [146]. However, there aren't many investigations that have been done to prove the scientific validity of their ethnopharmacological usage. Demonstrating the pharmacological processes and the precise phytochemical constitution required to produce the intended effect, provides a significant area of study that endorses the traditional usage of plant medicines. Additionally, ethnopharmacological research makes it possible to value medicinal plant biodiversity and use it in the sectors of pharmaceuticals and nutraceuticals. Finally, to prevent unregulated gathering that might jeopardize botanical species, ethnopharmacology is a crucial tool for the sustainable use of therapeutic plants [147]. Lamiaceae species are prized for their aesthetic qualities. Additionally, they can be used as medications, cosmetics, vegetables, and spices. Because of their curative and preventative qualities, these species have been utilized for food preservation, flavoring, and medicine. A diverse variety of bioactive chemicals with potential antiviral, anticancer, anti-inflammatory, antibacterial, and antioxidant properties may be found in Lamiaceae species [110]. Ocimum (basil), Rosmarinus (rosemary), Thymus (thyme), Origanum (oregano), Mentha (peppermint, spearmint), Lavandula (lavender), Marrubium (horehound), Nepeta (catnip), Salvia (sage), and Satureja (savory) are among the economically significant species in the Lamiaceae that are used for their essential oils or as spices or herbs. Plant antioxidants, particularly flavonoids and phenolic acids, are abundant in them [148]. Ocimum (basil), Rosmarinus (=*Salvia rosmarinus*) rosemary), With almost 1000 species and a global distribution, the genus Salvia L., or sage, is the most species-rich in the Lamiaceae (mint family). With 100 species, comprising 53 endemics, Turkey appears to have the most Salvia species in South-West Asia, one of the major sites of variety for the plant. The AChE and BChE actions of Salvia species have been identified in prior research as antibacterial, antifungal, wound-healing, antiproliferative, antitubercular, cytotoxic, and antioxidant [149]. Many terpenes and phenolic chemicals found in sage (Salvia) species cooperate with brain function systems to enhance mental capacity [150]. Sage extracts exhibit several biological actions that have been documented, including liver-protective, hypoglycemic, hypolipidemic, antibacterial, anticancer, anticholinesterase, antinociceptive, and antioxidant properties [151]. *Salvia spp*. and *Thymus spp*. have been widely used in traditional medicine since ancient times due to their biological properties in treating certain diseases, including coughs, colds, throat infections, arthritis, and digestive disorders [7]. *O. basilicum*, also known as basil, has been extensively studied for its pharmacological benefits, including antimicrobial, antifungal, antioxidant, anti-inflammatory, antiviral, and wound healing properties. As a result, this plant has the potential to treat a wide range of diseases in both humans and animals [54]. The application of lavender essential oils as components for scent and aromatherapy dates back many years. Many gastrointestinal, neurological, and rheumatic conditions are treated with the plant in traditional and folk remedies across the world. It is also utilized to alleviate anxiety, stress, and sleeplessness [152]. When making herbal teas and infusions, a sizable portion of imported dried thyme is utilized as a medicinal plant. Additionally, the potato and sausage businesses include thyme as a component in their spice blends. rising demand for fair-trade and organic-certified dried thyme in Europe is primarily driven by consumers' desire for reliable and sustainable sourcing as well as their growing interest in international ethnic cuisines [153]. 1,8-Cineole, α-pinene, limonene, and camphor are among the several monoterpenes found in the volatile oil that was isolated from *R. officinalis* [154]. Its significant antioxidant, analgesic, and anti-inflammatory properties, as well as those of its nanoemulsion in experimental models, have been emphasized in earlier studies [155]. The plant's anxiolytic, antiviral, and antispasmodic properties, together with its effects on mood, cognition, and memory, were the only pharmacological effects demonstrated in clinical studies using crude extracts and pure substances extracted from *M. officinalis* [112]. Potential pharmaceutical activities of Lamiaceae plants are indicated as in the figure.

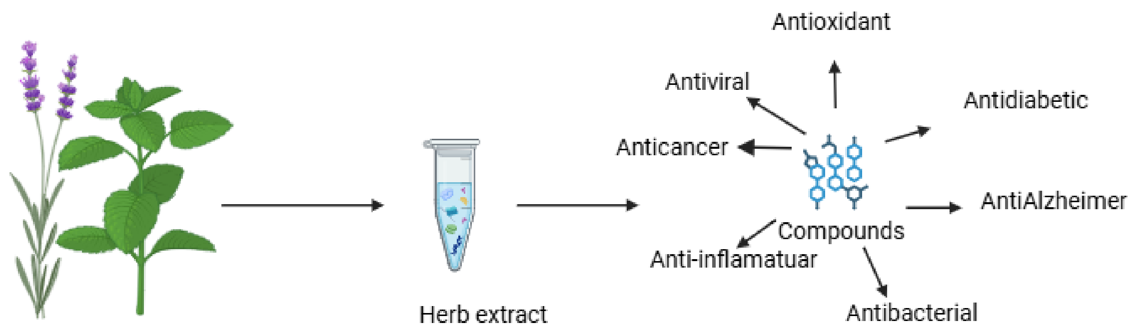

Figure 3. Lamiaceae family plants extracts secondary metabolites various pharmaceutical activities

5.2. Antioxidant Activities

In vitro bioassays such as DPPH$^{\bullet}$ and ABTS$^{\bullet+}$ scavenging, reducing power, and phosphomolybdate antioxidant tests were used to evaluate the antioxidant properties of the crude methanolic extract and fraction of *P. foetida* as plant of the Lamiaceae family, with ascorbic acid serving as a reference. For DPPH and ABTS, the crude methanolic extract displayed IC_{50} values of 256.38 ± 0.6 and 314.95 ± 1.1 mg/mL, respectively. The total antioxidant capacity of *P. foetida* was determined to be 55.79 ± 0.5 mg/mL, while ascorbic acid showed a total antioxidant capacity of 71.89 ± 2.3 mg/mL. The study found that *P. foetida* leaves were an abundant source of phytochemicals that act as antioxidants [110]. Pharmacological characteristics and fragrant components are well-known attributes of plants in the Lamiaceae family. According to several models, the various Ocimum species exhibit antioxidant capacity. These models include ferric reducing property, lipid peroxidation inhibition, hydrogen peroxide scavenging, hydroxyl radical scavenging, DPPH radical scavenging, and ABTS radical scavenging. It was shown that *O. gratissimum* and *O. basilicum* had strong DPPH radical scavenging activity, with IC_{50} values of 14.73±0.54 and 15.02±0.23 µg/mL, respectively. Additionally, *O. basilicum* exhibited significant levels of hydrogen peroxide scavenging activity using ABTS$^{\bullet+}$ scavenging (9.46 ± 0.28 and 6.22±0.13 µg/mL) [156]. While *M. spicata* has remarkable efficacy in suppressing β-carotene (IC_{50}: 62.67±0.01 µg/mL), *M. piperita* infusions have the highest capacity to decrease DPPH and chelate iron (IC_{50}:7.50±0.19 and 5.84±0.36 µg/mL, respectively). HPLC chromatographic tests revealed the preponderance of phenolic acids, particularly rosmarinic acid, and a substantial correlation between the antioxidant capacity and the total phenolic content [157]. With values of 0.0925±0.0003 and 0.0744±0.0001 mg/mL for the hexane and ethyl acetate extracts, respectively, the two investigated *S. verbenaca* extracts showed better antioxidant activity on DPPH$^{\cdot}$ These were nearly identical to the 0.0001 mg/mL values. With an IC_{50} of 0.1338±0.0003 mg/mL for the ethyl acetate sample and 0.1867 ± 0.0002 mg/mL for the hexane extract, the latter showed somewhat better activity than Trolox (0.0604±0.0002 mg/mL) in the term $ABTS^{•+}$ scavenging model test [158]. Several in vitro tests, including the DPPH and DMPD radical scavenging as well as the CUPRAC and FRAP assays, were used to measure the antioxidant activity of *M. officinalis* leaves. Water and ethanol, two supposedly distinct solvents, were employed for extractions. For antioxidant properties, water extract proved to be a more practical solvent than ethanol extract. The current study's findings demonstrated that radical scavenging capacity of water extract of *M. officinalis* leaves outperformed ethanol extract of *M. officinalis* leaves's in both the DPPH and DMPD tests. Likewise, in both the FRAP and CUPRAC tests, water extract of *M. officinalis* leaves's lowering power was greater than ethanol extract of *M. officinalis* leaves's [159]. *Mentha pulegium* methanol and water extracts should be evaluated for bioactivity and phytochemical screening. The biological activities of *M. pulegium* a natural source of phenolic compounds, were investigated, including their antioxidant properties. What's DPPH·, $DMPD^{•+}$, and $ABTS^{•+}$ radical scavenging activities, as well as Fe^{3+}, Cu^{2+}, and FRAP lowering capabilities, were among the bioanalytical tests that revealed the strong antioxidant qualities of pennyroyal's methanol and water extract [37]. The findings demonstrated the significant degree of antioxidant activity of chia (*S. hispanica*) seed oil. Consequently, of chia seed oil may be a promising natural source of polyphenols and antioxidants [160]. *S. officinalis*, *L. angustifolia*, and *R. officinalis* demonstrated significant free radical scavenging activity by the findings of the EOs' cancer-preventive abilities [161].

