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ARTICLE

Some medicinal plants of the family *Lamiaceae*: the composition of essential oils and bioavailability

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Abstract

This article provides information on the medical use of certain medicinal plants of the *Lamiaceae* family, as well as on compounds found in essential oils derived from them. The study used natural and artificial methods of drying, extraction, chromatographic methods (TLC, CC), UV spectroscopy methods, and the samples obtained were tested for gram-positive and gram-negative bacteria to determine antimicrobial activity in vitro. Plants that have shown high activity are later used as raw materials for the production of antibiotics.

Keywords: Mentha L, Origanum L, Ziziphora clinopodioides L. (sin. Ziziphora brevicalyx Juz), Ziziphora tenuior, Lavanda angustifolia, Bacillus subtilis, Pseudomonas aeruginosa, Staphylococcus aureus, Escherichia coli. Candida albicans.

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1 Introduction

Today, identifying the chemical composition and biological activity of medicinal plants widely used in traditional medicine and pharmacy, isolating biologically active compounds from them individually, and developing qualitative and quantitative analytical methods for these compounds are among the key tasks of biotechnology. The flora of Uzbekistan is rich in useful plants, including medicinal species that have fascinated people for centuries and are used in folk and scientific medicine to treat various diseases. A number of plants from this region — in particular, Origanium L., Ziziphora, Mentha arvensis, Turkestan motherwort Leonurus turkestanicus, Melissa officinalis L — are collected annually in large quantities. At present, drugs derived from various genera of the *Lamiaceae* family are widely used in global medical practice. Essential oils extracted from these plants are applied in the pharmaceutical and cosmetic industries as aromatic, antiseptic, and antifungal agents, as well as in balms for wound healing. Therefore, isolating natural compounds from *Lamiaceae* plants; evaluating their quality and quantity using new methods; testing the isolated substances for anti-inflammatory, anticancer, antimicrobial, and antifungal activity; and developing new medicines based on selected bioactive compounds are all highly relevant tasks [1]. For example, several compounds from the genus *Salvia* — such as tanshinones, miltirones, salvianolic acid A, and rosmarinic acid — have been shown to be effective in treating cancer. In recent years, clinical studies have demonstrated that flavonoids from *Scutellaria*, including baicalin, baicalein, wogonin, and other active compounds, exhibit anticancer activity [2]. This, in turn, highlights the relevance of the chosen research topic.

2 Essential oils of *Lamiaceae* components in the territory of Uzbekistan

Genus *Mentha* L. (Mint)

Mentha L. (mint) is a well-known genus of the Lamiaceae family due to its medicinal and aromatic properties. It comprises about 19 species and 13 natural hybrids, mostly perennial herbs, that grow wild in moist or wet habitats of temperate regions in Europe, Asia, Africa, Australia, and North America. The species of the *Mentha* genus are reported to contain various components such as cinnamic acids, flavonoids, and steroidal glycosides. However, the main active component of *Mentha* species is essential oil, which is responsible for many of its diverse properties [3]. In Uzbekistan, three species of *Mentha* grow naturally [4]. *Mentha longifolia* var. *asiatica* (Boriss) Rech. F. and *Mentha arvensis* are commonly used by people in the food industry. They have a pleasant aroma and are popular flavoring agents for foods and beverages. From *M. longifolia* var. *asiatica* 37 different compounds have been identified, with the main constituents of the oil being trans-piperitone oxide (64.51%), piperitenone oxide (12.34%), cis-piperitone oxide (7.24%), thymol (2.60%), and spathulenol (2.36%) [5].

Genus *Origanum* L. (Basil)

The genus *Origanum* L. comprises 43 species and 18 hybrids, most of which are distributed throughout the Eastern Mediterranean region [6]. Only one species, *Origanum tyttanthum* Gontsch., is found in Uzbekistan. This herbaceous perennial, rhizomatous plant grows on rocky and stony soils. The plant contains phenolic glycosides, lipids, and coumarins [7]. Approximately 40 compounds have been characterized [8], accounting for 98.6% of the total components in its essential oils. The main constituents of the essential oil are reported to be carvacrol (42.76%), thymol (27.18%), γ-terpinene (9.50%), *p*-cymene (5.90%), and β-bisabolene (2.65%) [8]. In another study [9], the oils of O. *tyttanthum* were analyzed to identify about 30 compounds, of which 20 were confirmed, with thymol and carvacrol (48–89%) being the predominant ones. The aerial parts of O. *tyttanthum* were found to contain between 0.3% and 2.1% oil. The oil content in different parts of the plant varies significantly depending on several factors, including the growth phase, sunlight exposure, and altitude of the growing site.

