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Some Bioecological Characteristics and Cultivation Technology of Inula Helenium L

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Annotation: Inula helenium L. (elecampane) is a medicinal plant that has been used in traditional medicine for centuries and is now gaining recognition in official medical practices. The roots and rhizomes of Inula helenium exhibit antibacterial, anthelmintic, and antiseptic properties, making it a valuable resource in food production, pharmaceuticals, and biotechnology. This plant's bioecological characteristics, natural habitat, and chemical composition contribute to its therapeutic potential. Inula helenium is cultivated using specific agricultural techniques to ensure high-quality raw materials for its various applications. This article provides an overview of the plant's cultivation methods, highlighting the importance of establishing a sustainable raw material base to meet growing demand. Additionally, the article explores its ecological and environmental requirements, which are crucial for successful cultivation. The chemical compounds found in Inula helenium, such as essential oils, flavonoids, and sesquiterpene lactones, further enhance its

medicinal properties. Through a comprehensive approach to its cultivation and utilization, Inula helenium has the potential to contribute significantly to both traditional and modern medicine. This article aims to offer valuable insights for the effective use and cultivation of Inula helenium in various industries.

Keywords: Inula helenium, medicinal plants, alantolactone, isoalantolactone, inulin, saponins, bioecological characteristics, domestication, pharmacopoeia.

INTRODUCTION

In recent years, there has been growing interest in the biological activity of medicinal plants, spurred by advancements in pharmacological research and the increasing demand for natural alternatives to synthetic pharmaceuticals. This research aims to develop new pharmaceutical products derived from plants, as well as to domesticate species that have long been used in folk medicine. Among these plants, Inula helenium L. (elecampane) stands out due to its significant therapeutic properties, which have been acknowledged for centuries [1]. Recognized for its antibacterial, anthelmintic, antiseptic, and immunomodulatory effects, elecampane has a well-established place in traditional medicine, especially for treating respiratory diseases, digestive disorders, and infections.The roots and rhizomes of I. helenium are particularly rich in biologically active compounds such as alantolactone, isoalantolactone, inulin, saponins, and flavonoids. Alantolactone and isoalantolactone, the primary sesquiterpene lactones in the plant, are particularly noted for their potent antibacterial and anti-inflammatory effects, making them valuable in the treatment of a variety of infections and inflammatory conditions. Inulin, a type of fructan, is a prebiotic with beneficial effects on the gut microbiota, enhancing digestive health and boosting immune function. The presence of saponins contributes to the plant's ability to enhance immune responses and has also been shown to have mild antitumor effects, expanding the plant's potential therapeutic applications [2]. These bioactive compounds make Inula helenium a versatile and promising source for the development of natural medicines and health products.Inula helenium is native to temperate regions of Europe and Asia, where it thrives in open, well-drained soil and moderate climates. The plant's natural habitat typically includes meadows, forest clearings, and riverbanks, providing a relatively stress-free environment that fosters optimal growth. Understanding its bioecological characteristics is crucial for successful cultivation, especially as demand for this medicinal plant increases globally [3]. As natural resources of wild I. helenium begin to dwindle due to overharvesting, there is a growing emphasis on establishing sustainable cultivation practices to ensure a steady supply of high-quality raw materials for the pharmaceutical, food, and biotechnology industries.Cultivating Inula helenium involves understanding the plant's specific requirements for growth, such as soil pH, temperature, and moisture levels [4]. The plant is known for its relatively slow growth, with the roots taking several months to mature fully. Propagation can be achieved through seed or rhizome cuttings, with the latter method being more effective in ensuring consistency in the plant's bioactive compound content. The plant requires careful soil management, including proper spacing between plants, to

minimize competition and ensure the healthy development of the root system, which is the primary source of medicinal compounds.The potential economic impact of I. helenium is significant, particularly in the pharmaceutical sector, where demand for natural, plant-based medicines is on the rise [5]. Additionally, the plant's bioactive compounds have applications in the food industry, where they can be used as natural preservatives or functional food ingredients, as well as in biotechnology, where they may be incorporated into the development of new bio-based products. The establishment of a stable raw material base for Inula helenium could not only meet the increasing demand for these products but also contribute to the rational use of natural resources and the sustainable development of agricultural practices [6].

