

Research Article

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Morphological and anatomical analysis of *Hedysarum gmelinii*, growing in the Karaganda region (Central Kazakhstan)

The study of the structure of medicinal plant raw materials is part of pharmacognostic analysis. In this work, anatomical and morphological studies were conducted on the promising plant *Hedysarum gmelinii*, whose herb and roots have potential for use in human and veterinary medicine. The raw materials were collected during the flowering phase, rehydrated, and analyzed at both macroscopic and microscopic levels. The following diagnostic macroscopic features were identified: shape and color of the stem, type of leaf pubescence, and characteristics of the inflorescence and flowers. At the microscopic level, diagnostic features included the structure of stem vascular tissues, fine ribbing of the stem, leaf anatomy (isobilateral type, if applicable), stomatal type and distribution, and the structure and arrangement of secondary xylem elements in the root. The results obtained can be used to verify the authenticity of plant raw materials and to prepare draft regulatory documentation for raw materials of this species.

Keywords: *Hedysarum gmelinii*, morphological and anatomical structure, aboveground and underground organs, diagnostic signs.

Introduction

The study of the useful flora of Kazakhstan has great potential, as it allows for the identification of promising sources of biologically active substances suitable for the production of new medicinal and veterinary preparations [1].

One of the most promising taxonomic groups is the genus *Hedysarum* L. (family Fabaceae), for certain species of which the Republic of Kazakhstan possesses a sufficient raw material base. In the natural flora, the genus *Hedysarum* L. comprises more than 200 species, of which 37 grow in the flora of Kazakhstan, including 12 endemic species [2].

From plants of the genus *Hedysarum* L., 115 biologically active compounds have been isolated, including flavonoids, triterpenes and triterpenoid saponins, coumarins, lignanoids, alkaloids, and sterols, which possess antioxidant, antitumor, anti-aging, antidiabetic, and antihypertensive effects [3–7].

Among the Kazakhstani representatives of the genus *Hedysarum* L., four species are known (*H. alpinum* L., *H. flavescens* Regel et Schmalh., *H. theinum* Krasnob., and *H. neglectum* Ledeb.), which possess expectorant, restorative, stimulant, antiviral, and antiprotozoal properties [8] and are used as antioxidants, immunostimulants, rejuvenating agents, restoratives, and tonics [9, 10].

In Central and Northern Kazakhstan, *Hedysarum gmelinii* Ledeb. is of interest, as it has significant raw material reserves and is a potential source of xanthones, phenolic compounds, tannins, and alkaloids.

To facilitate the use of this species for medical purposes, we conducted an anatomical and morphological study of *H. gmelinii* to identify diagnostic features necessary for assessing the authenticity of the raw material.

Experimental

H. gmelinii was collected in the vicinity of the village of Karagaily (Karkaraly District, Karaganda Region, GPS-coordinates: N 49.42714; E 75.75434) during the flowering and fruiting phase, in the first ten days of August 2025.

The raw material in the form of herbaceous parts was collected in the morning, and the roots were dug up in the evening. Drying was carried out in a room protected from sunlight until the moisture content reached 10–12 %. The species was identified by staff of the Department of Botany, Faculty of Biology and Geography, Karaganda National Research University named after academician E.A. Buketov. The herbarium specimen is stored in the herbarium collection (acronym QAR, barcode QAR00013920).

Air-dried raw material (shoot, leaf, root) was softened in a mixture of distilled water: glycerin: 96 % ethanol (in a 1:1:1 ratio), then boiled in a 5 % sodium hydroxide solution [11]. Surface preparations were prepared on a manual microtome using disposable blades.

During microscopy, the preparations were examined under a BIOLAM 06-12 microscope (Russia) using magnifications of 16×20, 16×10, and 16×4 [12]. Microscopic photographs were captured on a tablet using Altamy Studio software and processed in Paint 10.1.

Classic methodological guidelines were applied when describing the specimens and identifying diagnostic features [13–15].

Results and Discussion

External characteristics of the plant. It belongs to the ancient Mediterranean-steppe type of distribution. It inhabits mountainous gravelly and rocky slopes, scree, and chalk deposits. In terms of ecological group, it is a xeromesophyte, which is reflected in its internal structure.

H. gmelinii is a perennial herbaceous plant, 15 to 40 cm tall (Fig. 1). The root is short and taproot-like. The shoots are ascending or rising, ribbed, with a rough surface, and range in color from light green to greenish-yellow.



Figure 1. *H. gmelinii* in the flowering stage

The leaves are imparipinnate, with 4 to 8 pairs of leaflets on a compound leaf. The leaflets are elliptical or narrowly ovate, with the upper surface green and glabrous, and the lower surface silvery-green, pubescent with appressed hairs. The venation is pinnate, faintly visible on the upper side of the leaf. The flowers are arranged in terminal racemes, containing 10–25 flowers. The flowers are zygomorphic, with a pink-purple corolla.