5.3. Enzyme Inhibition Activities

When treating the cholinergic deficiency in AD patients, cholinesterase (ChE) inhibitors target AChE. AChE inhibitors are the mainstays of AD treatment, increasing acetylcholine levels in the synaptic cleft and improving cholinergic transmission. The pharmacotherapeutic alternatives available for AD are still rather limited and reflect an unmet need despite decades of study. Numerous natural AChE inhibitors and antioxidants isolated from Lamiaceae species have been shown in studies to be beneficial in the prevention and treatment of AD and other associated conditions [162]. Applying seven distinct techniques, the antioxidant properties of *Phlomis tuberosa*, which a plant in the Lamiaceae family, methanol and water extracts were examined. According to the study's findings, the methanol extract consistently shown higher levels of antioxidant activity than the water extract. Additionally, compared to the water extract, the plant's methanol extract showed a greater level of inhibition against the CA II and α-glycosidase enzymes [163]. Combining α-amylase and tyrosinase, the extracts of *Stachys cretica* showed intriguing enzyme inhibitory properties. The methanol extract exhibited the strongest α-amylase and tyrosinase inhibitory activity. According to the findings, *S. cretica* may be a useful new natural source with advantageous biological qualities for applications in medicine and food [164]. The endemic *Thymus canoviridis* and *Thymus pubescens* were shown to be efficient in inhibiting the α-glycosidase, AChE, and CA II enzymes. These enzymes are essential, but excessive usage can lead to major health problems. Because thymus extracts include phenolic and flavonoid compounds that have antioxidant, reducing, and radical scavenging properties, they may be employed as a natural product in the food and pharmaceutical sectors as well as in the treatment of dangerous and common diabetes, Alzheimer's disease, and glaucoma [69]. Studies have also been conducted on the inhibition of α-amylase, BChE, and AChE. *S. sclarea* had the strongest AChE inhibitory capacity (4.00 mg GALAE/g), ahead of *S. palaestina* (3.38 mg GALAE/g) and *S. absconditiflora* (3.01 mg GALAE/g). The extracts' α-amylase-inhibiting properties were comparable [165]. The enzymes AChE, BChE, α-glycosidase, and α-amylase were found to be inhibited by pennyroyal methanol and water extracts [37]. Recognized for its extensively reported characteristics and function, *R. officinalis* is one of the most popular spices. According to a study's findings, all rosemary extracts have a variety of antioxidant molecules that, in vitro, may efficiently scavenge different reactive oxygen species and free radicals [166]. CSO's ability to block three distinct metabolic enzymes was also investigated. While α-glycosidase and hCA II enzymes were found to be less inhibited by CSO, the AChE enzyme was found to be highly inhibited [76].

6. Traditional Uses and Clinical studies

Occasionally, plants with components with proven antibacterial capabilities are employed to treat microbial ailments in traditional herbal treatments [167]. Considering wound and skin infections are particularly prevalent issues in indigenous populations, microbial infections continue to represent a major hazard to public health worldwide [168]. A vast array of fragrant, medicinal, and attractive plants belonging to the Lamiaceae (mint family) yield essential oils that are utilized in the food, cosmetics, pharmaceutical, and traditional and modern medical industries. This family, which contains various fragrant medicinal spices including mint, oregano, basil, and rosemary, is well-known for its ability to effectively modulate pain and may have analgesic or antinociceptive effects [169]. One of the most significant families of plants, Lamiaceae is well-known for its therapeutic properties. With over 30 species spread over Asia, Europe, and Africa, the Ziziphora species is the archetype of the Lamiaceae family. But China and Kazakhstan, as well as parts of Afghanistan, Anatolia, Armenia, Caucasia, Iraq, Pakistan, Syria, Turkey, Turkmenistan, and West Siberia, are where they are most concentrated. Annuals, perennials, herbaceous plants, and sub-shrubs are all included in Ziziphora. For the treatment of colds, bronchitis, coughs, headaches, diarrhea, nausea, typhus, and even cardiovascular diseases, several of the identified species of the genus Ziziphora, especially *Z. clinopodioides* and *Z. tenuior*, were often given in traditional medicine throughout numerous nations. Some of these species are known to be aphrodisiacs and flavorings in addition to having potent analgesic, tranquilizing, and anti-inflammatory effects [170]. In the past, many plants from the genera Calamintha, Lavandula, Mentha, Melissa, Origanum, Rosmarinus, Salvia, Teucrium, and Thymus have been used to treat gastrointestinal issues, respiratory illnesses, and abnormalities of the neurological system in Croatia and its neighboring countries [171]. Traditionally, Mentha species have been utilized in food preparation as fragrant and flavoring ingredients. The aromatic leaves are prized as a great appetizer because of their superb fresh, sweet, toasty flavor and cool, refreshing aftertaste. Commonly utilized as flavorings in culinary items including ice creams, syrups, mint sauces, and beverages include species like *M. piperita* and *M. arvensis*. The two most popular mints, spearmint (*M. spicata*) and peppermint (*M. piperita*), are frequently used to make tea. Chewing gums, toothpaste, mint pills, and breath fresheners are frequently linked to menthol and Mentha essential oil [131]. The Lamiaceae family's medicinal plant *M. spicata*, also known as *Mentha viridis*, is distinguished by its ability to produce and secrete secondary metabolites, which are basically essential oils. The aerial portions of this plant are used by several people to make tea [172]. In a separate culture, spearmint is utilized in a wide range of traditional medicines. Since ancient times, traditional Iranian medicine has utilized spearmint to treat a variety of ailments, including flatulence, colds, influenza, sinusitis, headaches, indigestion, intestinal weakness, stomach discomfort, and diarrhea. The leaves of *M. spicata* are suggested by traditional Iranian medical practitioners as a treatment for flatulence and digestive issues [173]. Asthma, fever, colds, coughs, obesity, and digestive issues have all been treated using spearmint essential oil in traditional Arabic and Palestinian medicine [174]. The Lamiaceae family includes some of the most popular culinary herbs, including oregano, mint, thyme, and basil. Since ancient times, people have utilized these herbs for their nutritional qualities, as well as to enhance the qualities of food and as natural preservatives [152]. Aqueous and various solvent extracts of *Gmelina arborea* have been shown to have strong hypoglycemic potential in in vivo experimental animal model studies. Only in Wistar rats has the antidiabetic activity been investigated by many writers. Ethanol, methanol, and water were the extraction solvents employed. Additionally, several plant components were utilized. Bark samples were employed in two experiments, while roots and fruits were used in others. This implies that the majority of its components have anti-diabetic qualities. However, the dose differed depending on the portion employed. The lowest dosage was 300 mg/kg bw (fruits), while the maximum was 1 g/kg bw (bark). Either an intraperitoneal or oral route was used for delivery. The typical medication for diabetes that was most frequently used was glibenclamide. While just one author examined the activity in rats given alloxan for varying periods of time (ranging from 7 to 30 days), the majority of studies examined the antidiabetic action caused by streptozotocin. According to the findings, the bark's aqueous extract outperformed the standard, indicating that the active ingredients are soluble in water [117]. As for in vivo research, it was determined that male rats treated with phenolic compounds (200 mg/kg bw) isolated from the leaves of the *M. spicata* plant and given an intraperitoneal injection of alloxan (125 mg/kg bw) developed diabetes as a result of this activity. Blood glucose, triglyceride, cholesterol, plasma LDL, and VLDL levels all decreased throughout the course of the 14-day daily therapy, whereas plasma HDL levels significantly increased. Mentha spicata's promise in managing diabetes and its consequences was validated by this study [172]. In addition to being used as a food preservative, thyme is a crucial herb for adding flavor and spices to meals. Because of its anti-inflammatory, digestive, expectorant, carminative, and antispasmodic qualities, thyme essential oil has been used extensively in traditional medicine since ancient times [175]. Having notable therapeutic benefits reported for rheumatic arthralgia, severe injury, traumatic hemorrhage, and diabetes brought on by hemostatic imbalances, *Lamiophlomis rotata* (Lamiaceae) has been utilized in traditional Tibetan medicine for over a millennium. According to traditional Tibetan medicine, *L. rotata* increases blood circulation, reduces pain and swelling, and breaks blood stasis to achieve its therapeutic effects. *L. rotata* was used for marrow replacement and to make yellow water after treating edema, which is when its use in China was first documented [176]. The tiny, nutrient-rich seeds of *S. hispanica* plants are well-known for their many health advantages and have become a superfood. The most well-known component of the plant is chia seed oil, which is frequently eaten for its nutritional benefits [177]. Particularly in the Mediterranean diet, rosemary is frequently used as a culinary spice to improve the flavor of a variety of foods. Due to its abundance of bioactive chemicals, which are thought to provide exceptional phytopharmaceutical qualities and enhance the physiological functioning of the human body, it is one of the most fascinating plants. Fresh or dried leaves, as well as the entire aerial sections of the plant, are used to make rosemary extracts or rosemary essential oils. Bioactive substances are usually tested in two different categories: volatile and non-volatile. Camphor, linalool, borneol, and humulene are among the sesquiterpenes and ketone monoterpenes that make up the volatile fraction's essential oils. Conversely, the non-volatile fraction contains fewer hydrophobic substances that are important components of rosemary extracts, including terpenes and phenolic acids, flavonoids, mostly organic acids, diterpenoids, and triterpenoids [178]. Herbal remedies employ a variety of chemicals in their therapeutic actions, and these intricate processes may help to increase their effectiveness while lowering the possibility of negative side effects. Furthermore, distinct medicinal qualities can be produced by the distinct components of each species, as well as by the techniques of preparation and administration. In aromatherapy, for instance, *R. officinalis* and *M. officinalis* are utilized differently, and their volatile ingredient profiles differ significantly for sleeplessness and memory loss, respectively [180].

7. Toxicology

Multitude therapeutic and helpful components were found in Lamiaceae species used in various pharmacological and clinical research studies. This provides an excellent chance for the development of new medications that lower cholesterol, reduce pain, lower blood sugar, treat diabetes, treat depression, reduce inflammation, and protect the heart. The need to conduct more comprehensive and varied clinical research for the use of Lamiaceae species in the treatment of various illnesses is essential because of the genus's capacity to alleviate the symptoms and degenerative consequences of numerous disorders.