METHODOLOGY

The methodology for this study on Inula helenium L. (elecampane) focuses on a multi-faceted approach to assess its bioecological characteristics, chemical composition, and cultivation practices. Initially, a comprehensive review of existing literature is conducted to gather information on the plant's medicinal properties, natural habitat, and previous cultivation techniques. Field surveys are carried out in regions where I. helenium naturally grows to document its ecological preferences, such as soil type, climate, and associated plant species. This data helps identify the optimal environmental conditions necessary for successful cultivation. Experimental cultivation trials are then set up in controlled agricultural settings, simulating the conditions found in the plant's native habitat. These trials include testing different soil compositions, pH levels, and irrigation techniques to determine the most suitable growing conditions. Rhizome propagation is employed to ensure consistency in plant quality, with regular monitoring of growth parameters such as root development and plant height. During the growing season, the chemical composition of the roots and rhizomes is analyzed through chromatographic techniques to quantify the levels of key bioactive compounds, including alantolactone, isoalantolactone, and inulin. Additionally, the impact of cultivation practices on the concentration of these compounds is assessed. Finally, data from these experiments are analyzed to develop recommendations for large-scale cultivation and sustainable harvesting practices, with an emphasis on optimizing yield and maintaining high levels of bioactive compounds. This approach provides a holistic understanding of the plant's cultivation requirements and its potential for industrial use.

RESULT AND DISCUSSION

This research aimed to study the bioecological characteristics of *Inula helenium* L. (elecampane), determine its chemical composition, and develop a cultivation technology under controlled conditions [7]. The research was carried out in the following stages:

➢ Preparation of seed material

For the experiment, mature and healthy seed samples were collected from regions rich in medicinal plant diversity. To determine their germination capacity, a germination test was conducted in laboratory conditions on moist cotton for 7–10 days. As a result, seeds with high germination rates were selected and prepared for the next phases of the study [8].

Selection and Preparation of the Experimental Plot: A sunny location with good air circulation, sandy-loam soil, and moderate moisture was selected as the most suitable area for the plant. The soil was loosened to a depth of 25–30 cm and enriched with humus, superphosphate, and potassium-based fertilizers. Special attention was given to maintaining the soil pH level within the range of 6.5–7.5 [9].

- **Sowing Technology**

Sowing was carried out in early spring, once the soil temperature reached 8–10°C. The seeds were sown in rows at a depth of 1.5–2 cm. The row spacing was set at 50–60 cm, and the spacing between plants was maintained at 20–30 cm. After sowing, the soil surface was lightly leveled and moistened through irrigation [10].

- **Selection and Preparation of the Experimental Plot**

A fertile area with sandy soil, moderate moisture, ample sunlight, and good air circulation was selected as the most suitable location for plant cultivation. The soil was loosened to a depth of 25–30 cm and enriched with humus, superphosphate, and potassium-based fertilizers. Special attention was paid to maintaining the soil pH within the range of 6.5–7.5 [11].

- **Sowing Technology**

Sowing was carried out in early spring after the soil temperature rose to 8–10°C. The seeds were sown in rows at a depth of 1.5–2 cm. The spacing between rows was set at 50–60 cm, and the distance between plants was maintained at 20–30 cm. After sowing, the soil surface was gently leveled and irrigated to ensure adequate moisture [12].

- **Maintenance Measures**: During the vegetation period, weeds were regularly removed, and the inter-row spaces were loosened and hoed. Irrigation was carried out 1–2 times per week, with increased watering during the flowering and root development stages. Throughout the growing season, the plants were fertilized 2–3 times with nitrogen, phosphorus, and potassium-based fertilizers [13].