The following diagnostic features can be identified at the macroscopic level: the shape, color, and type of leaf pubescence, the shape of the inflorescence, and the color of the flowers.

Microscopy. The stem in cross-section (Fig. 2) is rounded and slightly lobed, hollow in the central part, and non-fasciculate in structure. The stem's perimeter is covered by a thin layer of bark, or periderm, consisting of small, dark-colored cells. Beneath the periderm, in the corners, lie areas of angular collenchyma, whose cells are oval-shaped with partially thickened walls.

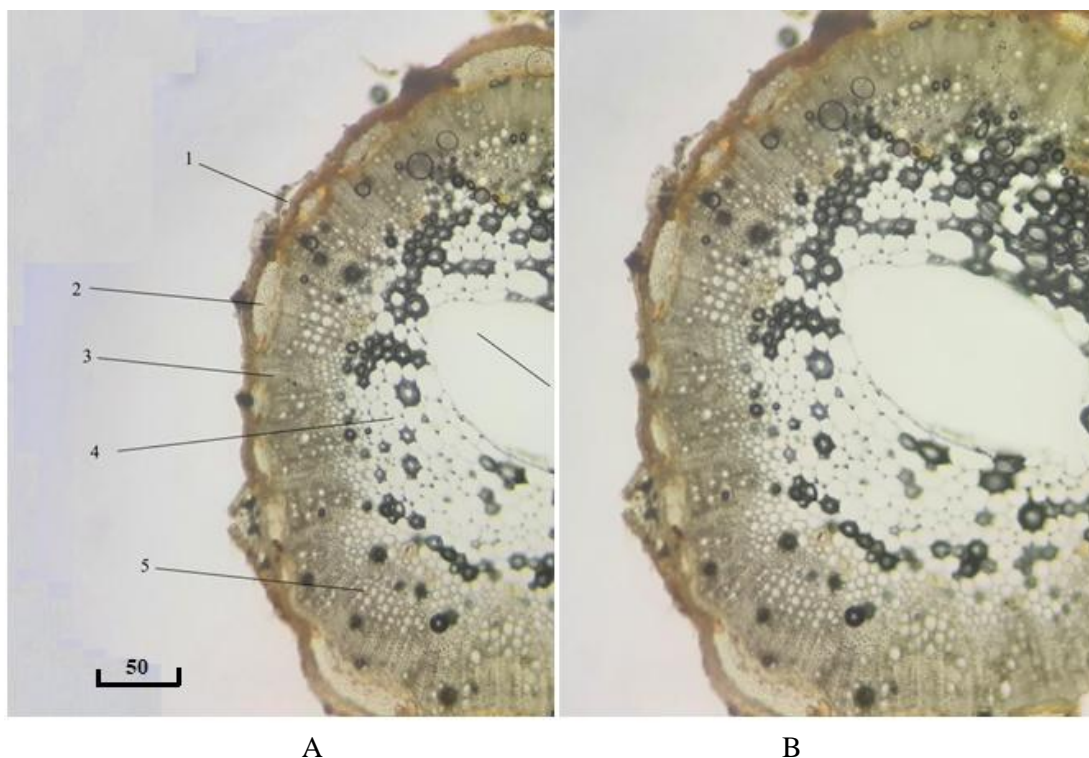


Figure 2. Cross-section of a *Hedysarum gmelinii* stem, fragment:
 A — stem fragment, B — fragment with remnants of medullary parenchyma;
 1 — bark, 2 — collenchyma, 3 — phloem, 4 — medullary parenchyma, 5 — xylem, 6 — stem cavity.
 Dimensions are given in μm

The vascular system consists of phloem regions corresponding to former vascular bundles, as well as xylem chains. The annular vascular zone is interrupted by rays of medullary parenchyma. The remnants of medullary parenchyma consist of large, thin-walled cells.

In cross-section, the leaf is flat, isolateral in shape, with an indistinct division into columnar and spongy tissues (Fig. 3). This characteristic is described for this species growing in more arid conditions, whereas in mesophytic habitats a dorsoventral structure is formed [16]. Veins protrude from the underside of the leaf. On both sides, the leaf is covered by a single-layered epidermis consisting of rounded cells that fit tightly together and are covered by a layer of cuticle on the outer side. The mesophyll is undifferentiated. Within its thickness lie the central and lateral vascular bundles, of the collateral type, closed. The phloem is oriented toward the upper side, the xylem toward the lower.

On the adaxial side of the leaf, the cells are more elongated in shape compared to the abaxial side. The stomata are not embedded in the epidermis and are of the anomocytic type. In terms of number, there is a predominance of stomata on the upper side—the epistomatic type. The stomatal index is 1.5–1.6.