Additionally, it is necessary to draw attention to and focus on some aspects of the significant safety and toxicity concerns that result from using extracts or products derived from Lamiaceae species. Before using any herbal medication, its quality and safety must be evaluated because assurance is a major concern associated with its use.

The effectiveness of a plant or natural component alone does not, in pharmacology, support its medicinal use. Indeed, at least in large dosages and for extended periods of time, every bioactive material is expected to have harmful consequences on human health. The plant is harmless, according to certain research that looked at the toxicological analysis of *M. spicata* extracts. However, not any clinical investigations were carried out, and given the plant's good safety profile from the toxicological analysis, it is imperative that these trials be carried out to encourage its usage [172]. The cytotoxic effects of *Otestegia fruticosa* leaf methanol extract was examined utilizing both in vitro and in animal models. Using MCF-7 breast cancer cells in vitro, the methanol extract showed moderate efficacy (IC_{50} = 51±9.8 µg/mL) [181].

6. Conclusion

The antiviral, antiglaucoma, anti-Alzheimer, antimicrobial, antioxidant, and anticancer properties of plant-based bioactive natural compounds are still being researched. Minerals, vitamins, flavonoids, phenolic acids, fiber, natural antioxidants, and saponins are all abundant in plant-based goods. Variants, origins, climate, location, cultivating circumstances, harvesting periods, storage, extraction procedures, and determination techniques all contribute to the high variances in chemical profile and functional qualities that remain problematic problems. Thus, it is imperative that the important traditional knowledge of ethnomedicinal plants be reviewed, documented, and verified for the benefit of humankind. This research promises to provide valuable insights for the development of new medications and medicines and may serve as a pilot that records the sustainable use of commonly used biological resources by understanding traditional knowledge systems.

Mentha, Thymus, Origanum, Salvia, Rosmarinus, Lavandula, Ocimum, and Melissa are among the Lamiaceae members whose efficacy we have discussed. The bioactive chemicals found in species of *R. officinalis*, *L. angustifolia*, and *S. officinalis* in particular make these medicinal plants excellent choices for a variety of therapeutic applications. These herbs have large concentrations of potentially beneficial components, and research shows that they can help with glaucoma, diabetes, cognitive decline, and a number of common illnesses.

Therefore, various analytical techniques such HPLC, GC-FID, GC-MS, UH-HPLC-HRMS, and LC-MS should be used to investigate the chemical components in these plant sections. The pharmaceutical properties of botanical extracts and oils from the Lamiaceae family have many biological effects, including analgesic, wound healing, cardioprotective, anticancer, antidiabetic, antibacterial, antifungal, antitumor, antihemolytic, antihypertensive, antileishmanial, immunomodulatory, and enzyme inhibitory activities. New medicinal preparations should be developed through additional studies, such as the extraction of phytochemical ingredients and clinical investigations, as the initial assessment of extracts and their pharmacological properties can lead to the discovery of new drug candidates.

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References

[1] H. Tohma, E. Köksal, Ö. Kılıç, Y. Alan, M. A. Yılmaz, İ. Gülçin, E. Bursal and S. H. Alwasel (2016). RP-HPLC/MS/MS analysis of the phenolic compounds, antioxidant and antimicrobial activities of Salvia L. species, *Antioxidants* **5**, 1–15.

[2] I. Gülçin, I. G. Sat, S. Beydemir and Ö. I. Küfrevioglu (2004). Evaluation of the in vitro antioxidant properties of broccoli extracts (*Brassica oleracea* L.), *Ital. J. Food Sci.* **16**, 17–30.

[3] P. Kalın, İ. Gülçin and A. C. Gören (2015). Antioxidant activity and polyphenol content of cranberries (*Vaccinium macrocarpon*), *Rec. Nat. Prod.* **9**, 496–502.

[4] D. Tazooa, K. Krohn, H. Hussain, S. F. Kouam and E. Dongoa (2007). Laportoside A and laportomide A: A new cerebroside and a new ceramide from leaves of *Laportea ovalifolia, Z. Naturforsch.* **62B**, 1208-1212.

[5] H. Han, H. Yılmaz and İ. Gülçin (2018). Antioxidant activity of flaxseed (*Linum usitatissimum* L.) shell and analysis of its polyphenol contents by LC-MS/MS, *Rec. Nat. Prod.* **12**, 397–402.

[6] K. Aslan, H. Kiziltas, L. Guven, H. Karagecili, D. Arslan and İ. Gülçin (2025). Enzyme inhibition property of different daisies from Asteraceae family; *Calendula officinalis*, *Matricaria chamomilla*, and *Anthemis pseudocotula*: Kinetics and molecular docking studies, *Rec. Nat. Prod.* **19**, 247-262.

[7] K. Aslan, E. E. Kopar, K. Kelle, H. Karageçili, M. A. Yilmaz, O. Cakir, S. Alwasel and I. Gulcin (2025). Phytochemical profile and bioactive properties of sage (*Salvia fruticosa*) and thyme (*Thymus vulgaris*) extracts, *Int. J. Food Proper.* **28**, 2481148.

[8] K. Z. Antoine, H. Hussain, E. Dongo, S. F. Kouam, B. Schulz and K. Krohn (2010). Cameroonemide A: A new ceramide from *Helichrysum cameroonensei, J. Asian Nat. Prod. Res.* **12**, 629-633.

[9] K. O. Eyong, K. Krohn, H. Hussain, G. N. Folefoc, A. E. Nkengfack, B. Schulz and Q. Hu (2005). Newbouldiaquinone and Newbouldiamide: A new naphthoquinone-anthraquinone coupled pigment and a new ceramide from *Newbouldia laevis, Chem. Pharm. Bull.* **53**, 616-619**.**

[10] M. Y. Bouberte, K. Krohn, H. Hussain, E. Dongo, B. Schulz and Q. Hu (2006). Tithoniamarin and Tithoniamide: A new isocoumarin dimer and a new ceramide from *Tithnonia diversifolia, Nat. Prod. Lett.* **20**, 842-849.

[11] F. Türkan, M. N. Atalar, A. Aras, İ. Gülçin and E. Bursal (2020). ICP-MS and HPLC analyses, enzyme inhibition and antioxidant potential of *Achillea schischkinii* Sosn, *Bioorg. Chem.* **94**, 103333.

[12] I. Gülçin, R. Elias, A. Gepdiremen, L. Boyer and E. Köksal (2007). A comparative study on the antioxidant activity of fringe tree (*Chionanthus virginicus* L.) extracts, *Afr. J. Biotechnol.* **6**, 410–418.

[13] M. Elmastas, S. M. Celik, N. Genc, H. Aksit, R. Erenler and İ. Gulcin (2018). Antioxidant activity of an Anatolian herbal tea-*Origanum minutiflorum*: Isolation and characterization of its secondary metabolites, *Int. J. Food Proper.* **21**, 374–384.

[14] I. Gulcin, S. Beydemir, F. Topal, N. Gagua, A. Bakuridze, R. Bayram and A. Gepdiremen (2012). Apoptotic, antioxidant and antiradical effects of majdine and isomajdine from *Vinca herbacea* Waldst. and kit, *J. Enzyme Inhib. Med. Chem.* **27(4)**, 587–594.

[15] E. Izol, H. Temel, M. A. Yilmaz, I. Yener, O. T. Olmez, E. Kaplaner, M. Fırat, N. Hasimi, M. Ozturk and A. Ertas (2021). A detailed chemical and biological investigation of twelve allium species from eastern Anatolia with chemometric studies, *Chem. Biodivers.* **18(1)**, e2000560.

[16] H. Kızıltaş, Z. Bingöl, A. C. Gören, S. H. Alwasel and İ. Gülçin (2023). *Verbascum speciousum* Schrad: Analysis of phenolic compounds by LC-HRMS and determination of antioxidant and enzyme inhibitory properties, *Rec. Nat. Prod*. **17**, 485-500.

[17] M. H. Sehitoglu, H. Han, P. Kalin, I. Gülçin, A. Ozkan and H. Y. Aboul-Enein (2015). Pistachio (*Pistacia vera* L.) Gum: A potent inhibitor of reactive oxygen species, *J. Enzyme Inhib. Med. Chem.* **30**, 264–269.

[18] İ. Gülçin, Ş. Beydemir, İ. G. Şat, Ö. İ. Küfrevioğlu (2005). Evaluation of antioxidant activity of cornelian cherry (*Cornus mas* L.), *Acta Aliment. Hung.* **34(2)**, 193-202.

[19] E. Bursal, P. Taslimi, A. Gören and I. Gulcin (2020). Assessments of anticholinergic, antidiabetic, antioxidant activities and phenolic content of *Stachys annua*, *Biocatal. Agric. Biotechnol*. **28**, 101711.

[20] İ. Gülçin, V. Mshvildadze, A. Gepdiremen and R. Elias (2004). Antioxidant activity of saponins isolated from ivy: α-Hederin, hederasaponin-C, hederacolchiside-E and hederacolchiside F, *Planta Med*. **70**, 561-563.

[21] İ. Gülçin (2006). Antioxidant activity of caffeic acid (3,4-dihydroxycinnamic acid), *Toxicology* **217(2-3)**, 213-220.

[22] İ. Gülçin, Z. Huyut, M. Elmastaş and H. Y. Aboul-Enein (2010). Radical scavenging and antioxidant activity of tannic acid, *Arab. J. Chem.* **3**, 43-53.

[23] M. Topal and İ. Gülçin (2014). Rosmarinic acid: a potent carbonic anhydrase isoenzymes inhibitor, *Turk. J. Chem.* **38**, 894-902.

[24]. I. Gulcin, A. Scozzafava, C. T. Supuran, Z. Koksal, F. Turkan, S. Çetinkaya, Z. Bingol, Z. Huyut and S. H. Alwasel (2016). Rosmarinic acid inhibits some metabolic enzymes including glutathione S-transferase, lactoperoxidase, acetylcholinesterase, butyrylcholinesterase, and carbonic anhydrase isoenzymes, *J. Enzyme Inhib. Med. Chem*. **31**, 1698-1702.

