UDC 581.8
AGRIS F40
https://doi.org/10.33619/2414-2948/132/04

ANATOMY OF VEGETATIVE ORGANS
Helichrysum aurantiacum Boiss. & Huet and *Helichrysum undulatum* Ledeb.

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АНАТОМИЯ ВЕГЕТАТИВНЫХ ОРГАНОВ
Helichrysum aurantiacum Boiss. & Huet И *Helichrysum undulatum* Ledeb.

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Abstract. A comparative study of the anatomical features of leaves and stems of *Helichrysum auranticum* and *Helichrysum undulatum* species was carried out. The transverse sections of the leaves and stems were examined with respect to the arrangement of the dermal tissue, ground parenchymatous tissue, mechanical elements, and vascular system. In both species, the leaves exhibited a dorsiventral structure, with the upper and lower epidermis clearly distinguishable. The mesophyll consisted of palisade and spongy parenchyma. In transverse sections of the stems, the epidermis, cortical parenchyma, mechanical tissue elements, open collateral vascular bundles, and central pith were observed. Comparative analysis revealed certain differences between the species in the thickness of the mesophyll layers, the size of the vascular bundles, the degree of development of mechanical tissues, and the structure of the pith parenchyma. The results obtained allow for the identification of diagnostic characteristics that can be used for the microscopic identification of species of the genus *Helichrysum*.

Аннотация. Проведено сравнительное изучение анатомических особенностей листьев и стеблей видов *Helichrysum auranticum* и *Helichrysum undulatum*. Поперечные срезы листьев и стеблей исследовали с точки зрения расположения покровной ткани, основной паренхимной ткани, механических элементов и проводящей системы. У обоих видов листья имели дорзивентральное строение, при этом верхняя и нижняя эпидерма были чётко различимы. Мезофилл состоял из палисадной и губчатой паренхимы. На поперечных срезах стеблей были выявлены эпидерма, коровая паренхима, элементы механической ткани, открытые коллатеральные проводящие пучки и центральная сердцевина. Сравнительный анализ выявил определённые различия между видами по толщине слоёв мезофилла, размерам проводящих пучков, степени развития механических тканей и строению паренхимы сердцевины. Полученные результаты позволяют определить диагностические признаки, которые могут быть использованы для микроскопической идентификации видов рода *Helichrysum*.

Keywords: Helichrysum, microscopic characteristics, phloem, xylem, pharmacognosy.

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https://doi.org/10.33619/2414-2948/132

Ключевые слова: *Helichrysum*, микроскопические особенности, флоэма, ксилема, фармакогнозия.

The genus *Helichrysum* is one of the widely distributed and pharmacologically important genera of the family Asteraceae. Species belonging to this genus are widely used in both traditional and modern medicine due to their richness in essential oils, flavonoids, phenolic compounds, and other biologically active substances [2, 3, 5, 8, 9, 11, 12].

Microscopic characteristics are considered important diagnostic features for the accurate identification and quality control of medicinal plants [20].

In pharmacognostic studies, examination of the internal structure of leaves and stems is of great importance for determining the authenticity of raw materials, preventing adulteration, and distinguishing species from one another [4, 6, 10, 19].

The use of anatomical and microscopic characteristics in the pharmacognostic identification of medicinal plants is one of the classical approaches in pharmacognosy [7, 16, 17].

In this regard, comparative microscopic investigation of species belonging to the same genus is relevant from both scientific and practical perspectives. The aim of this study was to investigate the microscopic characteristics of the leaves and stems of *Helichrysum auranticum* and *Helichrysum undulatum* and to identify their common and distinguishing features.

Materials & Methods

The vegetative organs (leaves and stems) of *Helichrysum auranticum* and *Helichrysum undulatum*, belonging to the genus *Helichrysum*, were used as the study material. The plants were collected during the vegetation period and transported to the laboratory. Leaf and stem segments obtained from the plant specimens were fixed in 70% ethyl alcohol. Following fixation, the materials were subjected to a series of dehydration steps, embedded in paraffin, and transverse sections 8 µm thick were prepared using a microtome.

The prepared sections were stained with Safranin O and Fast Green. The sections were examined using a light microscope (Motic BA310 Digital LED), and microphotographs were taken for subsequent analysis. During the microscopic examination, observations were made on the prepared sections, and the structural characteristics of the vegetative organs of both species were comparatively evaluated.

Results & Discussion

Microscopic characteristics of the leaf of Helichrysum auranticum. A dorsiventral structure is clearly observed in the transverse section of the *H. auranticum* leaf (Figure 1). The leaf is externally covered by a single-layered upper and lower epidermis. The epidermal cells are densely arranged and protect the leaf tissues from external influences. The mesophyll consists of two layers: palisade parenchyma composed of columnar, densely arranged cells beneath the upper epidermis, and spongy parenchyma located below, characterized by more loosely arranged cells and distinct intercellular spaces [13].