Figure 3. Cross-section of a *Hedysarum gmelinii* leaf, section through the midrib:
 A — section through the midrib, B — lateral section;
 1 — lower epidermis, 2 — upper epidermis, 3 — trichome remnants, 4 — mesophyll,
 5 — vascular bundle. Magnification is given in μm

The root of *H. gmelinii* (Fig. 4) is rounded with a well-defined cortex and has a secondary anatomical structure.



Figure 4. Cross-section of the root of *Hedysarum gmelinii*, fragment:
 1 — cortex, 2 — cortical parenchyma, 3 — xylem, 4 — parenchymatous rays.
 Magnification is given in μm

The covering tissue of the cork layer (periderm) accounts for about 5–7 % of the root's structure and consists of 4–5 layers of cells. Periderm cells are rectangular, strongly compressed from the surface, and dark brown in color. The cortex is slightly thinner than the periderm and consists of parenchyma cells that are tangentially flattened. Xylem elements, both primary and secondary, are present in the form of chains of vessels radiating from the center of the root—remnants of a polyarchic vascular bundle. Between the xylem chains lie sections of phloem and parenchyma rays.

The following diagnostic features have been identified at the microscopic level: a non-fascicular stem structure, fine ribbing, an isolateral leaf type, the type and arrangement of stomata, and the shape and arrangement of secondary xylem elements in the root.

Conclusion

Thus, anatomical and morphological studies of the above-ground and underground organs of *H. gmelinii* have been conducted. The structural characteristics of the shoot, root, and leaf at the macro- and microscopic levels have been identified. Diagnostic features of the raw material have been determined. Specifically, at the microscopic level: the shape, color, and type of leaflet pubescence; the shape of the inflorescence and the color of the flowers; at the microscopic level: the structure of the stem's vascular elements, the fine ribbing of the stem, the isolateral leaf type, the type and arrangement of stomata, and the shape and arrangement of the root's secondary xylem elements.

The data obtained can be used to identify the species and verify the authenticity of plant raw materials.

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Author Contribution

Suleimen Y.M. — research, field study, raw material collection, anatomical and morphological study, draft writing.

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Е.М. Сулеймен

Қарағанды облысында (Орталық Қазақстан) өсетін *Hedysarum gmelinii* морфологиялық және анатомиялық талдау

Дәрілік өсімдіктер шикізатының құрылымын зерттеу фармакогностикалық талдаудың бір бөлігі. Жұмыста шөбі мен тамыры медицина мен ветеринарияда қолдану әлеуетіне ие *Hedysarum gmelinii* перспективасы өсімдіктеріне анатомиялық-морфологиялық зерттеулер жүргізілді. Шикізат гүлдену фазасында жиналды, жібітілді, макро және микроскопиялық деңгейде жекелеген мүшелердің құрылымы сипатталды. Шикізаттың диагностикалық белгілері анықталды. Сыртқы белгілері бойынша келесі сипатты белгілерді бөліп көрсетуге болады: пішіні, сабағының түсі, жапырақтарының түгі, гүлінің пішіні және гүлдерінің түсі. Микроскопиялық деңгейде мынадай диагностикалық белгілер анықталған: сабақтың өткізгіш элементтерінің құрылысы, сабақтың ұсақ қырлы болуы, жапырақтың оқшауланған типі, сағаның типі мен орналасу ерекшеліктері, тамырдың қайталама ксилемдік элементтерінің нысаны мен орналасу типі. Алынған нәтижелер өсімдік шикізатының түпнұсқалығын растау және осы түрдегі шикізатқа нормативтік құжаттама жобасын дайындау үшін пайдаланылуы мүмкін.

Кілт сөздер: *Hedysarum gmelinii*, морфологиялық және анатомиялық құрылымы, жерүсті және жерасты органдары, диагностикалық белгілері.

Е.М. Сулеймен

Морфологический и анатомический анализ *Hedysarum gmelinii*, произрастающего в Карагандинской области (Центральный Казахстан)

Изучение строения сырья лекарственных растений является частью фармакогностического анализа. В нашей работе выполнены анатомо-морфологические исследования перспективного растения *Hedysarum gmelinii*, трава и корни которого имеют потенциал применения в медицине и ветеринарии. Сырье собирали в фазе цветения, размачивали, описывали строение отдельных органов на макро- и микроскопическом уровне. Определены диагностические признаки сырья. По внешним признакам можно выделить следующие характерные черты: форма, окраска стебля, тип опушения листочков, форма соцветия и окраску цветков. На микроскопическом уровне установлены следующие диагностические признаки: строение проводящих элементов стебля, мелкая ребристость стебля, изолатеральный тип листа, тип и особенности размещения устьиц, форма и тип размещения вторичных ксилемных элементов корня. Полученные результаты могут использоваться для подтверждения подлинности растительного сырья и подготовки проекта нормативной документации на сырье данного вида.

Ключевые слова: *Hedysarum gmelinii*, морфологическая и анатомическая структура, надземные и подземные органы, диагностические признаки.

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