[25] M. Topal and İ. Gulçin (2022). Evaluation of the in vitro antioxidant, antidiabetic and anticholinergic properties of rosmarinic acid from rosemary (*Rosmarinus officinalis* L.), *Biocatal. Agric. Biotechnol.* **43**, 102417.

[26] F. N. Ekinci Akdemir, M. Albayrak, M. Çalik, Y. Bayir and İ. Gulçin, (2017). The protective effects of p-coumaric acid on acute liver and kidney damages induced by cisplatin, *Biomedicines* **5**(**2**), 18.

[27] K. Çetin Çakmak and İ. Gülçin (2019). Anticholinergic and antioxidant activities of usnic acid-An activity-structure insight, *Toxicol. Rep.* **6**, 1273-1280.

[28] M. F. Kandemir, S. Küçükler, C. Çağlayan, C. Gür, A. A. Batıl and İ. Gulcin (2017). Therapeutic effects of silymarin and naringin on methotrexate-induced nephrotoxicity in rats: Biochemical evaluation of anti-inflammatory, anti-apoptotic and anti-autophagic properties, *J. Food Biochem.* **41**(**5**), e12398.

[29] C. Gürsul, F. N. Ekinci Akdemir, T. Akkoyun, İ. Can, M. Gul and İ. Gulcin (2016). Protective effect of naringin on experimental hindlimb ischemia-reperfusion injury in rats, *J. Enzyme Inhib. Med. Chem.* **31(S1)**, 56-61.

[30] İ. Gülçin, R. Elias, A. Gepdiremen and L. Boyer (2006). Antioxidant activity of lignans from fringe tree (*Chionanthus virginicus* L.), *Eur. Food Res. Technol.* **223**, 759-767.

[31] L. Polat Köse and İ. Gulçin (2021). Evaluation of the antioxidant and antiradical properties of some phyto and mammalian lignans, *Molecules* **26**, 7099.

[32] T. Ak and İ. Gülçin (2008). Antioxidant and radical scavenging properties of curcumin, *Chem. Biol. Interact.* **174**, 27-37.

[33] C. Çağlayan, Y. Demir, S. Küçükler, P. Taslimi, F. M. Kandemir and İ. Gulçin (2019). The effects of hesperidin on sodium arsenite-induced different organ toxicity in rats on metabolic enzymes as antidiabetic and anticholinergics potentials: A biochemical approach, *J. Food Biochem.* **43**(**2**), e12720.

[34] E. Köksal, İ. Gülçin, S. B. Öztürk Sarıkaya and E. Bursal (2009). On the in vitro antioxidant activity of silymarin, *J. Enzyme Inhib. Med. Chem.* **24**(**2**), 395–405.

[35] F. M. Kandemir, S. Kucukler, E. Eldutar, C. Caglayan and İ. Gülçin (2017). Chrysin protects rat kidney from paracetamol-induced oxidative stress, inflammation, apoptosis, and autophagy: A multi-biomarker approach, *Sci. Pharm.* **85**(**1**), 4.

[36] L. Durmaz, H. Karagecili and İ. Gulçin (2023). Evaluation of carbonic anhydrase, acetylcholinesterase, butyrylcholinesterase and α-glycosidase inhibition effects and antioxidant activity of baicalin hydrate, *Life* **13**, 2136.

[37] L. Durmaz, H. Karageçili, A. Erturk, E. M. Ozden, P. Taslimi, S. Alwasel and I. Gülçin, (2024). Hamamelitannin's antioxidant effect and its inhibition capability on α-glycosidase, carbonic anhydrase, acetylcholinesterase, and butyrylcholinesterase enzymes, *Processes* **12**(**11**), 2341.

[38] L. Durmaz, İ. Gulçin, P. Taslimi and B. Tüzün (2023). Isofraxidin: Antioxidant, anti-carbonic anhydrase, anti-cholinesterase, anti-diabetic, and in silico properties, *ChemistrySelect* **8**(**34**), e202300170.

[39] L. Durmaz, H. Kiziltas, L. Guven, H. Karagecili, S. H. Alwasel and İ. Gulçin (2022). Antioxidant, antidiabetic, anticholinergic, and antiglaucoma effects of magnofluorine, *Molecules* **27**(**18**), 5902.

[40] İ. Gülçin, R. Elias, A. Gepdiremen, K. Taoubi and E. Köksal (2009). Antioxidant secoiridoids from fringe tree (*Chionanthus virginicus* L.), *Wood Sci. Technol.* **43**(**3-4**), 195–212.

[41] L. Durmaz, H. Kiziltas, H. Karageçili, S. Alwasel and İ. Gulçin (2023). Potential antioxidant, anticholinergic, antidiabetic and antiglaucoma activities and molecular docking of spiraeoside as a secondary metabolite of onion (*Allium cepa*), *Saudi Pharm. J.* **31**(**10**), 101760.

[42] İ. Gülçin (2010). Antioxidant properties of resveratrol: A structure-activity insight, *Innov. Food Sci. Emerg.* **11**, 210-218.

[43] İ. Gülçin, R. Elias, A. Gepdiremen, A. Chea and F. Topal (2010). Antioxidant activity of bisbenzylisoquinoline alkaloids from Stephania rotunda: Cepharanthine and fangchinoline, *J. Enzyme Inhib. Med. Chem.* **25**(**1**), 44-53.

[44] L. Durmaz, A. Ertürk, M. Akyüz, L. Polat Köse, E. M. Uc, Z. Bingöl, R. Sağlamtaş, S. Alwasel and İ. Gulçin (2022). Screening of carbonic anhydrase, acetylcholinesterase, butyrylcholinesterase, and α-glycosidase enzyme inhibition effects and antioxidant activity of coumestrol, *Molecules* **27(10)**, 3091.

[45] İ. Gülçin (2011). Antioxidant activity of eugenol-A structure and activity relationship study, *J. Med. Food* **14**(**9**), 975-985.

[46] F. Topal, İ. Gulcin, A. Dastan and M. Guney (2017). Novel eugenol derivatives: potent acetylcholinesterase and carbonic anhydrase inhibitors, *Int. J. Biol. Macromol.* **94**, 845-851.

[47] H. Genc Bilgicli, A. Kestane, P. Taslimi, O. Karabay, A. Bytyqi-Damoni, M. Zengin and İ. Gulçin (2019). Novel eugenol bearing oxypropanolamines: Synthesis, characterization, antibacterial, antidiabetic, and anticholinergic potentials, *Bioorg. Chem.* **88**, 102931.

[48] P. Taslimi and İ. Gulçin (2018). Antioxidant and anticholinergic properties of olivetol, *J. Food Biochem.* **42**(**3**), e12516.

[49] R. Sağlamtaş and İ. Gülçin (2025). Investigation of the inhibition effect of gingerol on α-glycosidase cholinesterases, and monoamine oxidase enzymes: antioxidant activity and in silico study, *ChemistrySelect* **10**(**9**), e202404467.

[50] İ. Gülçin, A. C. Gören, P. Taslimi, S. H. Alwasel, O. Kılıc and E. Bursal (2020). Anticholinergic, antidiabetic and antioxidant activities of Anatolian pennyroyal (*Mentha pulegium*)-Analysis of its polyphenol contents by LC-MS/MS, *Biocatal. Agric. Biotechnol.* **23,** 101441.

[51] E. Koksal, S. H. Tohma, Ö. Kılıç, Y. Alan, A. Aras, İ. Gulcin and E. Bursal (2017). Assessment of antimicrobial and antioxidant activities of *Nepeta trachonitica*-Analysis of its phenolic compounds using HPLC-MS/MS, *Sci. Pharm.* **15**, **85**(**2**), 24.

[52] F. M. Birdane, M. Cemek, Y. O. Birdane, İ. Gülçin and M. E. Büyükokuroğlu (2007). Beneficial effects of *Foeniculum vulgare* on ethanol-induced acute gastric mucosal injury in rats, *World J. Gastroenterol.* **13**(**4**), 607-611.

[53] H. Tohma, A. Altay, E. Koksal, A. C. Gören and İ. Gülçin (2019). Measurement of anticancer, antidiabetic and anticholinergic properties of sumac (*Rhus coriaria*)-Analysis of its phenolic compounds by LC-MS/MS, *J. Food Measure. Charac.* **13**(**2**), 1607-1619.

[54] H. Karagecili, M. A. Yılmaz, A. Ertürk, H. Kiziltas, L. Güven, S. H. Alwasel and İ. Gulcin (2023). Comprehensive metabolite profiling of Berdav propolis using LC-MS/MS: Determination of antioxidant, anticholinergic, antiglaucoma, and antidiabetic effects, *Molecules* **28**(**4**), 1739.

[55] B. Aydin, I. Gülcin and S. H. Alwasel (2015). Purification and characterization of polyphenol oxidase from Hemşin apple (*Malus communis* L.), *Int. J. Food Proper*. **18**(**12**), 2735–2745.

[56] Z. Bingöl, H. Kızıltaş, A. C. Gören, L. Polat Köse, M. Topal, L. Durmaz, S. H. Alwasel and İ. Gulçin, (2021). Antidiabetic, anticholinergic and antioxidant activities of aerial parts of shaggy bindweed (*Convulvulus betonicifolia* Miller subsp.)-profiling of phenolic compounds by LC-HRMS, *Heliyon* **7**(**5**), e06986.

[57] M. K. Swamy and U. R. Sinniah (2015). A comprehensive review on the phytochemical constituents and pharmacological activities of *Pogostemon cablin* Benth.: An aromatic medicinal plant of industrial importance, *Molecules* **20**, 8521–8547.