A collateral vascular system is clearly distinguishable in the midrib region of the leaf. The xylem is located internally, whereas the phloem occupies the external part. The parenchymatous cells surrounding the vascular system maintain the structural integrity of the vascular region. The orderly arrangement of photosynthetic and conducting elements in the leaf tissues reflects the microscopic diagnostic characteristics of the species [1].

Microscopic characteristics of the stem of Helichrysum auranticum. In the transverse section of the *Helichrysum auranticum* stem, the tissues are clearly differentiated from the center toward the

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Т. 12. №11 2026
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periphery (Figure 2). The outer part is covered by a single-layered epidermis. Beneath the epidermis, the cortex consists of parenchymatous cells, with groups of cells performing a mechanical support function distinguishable in this region. In the central cylinder of the stem, the vascular bundles are arranged in a ring. In each vascular bundle, the phloem is located externally and the xylem internally, forming a collateral structure. The more pronounced development of the xylem elements indicates an efficient organization of water and mineral transport. The phloem region is relatively narrow and consists of living cells involved in the transport of assimilates [14].

A cambial zone is distinguishable between the conducting tissues, indicating the potential for secondary growth in the stem. The central part of the stem is occupied by a pith composed of large, thin-walled parenchymatous cells. The presence of intercellular spaces between the pith cells facilitates aeration of the internal tissues. Overall, the microscopic structure of the *H. auranticum* stem is characterized by a well-developed vascular system, clearly distinguishable mechanical tissues, and an orderly arrangement of tissues. These characteristics may be considered important diagnostic features for the pharmacognostic identification of the species [18].

These microscopic characteristics may be considered important diagnostic features for distinguishing species of the genus *Helichrysum* from one another and for their pharmacognostic identification.

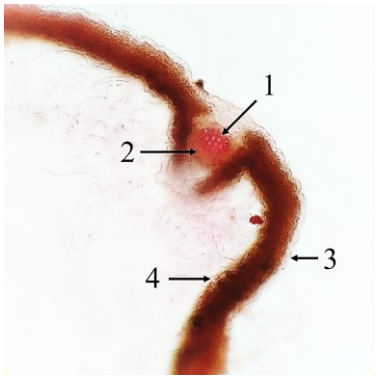


Figure 1. Transverse section of the leaf of *Helichrysum auranticum*. 1 - xylem, 2 - phloem, 3 - upper epidermis, 4 - lower epidermis

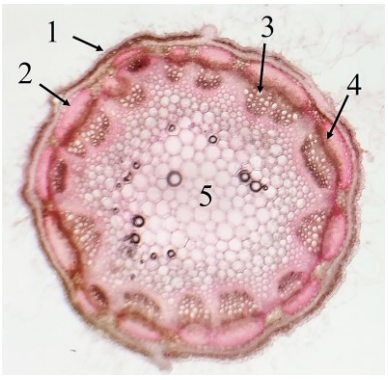


Figure 2. Transverse section of the stem of *Helichrysum auranticum*. 1 - epidermis, 2 - mechanical tissue, 3 - xylem, 4 - phloem, 5 - pith

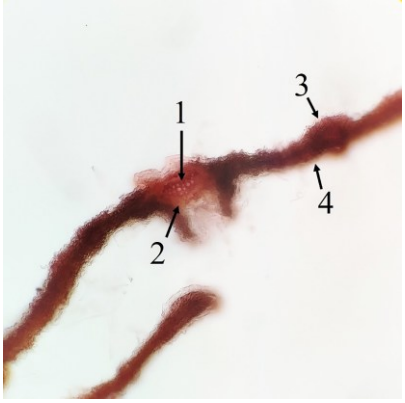


Figure 3. Transverse section of the leaf of *Helichrysum undulatum*. 1 - xylem, 2 - phloem, 3 - upper epidermis, 4 - lower epidermis

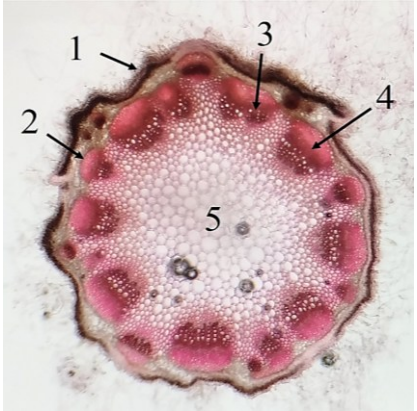


Figure 4. Transverse section of the stem of *Helichrysum undulatum*. 1 - epidermis, 2 - mechanical tissue, 3 - xylem, 4 - phloem, 5 - pith

Microscopic characteristics of the leaf of Helichrysum undulatum. A dorsiventral leaf structure is observed in the transverse section of the *H. undulatum* leaf (Figure 3). The leaf is covered by upper

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Т. 12. №11 2026
https://doi.org/10.33619/2414-2948/132

and lower epidermis. The mesophyll consists of palisade and spongy parenchyma layers, and a collateral vascular system is clearly distinguishable in the midrib region.

