BIOECOLOGICAL CHARACTERISTICS AND MEDICINAL IMPORTANCE OF THE RAW MATERIALS OF THYME (THYMUS VULGARIS L.) INTRODUCED IN THE CONDITIONS OF UZBEKISTAN

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Abstract. *This study analyzes the morphological, bioecological, and chemical properties of Thymus vulgaris L. (Thyme) introduced into the climatic conditions of Uzbekistan. The research results revealed that the total essential oil content in the plant's aerial parts ranges from 1,5% to 3,5%, with thymol being the dominant compound (35-60%). Furthermore, the total amino acid content (8,20-10,50%) and its significance for the human body were investigated. The article highlights the antiseptic, expectorant, and immunomodulatory properties of thyme raw materials, as well as their strategic importance as an import-substituting raw material for the local pharmaceutical and food industries. The findings confirm that Thymus vulgaris L. is a highly promising species for large-scale cultivation in the Republic's soil and climatic conditions.*

Keywords: *Thymus vulgaris L., introduction, thymol, amino acids, antiseptic, pharmaceuticals, expectorant, raw materials, Uzbekistan.*

Introduction. The flora of Uzbekistan is rich in more than 4,400 plant species, among which essential oil-bearing and medicinal plants occupy a special place. To provide the national pharmaceutical industry with local raw materials, it is relevant to study introduced plants such as Thyme (Thymus vulgaris L.) under introduction conditions. This species of thyme is a small perennial subshrub that naturally thrives in Mediterranean climates and is widely recognized for its high essential oil content. Today, nearly 40% of the medicines used in modern medicine are derived from plants. Preparations made from thyme raw materials are distinguished by their potent antiseptic, expectorant, and spasmolytic properties. In particular, the thymol and carvacrol substances in its volatile oil composition show high efficiency in treating respiratory diseases, strengthening the immune system, and acting as powerful natural antimicrobials. Establishing scientifically-based technologies for growing Thymus vulgaris in plantations within the Republic serves to preserve the reserves of wild medicinal plants. This plant is not only a source of valuable bioactive substances but also an economically effective introduced plant widely used in the food industry, perfumery, and traditional medicine. Its cultivation in a managed environment enriches the local flora with new species and serves as an important solution for meeting the pharmaceutical industry's need for high-quality, standardized raw materials.

Research Objects and Methods. The perennial subshrub Thyme (*Thymus vulgaris* L.), belonging to the *Lamiaceae* Martinov family, was selected as the object of study. Biometric, bioecological, and statistical methods used in the experiments were processed based on the obtained indicators using MS-Excel. This plant originates from the Mediterranean region and is cultivated as an introduction object in Europe, North America, as well as under the climatic conditions of Uzbekistan. Due to the valuable volatile oils, specifically thymol and carvacrol, and polyphenolic compounds in its composition, it is widely planted and cultivated on a global scale for pharmaceutical and culinary purposes.

Results and Discussion. Thyme is a perennial subshrub reaching a height of 20 to 40 centimeters, characterized by its upright or procumbent woody stems. The

root system is taproot-based and highly branched, providing stability and drought resistance. The leaves are small, linear-lanceolate to ovate, with revolute margins, and are covered in glandular hairs that secrete essential oils, giving them a distinct grayish-green appearance. The flowers possess a labiate structure, forming dense terminal verticillate inflorescences. The corollas are typically pale purple or whitish-pink, attracting numerous pollinators. The fruit consists of four small nutlets; while seed propagation is possible, the plant is also effectively propagated through stem cuttings and division of the bush.

The fragrant, grayish-green aerial parts (*herba Thymi*) are the primary product, harvested during the full flowering period, typically between June and August, when the concentration of essential oils is at its peak. This raw material is exceptionally rich in biologically active compounds, specifically volatile oils such as thymol and carvacrol, as well as flavonoids and tannins. Consequently, it is extensively utilized in medicine (for treating respiratory tract infections, bronchitis, and digestive disorders), food production (as a culinary herb and preservative), and the cosmetics industry (in the production of antiseptic hygiene products).

Thyme herba is regarded as a vital medicinal and functional raw material across Asia and Europe. It is an integral component of global pharmaceutical preparations, bioactive supplements, and medicinal teas. Due to its potent antiseptic and expectorant properties, thyme has gained global popularity as a "natural antibiotic." Historically, it has been used for treating respiratory ailments, relieving digestive spasms, and as a powerful disinfectant for wounds.