[58] G. Arumugam, M. K. Swamy and U. R. Sinniah (2016). *Plectranthus amboinicus* (Lour.) Spreng: Botanical, phytochemical, pharmacological and nutritional significance, *Molecules* **21**, 369.

[59] H. Kiziltas, A. C. Goren, Z. Bingol, S. H. Alwasel and I. Gulcin (2021). Anticholinergic, antidiabetic and antioxidant activities of *Ferula orientalis* L. determination of its polyphenol contents by LC-HRMS, *Rec. Nat. Prod*. **15,** 513-528.

[60] S. Karakaya, Z. Bingol, M. Koca, S. Dagoglu, N. M. Pınar, B. Demirci, İ. Gülçin, M. Brestic and O. Sytar (2020). Identification of non-alkaloid natural compounds of *Angelica purpurascens* (Avé-Lall.) Gilli. (Apiaceae) with acetylcholinesterase and cholinesterase inhibition potential, *Saudi Pharm. J.* **28**, 1-14.

[61] P. Taslimi and İ. Gulçin (2017). Antidiabetic potential: in vitro inhibition effects of some natural phenolic compounds on α-glycosidase and α-amylase enzymes, *J. Biochem. Mol. Toxicol.* **31**(**10**), e21956.

[62] P. Taslimi, İ. Gülçin N. Öztaşkın, Y. Çetinkaya, S. Göksu, S. H. Alwasel and C.T. Supuran, (2016). The effects of some bromophenol derivatives on human carbonic anhydrase isoenzymes, *J. Enzyme Inhib. Med. Chem.* **31**(**4**), 603-607.

[63] H. Kızıltaş, Z. Bingöl, A.C. Gören, L. Polat Köse, L. Durmaz, F. Topal, S. H. Alwasel and İ. Gulçin (2021). LC-HRMS profiling, antidiabetic, anticholinergic and antioxidant activities of aerial parts of kınkor (*Ferulago stelleta*), *Molecules* **26**, 2469.

[64] R. P. Adams (1995). Identification of essential oil components by gas chromatography/mass spectroscopy, Allured publishing Co. Carol Stream, Illinois.

[65] A. Bhatia, H. Singh Buttar, R. Arora, B. Singh, A. Singh, S. Kaur and S. Arora (2020). Antiproliferative effects of *Roylea cinerea* (D. Don) baillon leaves in immortalized L6 rat skeletal muscle cell line: role of reactive oxygen species mediated pathway, *Front. Pharmacol.* **11**, 1–13.

[66] I. Gulcin, E. Bursal, H. M. Şehitoğlu, M. Bilsel and A. C. Gören (2010). Polyphenol contents and antioxidant activity of lyophilized aqueous extract of propolis from Erzurum, Turkey, *Food Chem. Toxicol.* **48**(**8-9**), 2227-2238.

[67] G. Zengin, M. Terzic, N. Abul, İ. Gülçin, İ. Koyuncu, M. K. Basarali, T. Dordevic, Z. Cziaky and J. Jeko (2024). A multidimensional study for design functional foods: Chemical profiling, antioxidant potential, enzyme inhibition, and cytotoxic effects of *Alkanna tubulosa* extracts, *Food Biosci*. **60**, 104280.

[68] I. Gülçin (2006). Antioxidant activity of caffeic acid (3,4-dihydroxycinnamic acid), *Toxicology* **217**(**2–3**), 213–220.

[69] H. Kiziltas, A. C. Goren, S. H. Alwasel and İ. Gulcin (2022). Sahlep (*Dactylorhiza osmanica*): phytochemical analyses by LC-HRMS, molecular docking, antioxidant activity, and enzyme inhibition profiles, *Molecules* **27**(**20**), 6907.

[70] I. Gülçin, M. Oktay, E. Kireçci, and Ö. I. Küfrevioğlu (2003). Screening of antioxidant and antimicrobial activities of anise (*Pimpinella anisum* L.) seed extracts, *Food Chem.* **83**(**3**), 371–382.

[71] E. İzol, M. A. Yılmaz and İ. Gülçin (2025). Chemical characterization by chromatography techniques and comprehensive biological activities of Artvin bee products, *ChemistrySelect*. **10(18**), e202501545.

[72] D. Zheleva-Dimitrova, R. Gevrenova, S. Yagi, M. V. Cetiz, E. Yildiztugay, İ. Gulcin, İ. Yapici, S. C. Di Simone, G. Orlando, L. Menghini, C. Ferrante, A. Chiavaroli and G. Zengin (2025). Exploring hidden natural resources for bioactive compounds: Focused chemical and biological studies on some Anthemis species, *Food Chem. Toxicol.* **202**, 115467.

[73] H. Karageçili, M. A. Yilmaz, S. H. Alwasel, M. Arık and İ. Gülçin (2023). Comprehensively revealing the profile of *Pistacia vera* L. cv. Siirt turpentine-antioxidant, antidiabetic, anti-Alzheimer, and antiglaucoma effects, *Rec. Nat. Prod.* **17**, 918–937.

[74] I. Gülçin and S.A. Alwasel (2025). Fe^{3+} reducing power as the most common assay for understanding the biological functions of antioxidants, *Processes* **13**(**5**), 1296.

[75] Y. Liu, L. Shen, A. Matsuura, L. Xiang, and J. Qi, (2023). Isoquercitrin from *Apocynum venetum* L. exerts antiaging effects on yeasts via stress resistance improvement and mitophagy induction through the Sch9/Rim15/Msn Signaling pathway, *Antioxidants* **12**(**11**), 1939.

[76] M. Mutlu, Z. Bingöl, E. M. Ozden, E. Koksal, A. Erturk, A. C. Gören, S. H. Alwasel and İ. Gülçin (2025). Antioxidant, and enzyme inhibition effects of chia (*Salvia hispanica*) seed oil: A comprehensive phytochemical screening using LC-HR/MS, *Electron. J. Biotechnol.* **74**, 41-53.

[77] M. Akyuz, L. Yabo-Dambagi, T. Kilic and A. Cakir (2022). Antidiabetic, neuroprotective and antioxidant potentials of different parts of Pistacia terebinthus fruits, *S. Afr. J. Bot.* **147**, 443–456.

[78] W. Baccari, I. Saidi, M. Znati, A. M. Mustafa, G. Caprioli, A. H. Harrath and H. B. Jannet (2023). HPLC-MS/MS analysis, antioxidant and α-amylase inhibitory activities of the endemic plant *Ferula tunetana* using in vitro and in silico methods, *Process Biochem.* **129**, 230–240.

[79] A. Thapa and N. J. Carroll (2017). Dietary modulation of oxidative stress in Alzheimer's disease, *Int. J. Mol. Sci.* **18**, 14–16.

[80] H. Karageçili, T. Polat, M. A. Yılmaz, M. Fidan, M. C. Karaismailoğlu and İ. Gülçin (2024). Evaluation of the antioxidant, antidiabetic and anti-alzheimer effects of *Capsella bursa-pastoris*-Polyphenolic profiling by LC-MS/MS, *Rec. Nat. Prod.* **18**, 643–662.

[81] M. N. Atalar, M. Köktürk, F. Altındağ, G. Ozhan, T. Özen, İ. Demirtas and İ. Gülçin (2023). LC-ESI-MS/MS analysis of secondary metabolites of different St. John's wort (*Hypericum perforatum*) extracts used as food supplements and evaluation of developmental toxicity on zebrafish (*Danio rerio*) embryos and larvae, *S. Afr. J. Bot.* **159**, 580–587.

[82] I. Gülçin, Ö. I. Küfrevioğlu, M. Oktay and M. E. Büyükokuroğlu (2004). Antioxidant, antimicrobial, antiulcer and analgesic activities of nettle (*Urtica dioica* L.), *J. Ethnopharmacol.* **90**, 205–215.

[83] S. Çakmakçı, İ. Gülçin, E. Gündoğdu, H. Ertem Öztekin and P. Taslimi (2023). The comparison with commercial antioxidants, effects on colour, and sensory properties of green tea powder in butter, *Antioxidants* **12,** 1522.

[84] B. Hilal, M. M. Khan and Q. Fariduddin (2024). Recent advancements in deciphering the therapeutic properties of plant secondary metabolites: phenolics, terpenes, and alkaloids, *Plant Physiol. Biochem.* **211**, 108674.

[85] A. A. Hatamnia, N. Abbaspour and R. Darvishzadeh (2014). Antioxidant activity and phenolic profile of different parts of bene (*Pistacia atlantica* subsp. kurdica) fruits, *Food Chem.* **145**, 306–311.

[86] A. Z. Tel, K. Aslan, M. A. Yılmaz, İ. Gülçin (2025). A multidimensional study for design of phytochemical profiling, antioxidant potential, and enzyme inhibition effects of ışgın (*Rheum telianum*) as an edible planty, *Food Chem-X* **25**, 102125.

[87] H. Kızıltaş, A. B. Ortaakarsu, Z. Bingöl, A. Ertürk, A. C. Gören, S. M. Pınar, İ. Gulçin (2025). Chemical profiling by LC-HRMS, antioxidant potential, enzyme inhibition, molecular docking and molecular dynamics simulations of *Acantholimon acerosum*, *J. Mol. Struct.* **1321**(**4**), 140124.

[88] İ. Dursun, R. Sağlamtas, K. Fettahoğlu, M. Zor, A. Sinan, A. Demirci, Y. Demir and İ. Gulçin (2025). Antioxidant and antimicrobial activities of different extracts of *Tragopogon dubius* and *Tragopogon porrifolium* L. subsp. longirostris: Determination of their phytochemical contents by UHPLC-Orbitrap®-HRMS analysis, *Food Biosci.* **63**, 105604.