Ziziphora clinopodioides L. (sin. *Ziziphora brevicalyx Juz*)

Species of the genus *Ziziphora* are annual or perennial herbs and shrubs. *Ziziphora* species are rich in flavonoids, caffeic acid derivatives, fatty acids, triterpenes, and sterols. The essential oils of *Ziziphora* have been well studied [10]. The flora of Uzbekistan includes eight species of this genus: *Ziziphora capitata* L., *Z. clinopodioides* Lam., *Z. interrupta* Juz., *Z. pamiroalaica* Juz., *Z. pedicellata* Pazij & Vved., *Z. persica* Bunge, *Z. suffruticosa* Pazij & Vved., and *Z. tenuior* L. [4].

Ziziphora clinopodioides Lam. is an important aromatic and edible medicinal plant. The leaves, flowers, and stems of this species are commonly used as wild vegetables or as additives to food products. The chemical compositions of *Z. clinopodioides* growing in Iran, Turkey, Kazakhstan, the Altai Republic (Russia), Tajikistan, and Urumqi (China) have been previously analyzed [11]. The composition of essential oil samples obtained from flowers and leaves collected in Uzbekistan has also been identified [12]. The main component of the essential oils extracted from both the flowers and leaves was found to be pulegone, a compound characteristic of previously studied *Ziziphora* species. The pulegone content was 88% in the inflorescences and 75% in the leaves.The composition of the leaf oil was as follows: pulegone (75.0%), menthone (9.6%), menthol (4.7%), caryophyllene (1.5%), pinocamphone (1.5%), and limonene (1.4%). In the inflorescences, the composition was: pulegone (88.0%), menthone (3.2%), limonene (1.6%), pinocamphone (1.1%), caryophyllene (0.9%), and menthol (0.5%). The essential oil composition of the plant leaves differed from that of the flowers. The leaf essential oil was characterized by the presence of α-pinene, sabinene, and myrcene, and by the absence of linalool, linalyl acetate, carvacrol, and D-cedrene, which distinguished it from other plant parts.

Ziziphora pedicellata Pazij et Vved

Ziziphora pedicellata Pazij & Vved. grows on rocky and gravelly slopes in the foothills and midlands of the Tien Shan region. This plant contains organic acids, essential oils, vitamin C, saponins, and flavonoids. The seeds and leaves contain carotenoids and lipids, while the flowers include terpenes [13, 14]. Essential oils obtained by hydrodistillation were analyzed, and a total of 31 compounds were identified from *Z. pedicellata*. The essential oils of *Z. pedicellata* were found to be rich in oxygenated monoterpenes, with pulegone (62.0%), isomenthone (11.5%), menthol (9.2%), menthone (5.5%), and α-pinene (1.0%) as the main components.

3 Research Methods

As the research objects, plant species belonging to the Lamiaceae family and growing in the Fergana

region were selected: field mint (*Mentha arvensis* L.), common oregano (*Origanum tyttanthum* L.), delicate ziziphora (*Ziziphora tenuior* L.), and narrow-leaved lavender (*Lavandula angustifolia*). The subject of the study includes extracts obtained from the aerial parts of field mint, common oregano, delicate ziziphora, and narrow-leaved lavender plants, which were dried using various methods and extracted in several solvents. The microorganisms (bacterial strains) used in the research were cell cultures of conditionally pathogenic microorganisms preserved at the Laboratory of Molecular Genetics, Institute of the Chemistry of Plant Substances, Academy of Sciences of the Republic of Uzbekistan. These included *Bacillus subtilis*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Escherichia coli*, and *Candida albicans*.

In the course of the research, natural (open-air) and artificial (special drying equipment) drying methods, extraction, and chromatographic techniques (TLC, CC) were employed. The structures of the isolated compounds were determined using UV spectroscopy. The antimicrobial activity of the samples *in vitro* was tested against Gram-positive bacteria (*Staphylococcus aureus*, *Bacillus subtilis*), Gram-negative bacteria (*Pseudomonas aeruginosa*, *Escherichia coli*), and the fungus *Candida albicans*. Methods for sample preparation for biological testing and for culturing microorganism strains were applied.

4 Research Results

For the study, dried aerial parts of *Mentha arvensis* L. (field mint) and *Origanum tyttanthum* L. (common oregano), belonging to the Lamiaceae family, were extracted using two different solvents (96% ethyl alcohol and chloroform), and their biological activities were examined.

Table 1. *In vitro* activity of extracts obtained from plants against Gram-positive bacteria

Samples	**Inhibition diameter (mm, ± SD, P≤0.05)**	
	Gram-positive bacteria	
	Staphylococcus aureus	***Bacillus subtilis***
Mentha arvensis L. (ethyl alcohol extract)	12	7
Origanum tyttanthum L. (ethyl alcohol extract)	10	8
Mentha arvensis L. (chloroform extract)	NA	NA
Origanum tyttanthum L. (chloroform extract)	NA	6
Ampicillin (control)	**27**	**28.8**

As seen from the table, the extracts obtained from *Mentha arvensis* L. and *Origanum tyttanthum* L. showed varying effects on bacterial strains. The chloroform extract of *Mentha arvensis* L. exhibited activity against *S. aureus* and *B. subtilis*, while the chloroform extract of *Origanum tyttanthum* L. showed no activity against *S. aureus*. The activity indices of some samples did not differ significantly, with an average inhibition diameter of about 7 mm. Among them, the ethyl alcohol extract of *Mentha arvensis* L. demonstrated the highest activity (12 mm) against *Staphylococcus aureus*.