Chemical Composition. The composition of Thymus vulgaris L. is remarkably diverse, contributing to its medicinal, dietary, and pharmaceutical value. The primary components include:

Essential Oils (Thymol and Carvacrol). The most significant bioactive components, possessing strong antimicrobial, antifungal, and antioxidant properties that inhibit the growth of pathogenic bacteria;

Terpenoids. Contains compounds such as p-cymene, γ-terpinene, and linalool, which contribute to its characteristic aromatic profile and therapeutic synergy;

Flavonoids. Rich in luteolin, apigenin, and thymonin, which provide potent anti-inflammatory and radical-scavenging effects;

Phenolic Acids. Contains rosmarinic and caffeic acids, which enhance the plant's antioxidant capacity and protect tissues from oxidative stress;

Vitamins and Minerals. A natural source of Vitamins A, C, and the B-complex group, as well as essential elements including iron, manganese, calcium, and magnesium;

Tannins and Saponins. Organic compounds that provide astringent effects and assist in thinning mucus during respiratory infections.

Due to its active composition, thyme provides immunomodulatory, antitussive (cough-relieving), and spasmolytic effects. It is highly valued in treating bronchitis, pertussis, gastritis, and various stomatological conditions. Specific medicinal benefits of Thymus vulgaris L. are summarized below:

Antiseptic and Expectorant. Thymol and carvacrol act as powerful natural antibiotics, effectively thinning mucus and facilitating its removal from the respiratory tract.

Antispasmodic and Digestive. Relaxes smooth muscles in the gastrointestinal tract, alleviating cramps, bloating, and symptoms of chronic gastritis.

Antioxidant and Cytoprotective. High concentrations of flavonoids and phenolic acids neutralize free radicals, protecting lung and liver tissues from oxidative damage.

Antifungal and Antimicrobial. Demonstrates high efficacy against various strains of bacteria and fungi, making it a vital component in dermatological and oral hygiene treatments.

Immunomodulatory. Enhances the body's non-specific resistance to infections, particularly during seasonal outbreaks of influenza and other viral respiratory diseases.

Neurotrophic and Calming. Mild sedative properties help in reducing anxiety and improving sleep quality when used in medicinal tea formulations.

Experimental Results and Analysis. Modern and classical methodologies were employed to study Thymus vulgaris L., including Gas Chromatography-Mass Spectrometry (GC-MS) to identify and quantify the components of the essential oil (thymol, carvacrol, p-cymene, and linalool). Additionally, Spectrophotometric methods were used to determine the total flavonoid content and assess the overall antioxidant activity (DPPH assay) of the extracts."

Research findings indicate that the total essential oil content in the aerial parts (herba Thymi) of Thymus vulgaris L. ranges between 1,5% and 3,5% (on a dry weight basis). Thymol is the dominant substance (35-60%), providing the plant's potent antimicrobial and antiseptic activity. Additionally, the essential oil composition includes carvacrol (2-8%), p-cymene (15-25%), and γ-terpinene, which collectively enhance the antioxidant and spasmolytic effects of the plant (Table 1).

Table 1

Thyme (*Thymus vulgaris* L.) the composition of biologically active substances and basic components of the aerial parts

№	Components name	Amount (%)	Main feature
1.	Total Essential Oils	1,5 - 3,5	Antiseptic, fragrance
2.	including: Thymol	35,0 - 60,0*	Dominant active ingredient
3.	Carvacrol	2,0 - 8,0*	Antimicrobial, antioxidant
4.	Total Flavonoids	1,0 - 2,5	Anti-inflammatory
5.	Tannins & Additives	3,5 - 7,0	Adstringent (binding)

** - share in the total group (essential oil fraction).*

As you can see from the table above, the amount of the bioactive substance thymol (35-60%) in the composition of *Thymus vulgaris* L. is an absolute dominant, which determines the specific aromatic profile and healing (antiseptic, expectorant)

properties of the plant. Carvacrol and other volatile compounds enhance the plant's antimicrobial and antioxidant effects. The main biological activity of thyme is due to the complex of essential oils and flavonoids it contains.