[89] M. F. Kandemir, S. Küçükler, C. Çağlayan, C. Gür, A.A. Batıl and İ. Gulcin (2017). Therapeutic effects of silymarin and naringin on methotrexate-induced nephrotoxicity in rats: Biochemical evaluation of anti-inflammatory, anti-apoptotic and anti-autophagic properties, *J. Food Biochem.* **41**(**5**), e12398.

[90] İ. Gülçin, İ.G. Şat, Ş. Beydemir and Ö.İ. Küfrevioğlu, (2004). Evaluation of the in vitro antioxidant properties of extracts of broccoli (*Brassica oleracea* L.). *Ital J. Food Sci.*, **16(1)**, 17-30.

[91] E, Dikici, S. Altın, C. Alp, M. Işık, E. Köksal and İ. Gülçin (2024). Determination of secondary metabolites of *Cydonia oblonga* (Quince) by LC-MS/MS method together with evaluation of its antioxidant and cholinergic potentials, *J. Chem. Metrol.* **18**(**2**), 146-164.

[92] E. Bursal, E. Köksal, I. Gülçin, G. Bilsel and A. C. Gören (2013). Antioxidant activity and polyphenol content of cherry stem (*Cerasus avium* L.) determined by LC-MS/MS, *Food Res. Int.* **51**, 66–74.

[93] H. Karagecili, E. İzol, E. Kirecci and İ. Gulcin (2023). Determination of antioxidant, anti-Alzheimer, antidiabetic, antiglaucoma and antimicrobial effects of zivzik pomegranate (*Punica granatum*)-A chemical profiling by LC-MS/MS), *Life* **13**, 735.

[94] B. K. Kınalıoğlu, A. C. Gören and İ. Gülçin (2024). Quantification of secondary metabolites of *Satureja pilosa* (Lamiaceae) by LC-HRMS and evaluation of antioxidant and cholinergic activities, *Rec. Nat. Prod.* **18**, 674-686.

[95] Y. Çetinkaya, H. Göçer, A. Menzek and İ. Gülçin (2012). Synthesis and antioxidant properties of (3,4-dihydroxyphenyl)(2,3,4-trihydroxyphenyl)methanone and its derivatives, *Arch. Pharm.* **345**, 323-334.

[96] A. S. Sarac, H. Geyik, E. A. Parlak and M. Serantoni (2007). Electrochemical composite formation of thiophene and N-methylpyrrole polymers on carbon fiber microelectrodes: Morphology, characterization by surface spectroscopy, and electrochemical impedance spectroscopy, *Prog. Org. Coat.* **59**, 28–36.

[97] S. Venkateshappa and K. Sreenath (2013). Potential Medicinal plants of Lamiaceae, *Am. Int. J. Res. Formal, Appl. Nat. Sci.* **3**, 82–87.

[98] K. A. Qureshi, A. Parvez, M. M. Uzzaman Khan, A. Aspatwar, A. Atiya, G. O. Elhassan, R. A. Khan, S. Y. Erattil Ahammed, W. U. Khan and M. Jaremko (2024). Exploring nature's hidden treasure: Unraveling the untapped phytochemical and pharmacological potentials of *Clinopodium vulgare* L.-A hidden gem in the Lamiaceae family, *Heliyon* **10**, e24781.

[99] M. Khalil, G. Rita Caponio, F. Diab, H. Shanmugam, A. Di Ciaula, H. Khalifeh, L. Vergani, M. Calasso, M. De Angelis and P. Portincasa (2022). Unraveling the beneficial effects of herbal Lebanese mixture "Za'atar". History, studies, and properties of a potential healthy food ingredient, *J. Funct. Foods* **90**, 104993.

[100] Y. W. Yuan, D. J. Mabberley, D. A. Steane and R. G. Olmstead (2010). Further disintegration and redefinition of clerodendrum (Lamiaceae): Implications for the understanding of the evolution of an intriguing breeding strategy, *Taxon* **59**, 125–133.

[101] M. F. Hawwal, S. Ahmed, P. Alam, O. I. Fantoukh, G. A. AlHamoud, H. A. Alharbi, W. A. Alobaid and H. Khojah (2024). *Otostegia fruticosa* (Forssk.) – A comprehensive insight of its ethnopharmacology, phytochemistry, and pharmacological activities, *Saudi Pharm. J.* **32**(**11**), 102189.

[102] C. M. Uritu, C. T. Mihai, G. D. Stanciu, G. Dodi, T. Alexa-Stratulat, A. Luca, M. M. Leon-Constantin, R. Stefanescu, V. Bild, S. Melnic and B. I. Tamba (2018). Medicinal plants of the family Lamiaceae in pain therapy: A review, *Pain Res. Manag.* **2018**(**1**), 7801543.

[103] S. Das, K. W. Sultana and I. Chandra (2023). In vitro propagation, phytochemistry and pharmacology properties of *Basilicum polystachyon* (L.) Moench (Lamiaceae): A short review, *S. Afr. J. Bot.* **155**, 178-186.

[104] G. O. de Elguea-Culebras, E. M. Bravo and R. Sánchez-Vioque (2022). Potential sources and methodologies for the recovery of phenolic compounds from distillation residues of Mediterranean aromatic plants. An approach to the valuation of by-products of the essential oil market – A review, *Ind. Crops Prod.* **175**, 114261. doi:10.1016/j.indcrop.2021.114261

[105] İ. Gülçin, İ. G. Şat, Ş. Beydemir, M. Elmastaş and Ö. İ. Küfrevioğlu (2004). Comparison of antioxidant activity of clove (*Eugenia caryophylata* Thunb) buds and lavender (*Lavandula stoechas* L.), *Food Chem.* **87**, 393-400.

[106] K. Carović-Stanko, M. Petek, M. Grdiša, J. Pintar, D. Bedeković, M. H. Ćustić and Z. Satovic (2016). Medicinal plants of the family lamiaceae as functional foods-A review, *Czech J. Food Sci.* **34**, 377–390.

[107] A. J. Paton, D. Springate, S. Suddee, D. Otieno, R. J. Grayer, M. M. Harley, F. Willis, M. S. J. Simmonds, M. P. Powell and V. Savolainen (2004). Phylogeny and evolution of basils and allies (Ocimeae, Labiatae) based on three plastid DNA regions, *Mol. Phylogenet. Evol.* **31**, 277–299.

[108] M. Arshad, M. Ahmad, E. Ahmed, A. Saboor, A. Abbas and S. Sadiq (2014). An ethnobiological study in Kala Chitta hills of Pothwar region, Pakistan: Multinomial logit specification, *J. Ethnobiol. Ethnomed.* **10,** 13, doi:10.1186/1746-4269-10-13

[109] M. S. Amjad, M. F. Qaeem, I. Ahmad, S. U. Khan, S. K. Chaudhari, N. Z. Malik, H. Shaheen and A. M.

Khan (2017). Descriptive Study of plant resources in the context of the ethnomedicinal relevance of indigenous flora: A case study from Toli Peer national park, Azad Jammu and Kashmir, Pakistan, *PLoS One* **12**(**2**), e0171896.12.

[110] T. Afzal, Y. Bibi, M. Ishaque, S. Masood, A. Qayyum, S. Nisa, Z. H. Shah, H. Alsamadany and G. Chung (2022). Pharmacological properties and preliminary phytochemical analysis of *Pseudocaryopteris foetida* (D.Don) P.D. Cantino leaves, *Saudi J. Biol. Sci.* **29**, 1185–1190.

[111] D. E. S. Gonçalves, J. A. Araújo, H. de Oliveira Carvalho, A. de Melo Santos, K. R. T. Picanço, A. V. T. L. T. dos Santos, A. L. do Nascimento and J. C. T. Carvalho (2024). *Rosmarinus officinalis* volatile oil nanogel modulated muscle damage induced by bothrops moojeni venom: a phonophoresis method, *Rev. Bras. Farmacogn.* **34**, 270–279.

[112] A. Shakeri, A. Sahebkar and B. Javadi (2016). *Melissa officinalis* L. - A review of its traditional uses, phytochemistry and pharmacology, *J. Ethnopharmacol.* **188**, 204–228.

[113] I. Batubara, K. Komariah, A. Sandrawati and W. Nurcholis (2020). Genotype selection for phytochemical content and pharmacological activities in ethanol extracts of fifteen types of *Orthosiphon aristatus* (Blume) Miq. leaves using chemometric analysis, *Sci. Rep.* **10**, 20945.

[114] L. Güven, H. Can, A. Ertürk, F. D. Miloğlu, M. Koca, F. İnce and İ. Gülçin (2024). Comprehensive metabolic profiling of *Thymus canoviridis* (endemic) and *Thymus pubescens* var. pubescens using LC-MS/MS and evaluation of their antioxidant activities, enzyme inhibition abilities, and molecular docking studies, *S. Afr. J. Bot.* **165**, 478-493.

[115] L. Güven, U. Behbudbayli, A. Ertürk, H. Hancı, B. Yılmaz, Y. Kaya and İ. Gülçin (2023). Determination of antioxidant, antimicrobial, anticholinesterase, antityrosinase, antidiabetic and antiglaucoma activities of essential oils from three different Thymus species and their chemical characterization by GC-MS analysis, *J. Essent. Oil-Bearing Plants* **26**(**6**), 1424-1446.

[116] L. Güven, A. Ertürk, M. Koca and İ. Gülçin (2023). Phenolic compounds of Phlomis tuberosa by LC-MS/MS-Determination of antioxidant activity, molecular docking, and enzyme inhibition profiles, *ChemistrySelect.* **8**(**48**), e20230310.

[117] E. İzol, M. Turhan, M. A. Yılmaz, C. Çağlayan and İ. Gülçin (2024). Determination of antioxidant, antidiabetic, anticholinergic, antiglaucoma properties and comprehensive phytochemical content by LC-MS/MS of Bingöl honey, *J. Food Biochem.* **1321**, 7488590.