Table 2. *In vitro* activity of extracts obtained from plants against Gram-negative bacteria

Samples	**Inhibition diameter (mm, ± SD, P≤0.05)**	
	Gram-positive bacteria	
	P. aeruginosa	***E. coli***
Mentha arvensis L. (ethyl alcohol extract)	8	NA
Origanum tyttanthum L. (ethyl alcohol extract)	7	NA
Mentha arvensis L. (chloroform extract)	NA	8
Origanum tyttanthum L. (chloroform extract)	NA	6
Ceftriaxone	**26.12 ± 0.13**	**27.12 ± 0.13**

The ethyl alcohol extract of *Mentha arvensis* L. showed activity against *E. coli*, while the ethyl alcohol extract of *Origanum tyttanthum* L. also demonstrated slight activity against *E. coli*. However, the chloroform extracts of both *Mentha arvensis* L. and *Origanum tyttanthum* L. showed no activity against *P. aeruginosa*. The *Mentha arvensis* L. (ethyl alcohol) extract exhibited an inhibition diameter of 8 mm against *P. aeruginosa*, whereas the *Origanum tyttanthum* L. (ethyl alcohol) extract showed a 7 mm inhibition diameter against the same bacterium. The *Mentha arvensis* L. (chloroform) extract had an 8 mm inhibition diameter against *E. coli*, and the *Origanum tyttanthum* L. (chloroform) extract showed 6 mm. For comparison, ceftriaxone exhibited inhibition diameters of 26 mm against *P. aeruginosa* and 27 mm against *E. coli*.

The alcohol extracts of *Origanum tyttanthum* L., *Ziziphora tenuior* L., and *Lavandula angustifolia*, as well as the chloroform extracts of *Origanum tyttanthum* L. and *Lavandula angustifolia*, showed no activity against *Candida albicans*. The chloroform extract of *Ziziphora tenuior* L. exhibited an inhibition diameter of 6 mm, and the chloroform extract of *Mentha arvensis* L. showed 7 mm. Among these samples, the alcohol extract of *Mentha arvensis* L. demonstrated relatively higher activity (9 mm). For comparison, fluconazole exhibited an inhibition diameter of 28.04 ± 0.10 mm.

Table 3. *In vitro* activity of extracts obtained from plants against Gram-negative bacteria

Samples	**Inhibition diameter (mm, ± SD, P≤0.05)**
	Candida albicans
Mentha arvensis L. (alcohol extract)	9
Origanum tyttanthum L. (alcohol extract)	NA
Ziziphora tenuior L. (alcohol extract)	NA
Lavandula angustifolia (alcohol extract)	NA
Mentha arvensis L. (chloroform extract)	7
Origanum tyttanthum L. (chloroform extract)	NA
Ziziphora tenuior L. (chloroform extract)	6
Lavandula angustifolia (chloroform extract)	NA
Fluconazole	**28.04 ± 0.10**

5 Conclusion

This article provides information on the traditional medicinal use of certain plants belonging to the Lamiaceae family and the compounds identified in the essential oils of mint (*Mentha* L.), oregano (*Origanum* L.), and *Ziziphora clinopodioides* L. Extracts obtained from these Lamiaceae plants were tested *in vitro* for their activity against Gram-positive and Gram-negative bacteria, as well as fungi. The extracts from *Mentha arvensis* L., *Origanum tyttanthum* L., *Ziziphora tenuior* L., and *Lavandula angustifolia* L. were evaluated against Gram-positive bacteria (*Staphylococcus aureus*, *Bacillus subtilis*), Gram-negative bacteria (*Pseudomonas aeruginosa*, *Escherichia coli*), and the fungus *Candida albicans*. The chloroform extract of *Mentha arvensis* L. exhibited activity against *Staphylococcus aureus* and *Bacillus subtilis*, while the chloroform extract of *Origanum tyttanthum* L. showed no activity against *Staphylococcus aureus*. The ethyl alcohol extract of *Mentha arvensis* L. demonstrated the highest inhibition diameter (12 mm) against *Staphylococcus aureus* compared to the other extracts. Regarding Gram-negative bacteria, the ethyl alcohol extracts of *Mentha arvensis* L. and *Origanum tyttanthum* L. showed activity against *E. coli*, whereas the chloroform extracts of *Mentha arvensis* L. and *Origanum tyttanthum* L. were inactive against *P. aeruginosa*. The remaining extracts exhibited moderate activity (8 mm) against both *P. aeruginosa* and *E. coli*. The antifungal activity of these plant extracts was also tested against *Candida albicans*, with the ethyl alcohol extract of *Mentha arvensis* L. demonstrating relatively higher activity (9 mm) among the samples.

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