- **Phenological Observations**

The stages of seedling emergence, leaf development, flowering, fruiting, and the completion of the vegetation period were regularly observed and recorded. Flowering typically begins in the second year.

- **Harvesting and Drying**

The medicinal parts of the plant roots and rhizomes were harvested during September–October. The roots were cleaned and dried in specialized dryers at a temperature of 50–60°C. The dried samples were then prepared for chemical analysis [14].

➢ Chemical Composition Analysis

Extracts were prepared from the dried roots and rhizomes, and the contents of alantolactone, isoalantolactone, saponins, inulin, flavonoids, essential oils, and other biologically active compounds were determined using HPLC and GC-MS methods. The results were processed using statistical methods, and scientific conclusions were drawn.


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➢ Development of Recommendations

Based on the obtained data, practical recommendations for cultivating *Inula helenium* L. under cultural (cultivated) conditions were developed. In addition, the prospects of growing this species as a source of medicinal raw material were substantiated [15].

Inula helenium L. – commonly known as elecampane – is a medicinal plant that has long been used in traditional medicine and today continues to hold significant scientific and practical value. Numerous studies have been conducted to scientifically investigate its medicinal properties, determine its chemical composition, and assess its potential use based on pharmacologically active compounds. H.Kh. Kholmatov and Z.Kh. Khabibov, in their research, identified a range of biologically active compounds in the rhizome of *Inula helenium*, including essential oils, saponins, resins, mucilage, bitter substances, alantolactones, isoalantolactones, phytomelin, inulin, and pseudo-inulin. According to their findings, many of these compounds exhibit antibacterial, anthelmintic, anti-inflammatory, and immunostimulatory properties. In the works of Q. Khojimatov, M. Olloyorov, and A.Yu. Ibragimov, detailed information is provided on the plant's distribution area, growing conditions, chemical composition, and its medical applications. Their research offers particularly valuable conclusions regarding the growth stages and ecological adaptability of *Inula helenium*. Studies by J. Wang, Y.M. Zhao, and C.Y. Guo revealed that the plant’s root extracts are rich in biologically active compounds such as inulin, polysaccharides, fructooligosaccharides, and flavonoids, positioning it as a promising raw material for the production of bioactive supplements.S. Amin and Z.A. Kaloo reported the presence of

alantolactone, isoalantolactone, galenin, and alantoic acids in the essential oil of *Inula helenium*, emphasizing their antimicrobial properties. In a similar line of research, D. Polina confirmed that these compounds could be effectively used against microorganisms like *Staphylococcus aureus*. According to J.M. Dergachyova and N.A. Troskaya, while previously only the rhizome of the plant was recognized as official pharmaceutical raw material, today, the flowers of *Inula helenium* have also been included in the State Pharmacopoeia of Belarus, further expanding its pharmaceutical importance.Moreover, based on the findings of Iuliana Sp, the lactone compounds found in the root of the plant are being evaluated as active agents against the proliferation of cancer cells, which highlights its potential in oncology as well.Analysis of the literature shows that *Inula helenium* is rich in biologically active compounds, highly adaptable to various ecological conditions, and possesses great economic and pharmacological value as a medicinal raw material. Therefore, the need to cultivate it in managed plantations, conserve its natural resources, and widely implement it in practical applications is increasing. Currently, in many countries around the world, intensive scientific research is being conducted to develop new medicinal products based on the biologically active substances of medicinal plants. In this context, *Inula helenium* L., belonging to the Asteraceae family, is recognized as one of the most promising species. It has been used in traditional medicine for many years, and its medicinal properties are being confirmed by modern scientific studies.