[118] H. İnci, E. İzol, M. A. Yılmaz, M. İlkaya, Z. Bingöl and İ. Gülçin (2023). Comprehensive phytochemical content by LC-MS/MS and anticholinergic, antiglaucoma, antiepilepsy, and antioxidant activity of apilarnil (drone larvae), *Chem. Biodivers.* **20**(**10**), e202300654.

[119] H. Kızıltaş, A.B. Ortaakarsu, Z. Bingöl, A.C. Gören, S.M. Pınar and İ. Gulçin (2024). Sage (Salvia macrochlamys): LC-HRMS for phytochemical analysis, cytotoxicity, enzyme inhibition, antioxidant activity, molecular docking and molecular dynamics simulations, *Plant Biosyst.* **158**(**5**), 1057-1075.

[120] E. M. Ozden, Z. Bingol, M. Mutlu, H. Karagecili, E. Köksal, A. C. Goren, S. H. Alwasel and İ. Gulcin (2023). Antioxidant, antiglaucoma, anticholinergic, and antidiabetic effects of kiwifruit (*Actinidia deliciosa*) oil: Metabolite profile analysis using LC-HR/MS, GC/MS and GC-FID, *Life* **13**, 1939.

[121] H. Karageçili, E. Izol, E. Kireçci,and I. Gülçin (2023). Antioxidant, antidiabetic, antiglaucoma, and anticholinergic effects of Tayfi grape (*Vitis vinifera*): A phytochemical screening by LC-MS/MS analysis, *Open Chem.* **21**, 20230120.

[122] A. Çiçek Kaya, H. Özbek, H. Yuca, G. Yılmaz, Z. Bingöl, C. Kazaz, İ. Gülçin and Z. Güvenalp (2023). Phytochemical content and enzyme inhibitory effect of *Heptaptera triquetra* (Vent.) Tutin fruit against acetylcholinesterase and carbonic anhydrase I and II isoenzymes, *Chem. Pap.* **77**, 5829–5837.

[123] S. Çakmakçı, İ. Gulçin, E. Gündoğdu, H. Ertem Öztekin and P. Taslimi (2023). The comparison with commercial antioxidants, effects on colour, and sensory properties of green tea powder in butter, *Antioxidants* **12**(**8**), 1522.

[124] A. Sharma, R. Cooper, G. Bhardwaj and D. S. Cannoo (2021). The genus Nepeta: Traditional uses, phytochemicals and pharmacological properties, *J. Ethnopharmacol.* **268**, 113679.

[125] M. Karamac, L. Koleva, V. D. Kancheva and R. Amarowicz (2017). The structure-antioxidant activity relationship of ferulates, *Molecules* **22**, 15–19.

[126] M. Wink (2015). Modes of action of herbal medicines and plant secondary metabolites, *Medicines* **2**, 251–286.

[127] M. Koca, İ. Gulçin, E. M. Üç, S. Bilginer and A. S. Aydın (2023). Evaluation of antioxidant potentials and acetylcholinesterase inhibitory efects of some new salicylic acid-salicylamide hybrids, *J. Iran. Chem. Soc.* **20**, 1535–1543.

[128] A. Bandyopadhyay and A. Dey (2022). Medicinal pteridophytes: ethnopharmacological, phytochemical, and clinical attributes, *Beni-Suef Univ. J. Basic Appl. Sci.* **11**, 113.

[129] G. Vassilina, A. Sabitova, Z. Idrisheva, A. Zhumabekova, F. Kanapiyeva, R. Orynbassar, M.

Zhamanbayeva, M. Kamalova, J. Assilbayeva and A. Turgumbayeva (2025). Bio-active compounds and major biomedical properties of basil (*Ocimum basilicum* , lamiaceae), *Nat. Prod. Res.* **39**, 1326–1344.

[130] K. Zhakipbekov, A. Turgumbayeva, S. Akhelova, K. Bekmuratova, O. Blinova, G. Utegenova, K. Shertaeva, N. Sadykov, K. Tastambek, A. Saginbazarova, K. Urazgaliyev, G. Tulegenova, Z. Zhalimova and Z. Karasova (2024). Antimicrobial and other pharmacological properties of *Ocimum basilicum*, Lamiaceae, *Molecules* **29(2)**, 388.

[131] S. Yousefian, F. Esmaeili and T. Lohrasebi (2023). A comprehensive review of the key characteristics of the Genus *Mentha*, natural compounds and biotechnological approaches for the production of secondary metabolites, *Iran. J. Biotechnol.* **21**, 2–29.

[132] M. H. K. Abad and M. Nadaf (2023). The ethnobotanical properties and medicinal application of essential oils of *Ziziphora persica* Bunge from different habitats: A review, *J. Essent. Oil Res.* **35**, 177–196.

[133] H. P. Tang, E. L. Zhu, Q. X. Bai, S. Wang, Z. B. Wang, M. Wang and H. X. Kuang (2024). *Mentha haplocalyx* Briq. (Mint): a comprehensive review on the botany, traditional uses, nutritional value, phytochemistry, health benefits, and applications, *Chin. Med.* **19**, 168.

[134] M. Soleimani, A. Arzani, V. Arzani and T. H. Roberts (2022). Phenolic compounds and antimicrobial properties of mint and thyme, *J. Herb. Med.* **36**, 100604.

[135] S. Ka, M. Koirala and M. Natacha (2020). Biosynthesis and biological activities of newly discovered amaryllidaceae alkaloids, *Molecules* **25**(**21**), 4901.

[136] J. Xu, K. Wei, G. Zhang, L. Lei, D. Yang, W. Wang, Q. Han, Y. Xia, Y. Bi, M. Yang and M. Li (2018). Ethnopharmacology, phytochemistry, and pharmacology of Chinese Salvia species: A review, *J. Ethnopharmacol.* **225**, 18–30.

[137] P. K. T. R, D. S. V S, S. N. G. K, S. B. K. and R. H. L. (2019). J Ethnobotanical uses, phytochemistry and pharmacological activities of *Clerodendrum infortunatum* L. (Lamiaceae): A review, *J. Drug Deliv. Ther.* **9**, 547–559.

[138] J. Andary, H. El Ballouz and R. Abou-Khalil (2025). Lebanese medicinal plants with ophthalmic properties, *Pharmaceuticals* **18(2)**, 155.

[139] M. Ajjoun, L. Kharchoufa, I. Alami Merrouni and M. Elachouri (2022). Moroccan medicinal plants traditionally used for the treatment of skin diseases: From ethnobotany to clinical trials. *J. Ethnopharmacol.* **297**, 115532.

[140] T. Botanical and S. A. Lamiaceae (2021). The botanical, chemical and ethnobotanical diversity of southern African Lamiaceae, *Molecules* **26**(**12**), 3712

[141] G. Mahendran, S. K. Verma and L. U. Rahman (2021). The traditional uses, phytochemistry and pharmacology of spearmint (*Mentha spicata* L.): A review, *J. Ethnopharmacol.* **278**, 114266.

[142] A. Maroyi (2022). *Pseudodictamnus africanus* (L.) Salmaki & Siadati (Lamiaceae): Ethnomedicinal uses, phytochemistry and pharmacological properties, *Plant Sci. Today* **9**, 1102–1109.

[143] E. Skoufogianni, A. D. Solomou and N. G. Danalatos (2019). Ecology, cultivation and utilization of the aromatic Greek oregano (*Origanum vulgare* L.): A review. *Not. Bot. Horti Agrobot, Cluj-Napoca* **47**, 545–552.

[144] N. Karim, I. Khan, A. Abdelhalim, H. Abdel-Halim and J. R. Hanrahan (2017). Molecular docking and antiamnesic effects of nepitrin isolated from *Rosmarinus officinalis* on scopolamine-induced memory impairment in mice, *Biomed. Pharmacother.* **96**, 700–709.

[145] F. Fernandes, M. F. Barroso, A. De Simone, E. Emriková, M. Dias-Teixeira, J. P. Pereira, J. Chlebek, V. C. Fernandes, F. Rodrigues, V. Andrisano, C. Delerue-Matos and C. Grosso (2022). Multi-target neuroprotective effects of herbal medicines for Alzheimer's disease, *J. Ethnopharmacol.* **290**, 115107.

[146] E. Guzman and J. Molina (2018). The predictive utility of the plant phylogeny in identifying sources of cardiovascular drugs, *Pharm. Biol.* **56**, 154–164.

[147] S. Di Giacomo, A. Di Sotto, A. Angelis, E. Percaccio, A. Vitalone, M. Gullì, A. Macone, E. Axiotis and A. L. Skaltsounis (2022). Phytochemical composition and cytoprotective properties of the endemic *Sideritis sipylea* Boiss Greek species: A valorization study, *Pharmaceuticals* **15**(**8**)**,** 987.

[148] A. Khojasteh, M. H. Mirjalili, M. A. Alcalde, R. M. Cusido, R. Eibl and J. Palazon (2020). Powerful plant antioxidants: A new biosustainable approach to the production of rosmarinic acid, *Antioxidants* **9(2)**, 1273.

[149] S. Güzel, A. Kahraman, M. Ülger, Y. Özay, İ. Bozgeyik and Ö. Sarikaya (2019). Morphology, myxocarpy, mineral content and in vitro antimicrobial and antiproliferative activities of mericarps of the vulnerable Turkish endemic *Salvia pilifera*, *J. Res. Pharm.* **23**, 729–739.

[150] A. Ertas, S. Yigitkan and I. E. Orhan (2023). A focused review on cognitive improvement by the genus Salvia L. (sage)-from ethnopharmacology to clinical evidence, *Pharmaceuticals* **16**(**2**), 171.

[151] D. Iacopetta, J. Ceramella, D. Scumaci, A. Catalano, M. S. Sinicropi, R. Tundis, S. Alcaro and F. Borges (2023). An update on recent studies focusing on the antioxidant properties of Salvia species, *Antioxidants* **12**(**12**), 2106.

