

Review

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Anatomical and morphological characteristics of *Ferula varia* growing in Karaganda region (Central Kazakhstan)

The study of plant structure makes it possible to identify characteristic features necessary for species identification and understanding of biological traits. For potentially medicinal plant raw materials, morphological and anatomical studies are an essential component of pharmacognostic analysis. The aim of this study is to investigate the structural features of the above-ground and underground organs of *Ferula varia*, a plant used in folk medicine, at both macro- and microscopic levels. The study was conducted on dried, crushed raw materials using staining techniques and the preparation of temporary slides. The results made it possible to describe the shape and structure of the surface of the stem and leaf plate, as well as the structural features of inflorescences and root fragments. Sparse pubescence on the stem and denser pubescence on the abaxial surface of the leaf blade were observed. At the microscopic level, the structural features and arrangement of tissues in the leaf epidermis, as well as transverse sections of the root, leaf, and stem were characterized. The obtained results made it possible to identify diagnostic features at the macro- and microscopic levels, which allows for species identification of both whole and crushed raw materials. The data obtained may be included in the draft regulatory documents for *Ferula varia* plant raw materials.

Keywords: *Ferula varia*, above-ground and underground organs, medicinal plant raw materials, macro- and microscopy, diagnostic features.

Introduction

The flora of Kazakhstan has a significant number of species [1], many of which have medicinal properties [2]. Among the considerable diversity of plants, those of the genus *Ferula* L. (family Apiaceae) are of practical interest. Species of this genus are perennial plants that usually grow in arid areas such as steppes and deserts [3], often forming extensive thickets with significant reserves of raw materials [4].

Plants of the *Ferula* genus accumulate various groups of biologically active substances in their above-ground and underground organs, such as coumarins, glycosides, essential oils, sesquiterpene lactones, sulfur-containing metabolites, and gums [2, 5–7]. These substances exhibit a wide range of biological activities, such as anticancer, antimicrobial, anthelmintic, anti-inflammatory, antifungal, antihypertensive, antiprotozoal, antiviral, and others [6–11]. Various parts of plants and their components are widely used in medicine to treat diseases of the cardiovascular system, joints, and oncology, as well as an antispasmodic, antimicrobial, diuretic, and analgesic agent.

There are 46 species of the genus *Ferula* growing in Kazakhstan [1], of which *Ferula foetida* (Bunge) Regel, *Ferula iliensis* Krasn. ex Korovin., and *Ferula songarica* Pall. ex Willd. are the most widely used [12–14]. There is fragmentary information on the other species [3], but many species have the potential to be used as a source of medicinal raw materials.

In the Karaganda region, significant areas of thickets have been noted for *Ferula varia* (Schrenk) Trautv., which is typical of the deserts and decertified steppes of Northern Balkhash Region. The roots of this plant are used in folk medicine to treat toothache and fever, as an anthelmintic and wound-healing agent, and a decoction of the seeds stimulates lactation [15].

Pharmacognostic studies, in particular, analysis of the morphological and microscopic indicators of raw materials, are necessary for the introduction of this species into official use.

The aim of this study is to conduct an anatomical and morphological analysis of the above-ground and underground organs of *Ferula varia* and to identify the diagnostic features of potential medicinal raw materials.

Experimental

Samples of *Ferula varia* raw materials (Fig. 1) for research were collected on April 20–23, 2025, 8 km from the village of Torangylyk (Northern Balkhash Region; coordinates of the collection points: N 46.806017; E 74.794949). Raw materials in the budding phase—early flowering—were harvested in the afternoon, in sunny, dry weather. Above-ground organs were cut at a height of 10 cm from the soil surface, and underground organs were dug up at a depth of up to 50 cm. Species identification was carried out by staff of the Botany Department at the Karaganda National Research University named after academician E.A. Buketov. Plant samples are stored in the herbarium of the Faculty of Biology and Geography (acronym QAR), herbarium sheet number QAR 04328. The air-dried raw materials were soaked in hot water and then fixed in a Feling mixture (90 % ethyl alcohol: distilled water: 40 % glycerin in a 1:1:1 ratio) [16].



Figure 1. Flowering plants *Ferula varia*

When describing the morphological characteristics, attention was paid to the surface structure of individual organs, the presence of pubescence, the color of the organs, the degree of dissection, and the structure at the fracture. Plants parts were examined using a Levenghuk macroscope (China).

Surface preparations were made manually, and sections were made on a Delta Optical manual microtome using Pellucid CW75 microtome blades (China). The resulting micro-preparations were viewed on an EX30 microscope, OD400UHW-P camera (China) with a tablet. The photos with measurements of individual tissues were processed using ImageV software. To obtain higher quality preparations, staining was performed using iron chloride and methylene blue [17].

The micro-preparations were described taking into account the recommendations of R. Crang et al. [18] and publications on the anatomy of plants of the genus *Ferula* L. [19–22].

Results and Discussion

Macroscopy. The stem of *Ferula varia* is rounded in cross section, with small ribs (Fig. 2). The surface is smooth, the color of the upper part of the stem is light green, the lower part is light brown, and the fracture is white or beige. The inflorescence is a complex umbel. The umbels are located at the ends of the fruiting shoots. There are two types of umbels: the central umbels are almost sessile, with 10–15(25) rays. The lateral umbels have 13–18 rays, usually on long pedicels. There may be 1–3 small and underdeveloped umbels.

The flowers are yellow, the calyx is without teeth; the petals are oblong-elliptical, slightly narrowed at the top and curled inward, drooping after flowering. The underside of the leaf is rough, densely pubescent

with white, protruding simple trichomes. Longer trichomes are concentrated along the central vein. The vein protrudes above the surface of the leaf blade. The color is green, light green. The upper side of the leaf is rough, marked with rare simple white hairs. The main vein runs through the central part of the blade. The color is green.