Table 2

Thyme (*Thymus vulgaris* L.) amino acid composition of the aerial parts

№	Amino acid content (on dry matter basis)	Thymus vulgaris L. (%)
1.	Aspartic acid (Asparaginic acid)	0,85 - 1,10
2.	Glutamic acid	0,70 - 0,95
3.	Leucine (Leysin)	0,55 - 0,65
4.	Valine	0,45 - 0,55
5.	Phenylalanine	0,40 - 0,48
6.	Lysine	0,35 - 0,42
7.	Arginine	0,30 - 0,38
8.	Histidine	0,18 - 0,25

As shown in the table above, aspartic and glutamic acid levels in the plant are remarkably high. These amino acids play a vital role in plant metabolism and protein synthesis, particularly in enhancing the plant's resistance to environmental stress. Furthermore, the presence of essential amino acids such as leucine, valine, and lysine increases the biological value of thyme raw materials and explains its use for both medicinal and dietary purposes.

Total Amount and Biological Value. Research results indicate that Thymus vulgaris L. aerial parts are rich in amino acids, with their total amount ranging from 8,20% to 10,50% relative to absolute dry raw material. This indicator demonstrates that the plant is not only a source of volatile oils (thymol and carvacrol) but also a source of high-nutritional protein compounds.

In this context, the sum of essential amino acids required for the human body constitutes approximately 36-40% of the total amount, which signifies the plant's high-quality protein composition. Additionally, the highest concentrations

found in thyme leaves are aspartic acid (1,10%), glutamic acid (0,95%), and leucine (0,65%).

Aspartic and glutamic acids play a decisive role in nitrogen metabolism processes in the body and provide energy for immune system cells. Adequate levels of leucine and lysine are important for muscle tissue regeneration and enzyme synthesis. In the case of Thymus vulgaris, these amino acids act synergistically with thymol to protect the respiratory system and enhance antimicrobial defense.

In conclusion, with its balanced amino acid composition, *Thymus vulgaris* L. aerial parts are significantly important not only for pharmaceutical preparations (antiseptic, expectorant, and spasmolytic) but also for dietetics, functional foods, and the production of immune-strengthening agents.

Conclusion. The conducted research demonstrates that Thyme (*Thymus vulgaris* L.) is a highly promising introduced plant for enriching the flora of Uzbekistan and providing the pharmaceutical industry with high-quality raw materials. The main findings of the study are summarized as follows:

The introduction of Thymus vulgaris L. into the climatic conditions of Uzbekistan holds strategic importance in supplying the local pharmaceutical sector with quality and affordable raw materials. Based on their morphological and bioecological characteristics, the plant's aerial parts (*herba Thymi*) serve as a source of raw materials with high biological activity and essential oil content.

Research results indicated that the total essential oil content in thyme ranges from 1,5% to 3,5%, with thymol (35-60%) being the absolute dominant compound. This dominant constituent is the primary factor determining the plant's potent antiseptic, expectorant, and antimicrobial properties.

Amino acid analysis revealed that thyme leaves possess high dietary value in addition to their medicinal properties. The total amino acid content constitutes 8,20-10,50% of the absolute dry raw material, with nearly 40% consisting of essential amino acids vital for the human body. The high levels of aspartic and glutamic acids confirm the plant's activity in metabolic processes and its adaptation to local soil conditions.

Thyme raw material is a versatile product for modern medicine, dietetics, and the food industry, owing to its potent antitussive (cough-relieving), spasmolytic, and immunomodulatory effects. Its industrial-scale cultivation in local conditions enables the production of natural preparations that serve as local substitutes for imported antiseptic and respiratory medicines.

The wide-scale cultivation of Thymus vulgaris L. through plantation methods in the Republic, while enriching the local flora, contributes to creating a stable raw material base for the pharmaceutical, perfumery, and food industries.

Furthermore, the synergy between volatile oils and amino acids in the plant's aerial parts enhances its adaptogenic and protective properties. Specifically, the potent antimicrobial effect of thymol, combined with the immune-supporting properties of aspartic and glutamic acids, allows for the production of complex medications that ensure body resistance to respiratory infections and oxidative stress.

The significant proportion of essential amino acids (36-40%) enables the use of thyme raw material not only as a culinary herb but also in the functional food and phytopharmaceutical industries as a source of highly bioavailable proteins. This elevates the plant's nutritional and pharmaceutical value to a new level.

In final conclusion, the chemical composition of Thymus vulgaris L. confirms that it is not merely a traditional herb but a strategic raw material for modern phytopreparations that regulate respiratory functions, combat pathogenic microflora, and strengthen the immune system. Expanding the cultivation of this plant under the soil and climatic conditions of the Republic serves as an important source of raw materials for increasing the volume of local import-substituting products in the pharmaceutical and culinary sectors.

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