[152] N. Nazar, C. Howard, A. Slater and T. Sgamma (2022). Challenges in medicinal and aromatic plants DNA barcoding-lessons from the Lamiaceae, *Plants* **11**(**1**), 137.

[153] B. Jalil, I. Pischel, B. Feistel, C. Suarez, A. Blainski, R. Spreemann, R. Roth-Ehrang and M. Heinrich (2024). Wild thyme (*Thymus serpyllum* L.): a review of the current evidence of nutritional and preventive health benefits, *Front. Nutr.* **11**, 1380962.

[154] C. Takayama, F. M. de-Faria, A. C. A. de Almeida, R. J. Dunder, L. P. Manzo, E. A. R. Socca, L. M. Batista, M. J. Salvador, A. R. M. Souza-Brito and A. Luiz-Ferreira (2016). Chemical composition of Rosmarinus officinalis essential oil and antioxidant action against gastric damage induced by absolute ethanol in the rat, *Asian Pac. J. Trop. Biomed.* **6**, 677–681.

[155] R. S. Borges, B. L. S. Ortiz, A. C. M. Pereira, H. Keita and J. C. T. Carvalho (2019). *Rosmarinus officinalis* essential oil: A review of its phytochemistry, anti-inflammatory activity, and mechanisms of action involved, *J. Ethnopharmacol.* **229**, 29–45.

[156] K. M. Anusmitha, M. Aruna, J. T. Job, A. Narayanankutty, B. Pb, R. Rajagopal, A. Alfarhan and D. Barcelo (2022). Phytochemical analysis, antioxidant, anti-inflammatory, anti-genotoxic, and anticancer activities of different Ocimum plant extracts prepared by ultrasound-assisted method, *Physiol. Mol. Plant Pathol.* **117**, 101746.

[157] W. Ben Bakrim, A. Aghraz, F. Hriouch, M. Larhsini, M. Markouk, K. Bekkouche, R. Costa, S. Arrigo, N. Cicero and G. Dugo (2022). Phytochemical study and antioxidant activity of the most used medicinal and aromatic plants in Morocco, *J. Essent. Oil Res.* **34**, 131–142.

[158] F. E. Guaouguaou, S. Yadlapalli and N. E. Es-Safi (2023). Ultra-High-performance liquid chromatography with photodiode array and high-resolution time-of-flight mass spectrometry detectors (UHPLC-PDA-ESI-ToF/HRMS) f for the Tentative structural characterization of bioactive compounds of *Salvia verbenaca* extracts in relation to their biological activities, *Front. Biosci* **58**(**5**), 86.

[159] E. Koksal, E. Bursal, E. Dikici, F. Tozoglu and I. Gulcin (2011). Antioxidant activity of *Melissa officinalis* leaves, *J. Med. Plants Res.* **5**, 217–222.

[160] M. Mutlu, Z. Bingol, E. M. Ozden, E. Köksal, A. Erturk, A. C. Goren, S. Alwasel and İ. Gulcin (2025). Antioxidant, and enzyme inhibition effects of chia (*Salvia hispanica*) seed oil: A comprehensive phytochemical screening using LC-HR/MS, *Electron. J. Biotechnol.* **74**, 41–53.

[161] S. Gezici, M. Turkmen and F. Karahan (2024). Exploring the anti-cancer properties of essential oils from some Lamiaceae species against human cancer cells with multivariate analysis, *S. Afr. J. Bot.* **166**, 287–296.

[162] A. R. Antão, G. Bangay, E. M. Domínguez-Martín, A. M. Díaz-Lanza and P.Ríjo (2021). *Plectranthus ecklonii* Benth: A Comprehensive review into its phytochemistry and exerted biological activities, *Front. Pharmacol.* **12,** 768268.

[163] L. Guven, A. Erturk, M. Koca and I. Gulcin (2023). Phenolic compounds of *Phlomis tuberosa* by LC–MS/MS-Determination of antioxidant activity, molecular docking, and enzyme inhibition profiles, *ChemistrySelect* **8**(**48**), e202303101.

[164] M. A. Benabderrahim, C. Sarikurkcu, W. Elfalleh, M. S. Ozer and O. Ceylan (2021). Phenolic composition and biological activities of Turkish endemic plant: *Stachys cretica* subsp. kutahyensis, *S. Afr. J. Bot.* **138**, 124–128.

[165] A. Onder, M. N. Izgi, A. S. Cinar, G. Zengin and M. A. Yilmaz (2022). The characterization of phenolic compounds via LC-ESI-MS/MS, antioxidant, enzyme inhibitory activities of *Salvia absconditiflora*, Salvia sclarea, and Salvia palaestina: A comparative analysis, *S. Afr. J. Bot.* **150**, 313–322.

[166] M. Ben Jemia, R. Tundis, A. Maggio, S. Rosselli, F. Senatore, F. Menichini, M. Bruno, M. E. Kchouk and M. R. Loizzo (2013). NMR-based quantification of rosmarinic and carnosic acids, GC-MS profile and bioactivity relevant to neurodegenerative disorders of *Rosmarinus officinalis* L. extracts, *J. Funct. Foods* **5**, 1873–1882.

[167] B. Patwardhan, H. S. Datta and S. K. Mitra (2011). Wound healing activity of topical application forms based on ayurveda, *Evid. Based Complement. Alternat. Med.* **2011**.

[168] M. O. Faruque, U. R. Ankhi, M. Kamaruzzaman, J. W. Barlow, B. Zhou, J. Hao, X. Yang and X. Hu (2019). Chemical composition and antimicrobial activity of *Congea tomentosa*, an ethnomedicinal plant from Bangladesh, *Ind. Crops Prod.* **141**, 111745.

[169] M. L. G. Dapar, G. J. D. Alejandro, U. Meve and S. Liede-Schumann (2020). Quantitative ethnopharmacological documentation and molecular confirmation of medicinal plants used by the Manobo tribe of Agusan del Sur, Philippines, *J. Ethnobiol. Ethnomed.* **16**(**1**), 14.

[170] M. Tomczyk, O. Ceylan, M. Locatelli, A. Tartaglia, V. Ferrone and C. Sarikurkcu (2019). *Ziziphora taurica* subsp. Taurica: Analytical characterization and biological activities, *Biomolecules* **9**(**8**), 367.

[171] S. Vladimir-Knezevic, B. Blazekovic, M. Kindl, J. Vladic, A. D. Lower-Nedza and A. H. Brantner (2014). Acetylcholinesterase inhibitory, antioxidant and phytochemical properties of selected medicinal plants of the lamiaceae family, *Molecules* **19**, 767–782.

[172] N. El Menyiy, H. N. Mrabti, N. El Omari, A. E. I. Bakili, S. Bakrim, M. Mekkaoui A. Balahbib, E. Amiri-Ardekani, R. Ullah, A. S. Alqahtani, A. A. Shahat and A. Bouyahya (2022). Medicinal uses, phytochemistry, pharmacology, and toxicology of *Mentha spicata*, *Evid. Based Complement. Alternat. Med.* **2022**, 7990508.

[173] M. Mahboubi (2021). Mentha spicata L. essential oil, phytochemistry and its effectiveness in flatulence, *J. Tradit. Complement. Med.* **11**, 75–81.

[174] M. S. Ali-Shtayeh, R. M. Jamous, S. Y. Abu-Zaitoun, A. I. Khasati and S. R. Kalbouneh (2019). Biological properties and bioactive components of *Mentha spicata* L. essential oil: Focus on potential benefits in the treatment of obesity, Alzheimer's disease, dermatophytosis, and drug-resistant infections, *Evid. Based Complement, Alternat. Med.* **2019,** 3834265.

[175] B. Tohidi, M. Rahimmalek and A. Arzani (2017). Essential oil composition, total phenolic, flavonoid contents, and antioxidant activity of Thymus species collected from different regions of Iran, *Food Chem.* **220**, 153–161.

[176] Z. H. Cui, S. S. Qin, E. H. Zang, C. Li, L. Gao, Q. C. Li, Y. L. Wang, X. Z. Huang, Z. Y. Zhang and M. H. Li (2020). Traditional uses, phytochemistry, pharmacology and toxicology of: *Lamiophlomis rotata* (Benth.) Kudo: A review, *RSC Adv.* **10**, 11463–11474.

[177] A. N. Ngigi and B. M. Muraguri (2019). ICP-OES determination of essential and non-essential elements in *Moringa oleifera*, *Salvia hispanica* and *Linum usitatissimum*, *Sci. Afr.* **6**, e00165.

[178] P. K. Singh, N. Singh, R. Chopra, M. Garg, M. Chand, A. Dhiman, S. Homroy and B. Talwar (2025). Rosemary bioactives as antioxidant agent: A bidirectional approach to improving human health and vegetable oil stability, *Food Chem. Adv.* **7**, 100952.

[179] N. Shinjyo and J. Green (2017). Are sage, rosemary and lemon balm effective interventions in dementia? A. narrative review of the clinical evidence, *Eur. J. Integr. Med.* **15**, 83–96.

[180] E. Köksal, E. Bursal, E. Dikici, F. Tozoğlu and İ. Gülçin (2011). Antioxidant activity of *Melissa officinalis* leaves, *J. Med. Plants Res.* **5(2)**, 217-222.

[181]. A. Al-Madhagy, Somaia, S. S. Gad, E. S. Mostafa, S. Angeloni, M. A. Saad, O. M. Sabry, G. Caprioli and S. S. El-Hawary (2022). A new firewall in the fight against breast cancer: *in-vitro* and *in-silico* studies correlating chemistry to apoptotic activity of *Otostegia fruticose*, *Nat. Prod. Res.* **37**(**16**), 2770–2775.