The palisade parenchyma cells are densely arranged in the upper part of the leaf and perform a photosynthetic function. The spongy parenchyma is characterized by more loosely arranged cells and intercellular spaces. This feature facilitates effective gas exchange within the leaf. In the midrib region, the xylem and phloem elements are clearly differentiated. The parenchymatous cells surrounding the vascular bundle increase the mechanical stability of the conducting tissues. The overall microscopic structure of the leaf reflects characteristics typical of the genus *Helichrysum*.

Microscopic characteristics of the stem of Helichrysum undulatum. In the transverse section of the stem, the outer covering tissue consists of a single-layered epidermis (Figure 4). The cortical parenchyma is located beneath the epidermis and is clearly separated from the vascular system situated internally. The vascular system is arranged in a ring. The phloem is located toward the periphery, whereas the xylem is positioned toward the center, forming a typical collateral vascular system. A cambial zone is distinguishable between the conducting tissues. The central region contains a pith composed of large parenchymatous cells.

The microscopic structure of the stem demonstrates clear boundaries between the tissues and an orderly organization of the vascular system. These characteristics represent important microscopic features that can be used for the diagnostic identification of the species [15].

Comparison of the microscopic characteristics of Helichrysum auranticum and Helichrysum undulatum. Both species exhibit a similar structural organization in the general microscopic structure of their leaves and stems. The dorsiventral mesophyll, single-layered epidermis, and collateral vascular bundles in the leaves, as well as the epidermis, cortex, ring-arranged vascular bundles, and central pith in the stems, are common characteristics of both species.

Nevertheless, certain differences are observed in their microscopic structure. In *H. auranticum*, the mesophyll has a more compact structure, while the mechanical tissues are more highly developed. The vascular bundles are relatively more densely arranged, and the xylem elements are more clearly distinguishable.

In *H. undulatum*, wider intercellular spaces in the spongy parenchyma, relatively larger cells in the pith parenchyma, and more pronounced morphological boundaries of the vascular bundles are noteworthy.

Conclusion

Microscopic examination of the leaves and stems of *Helichrysum auranticum* and *Helichrysum undulatum* showed that, although both species share a common structural plan, certain differences were observed in the degree of development of individual tissues. In transverse sections of the leaves, the upper and lower epidermis were clearly distinguishable in both species, while the mesophyll consisted of palisade and spongy parenchyma. Collateral vascular bundles were clearly visible in the midrib region. In transverse sections of the stems, the epidermis, cortical parenchyma, mechanical tissue elements, phloem, xylem, and central pith were clearly differentiated. The ring-shaped arrangement of the vascular bundles and the well-developed pith were identified as characteristic features of both species. Comparative analysis showed that *H. auranticum* had a more compact leaf mesophyll, more densely arranged conducting tissues, and relatively well-developed mechanical tissues. In *H. undulatum*, wider intercellular spaces in the spongy parenchyma, larger cells in the pith parenchyma, and differences in the size characteristics of the vascular bundles were noteworthy. The microscopic characteristics identified are of diagnostic significance for the pharmacognostic identification of both species and can be used as reliable criteria for distinguishing species belonging

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to the same genus. These characteristics are also of practical importance for assessing the authenticity and quality control of medicinal plant raw materials.

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Поступила в редакцию
27.08.2026 г.

Принята к публикации
06.09.2026 г.

Ссылка для цитирования:

Sardarova A., Agayeva N. Anatomy of Vegetative Organs *Helichrysum aurantiacum* Boiss. & Huet and *Helichrysum undulatum* Ledeb. // Бюллетень науки и практики. 2026. Т. 12. №11. С. 44-50. https://doi.org/10.33619/2414-2948/132/04

Cite as (APA):

Sardarova, A., & Agayeva, N. (2026). Anatomy of Vegetative Organs *Helichrysum aurantiacum* Boiss. & Huet and *Helichrysum undulatum* Ledeb. *Bulletin of Science and Practice, 12*(11), 44-50. https://doi.org/10.33619/2414-2948/132/04

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