According to research findings, the roots and rhizomes of *Inula helenium* contain essential oils (1–3%), saponins, resins, mucilage, bitter substances, alantolactone, isoalantolactone, phytomelin, inulin, pseudoinulin, and other acetylenic compounds. In particular, alantolactone and isoalantolactone have been identified for their anthelmintic, antibacterial, and anti-inflammatory effects. Their pharmacological importance and healing properties significantly expand the potential of this plant for use as a medicinal remedy. Additionally, *I. helenium* extract includes biologically active compounds such as inulin, polysaccharides, flavonoids, and fructooligosaccharides. This enables the plant to be utilized not only in medicine but also in the food, biotechnology, and dietary industries.Studies conducted by Malarz and other researchers have shown that the plant extract exhibits high activity against *Candida* fungi and bacteria such as *Staphylococcus aureus* and *Escherichia coli*.

In the flora of Uzbekistan, the effective use of medicinal plants, preservation of their natural resources, and expansion of raw material bases through domestication are urgent issues. From this point of view, the ecological adaptability, cold resistance, and fast-growing vegetation period of *I. helenium* make it suitable for successful cultivation in artificial plantations. Research conducted by Q. Hojimatov, M. Olloyorov, and A. Yu. Ibragimov confirms the successful growth of this plant in certain regions of Uzbekistan.According to the cultivation technology, *I. helenium* seeds are sown in spring in open fields or greenhouses. The plant grows well in loose, well-aerated, and sufficiently moist soils. During the vegetation period, 2–3 fertilizations, weeding, and regular irrigation are required. The roots and rhizomes are harvested in autumn or spring after two years, then dried and processed.Thus, *Inula helenium L.*, commonly known as Elecampane, occupies a special place among medicinal plants. Expanding its raw material base, developing scientifically grounded domestication technologies, and applying it in the pharmaceutical industry are recognized as relevant scientific and practical tasks. This opens up opportunities for its successful application in the conditions of Uzbekistan.*Inula helenium L.* Elecampane is considered one of the most promising medicinal plants due to its medical and biological properties. The biologically active compounds in its roots and rhizomes such as essential oils, alantolactone, inulin, polysaccharides, flavonoids, and other components can be effectively used to treat various diseases. Its antibacterial, anthelmintic, anti-inflammatory effects, and immune-enhancing properties allow for widespread medical application. Moreover, the natural resources of *I. helenium*, particularly in Uzbekistan, provide great potential for expanding the medicinal plant base and developing natural substitutes for synthetic drugs. Cultivating this plant and developing production technologies based on it can enhance its raw material base and yield economically

beneficial results.

Additionally, studying the biological and ecological characteristics of Elecampane and developing effective methods for its large-scale cultivation and propagation is of great importance. Exploring this plant allows for the utilization of its advantages not only in medicine but also in the food industry and biotechnology. Therefore, it is essential to conduct in-depth scientific research on *Inula helenium*, fully assess its potential, and broaden its applications in medicine and beyond. This will also contribute to improving the raw material base of medicinal plants and using natural resources more efficiently.

CONCLUSION

In conclusion, this study on *Inula helenium* (elecampane) highlights the plant's significant potential as a valuable source of bioactive compounds, such as alantolactone, isoalantolactone, and inulin, which exhibit notable antibacterial, anthelmintic, and immunomodulatory properties. The findings underscore the importance of optimizing cultivation practices, particularly the selection of appropriate soil conditions and propagation methods, to ensure a consistent supply of high-quality raw materials for use in pharmaceuticals, biotechnology, and the food industry. The research also emphasizes the need for sustainable cultivation techniques to support the growing demand for *I. helenium* while maintaining environmental balance. The successful domestication of this plant could contribute significantly to the national economy by expanding the medicinal raw material base. However, further research is needed to explore the long-term impacts of cultivation practices on the plant’s chemical composition and yield, as well as to evaluate the potential for enhancing the concentration of bioactive compounds through advanced agricultural technologies. Additionally, investigations into the plant's broader ecological role and its interactions with surrounding flora and fauna would provide valuable insights for optimizing its cultivation in diverse environmental settings

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