The root is ovoid, with a solid neck covered with the remains of dead leaves. The raw material consists of pieces of root of various sizes. The surface of the bark is coarsely wrinkled with remnants of lateral roots. The color is brown, and the fracture is loose and white.

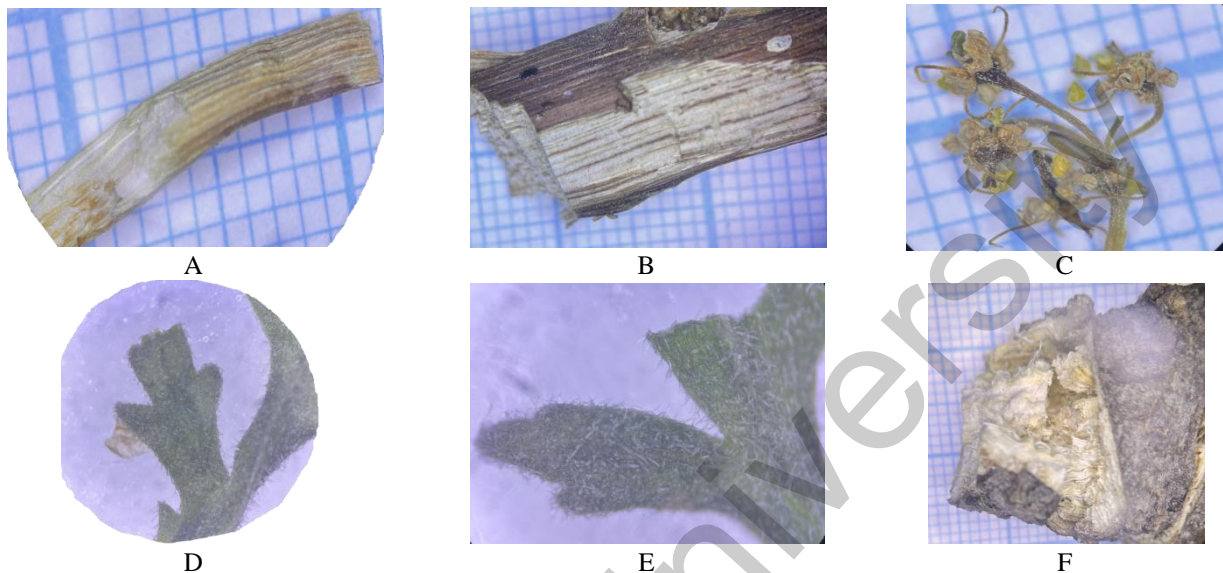


Figure 2. External characteristics of the above-ground and underground organs of *Ferula varia*:

A — stem fragment, B — stem at the break, C — inflorescence fragment,
D — upper side of the leaf, E — lower side of the leaf, F — root fragment

The following diagnostic features can be suggested: stem surface structure, presence of small ribs; shape of second-order umbels; shape of leaf blade, presence of dense pubescence on the underside, color of root and stem at the break.

Microscopy. The stem of *Ferula varia* is rounded in cross section, with small ribs protruding on the surface (Fig. 3). The perimeter of the stem is occupied by a single-layer epidermis consisting of chelicerate cells. Their outer side is thickened and covered with a noticeable layer of cuticle. Rare simple trichomes are found. Under the epidermis lies 2-3 layers of chlorenchyma, which are interrupted under the ribs by small strands of mechanical collenchyma tissue. The bundles are numerous, collateral, closed (phloem and xylem, no cambium). The peripheral bundles are elliptical in shape, with larger and smaller bundles alternating. Medullary bundles, usually round or ovoid in shape, lie in the central parenchyma. The peripheral bundles are covered with small “caps” of sclerenchyma. Schizogenous cavities, oval or rounded in shape, are located around the entire perimeter of the stem, above the bundles. The central part is filled with loose and thin-walled cells of the heart parenchyma.

A similar structure is noted for the stems of *Ferula foetida*, with differences in the shape of the cavities. In *Ferula foetida* [22], the cavities are oval in shape and almost identical in size, while in *Ferula varia*, they are rounded and vary in diameter.

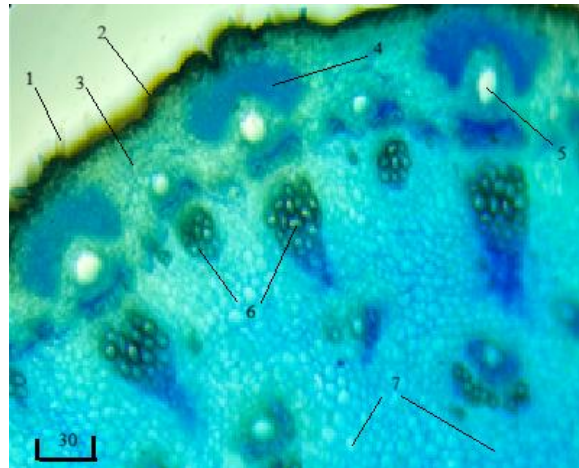


Figure 3. Cross section of the stem of *Ferula varia*, fragment. Staining: methylene blue: 1 — trichome, 2 — epidermis, 3 — cork parenchyma, 4 — chlorenchyma, 5 — vessels, 6 — vascular bundles, 7 — pith parenchyma cells; dimensions in μm

The epidermis of the upper and lower sides of the *Ferula varia* leaf is identical in structure, consisting of elongated cells with straight or slanted walls. Trichomes are rare on the upper side and more abundant on the lower side of the leaf. The stomata are small, few in number, diacytic, and located on both sides—amphistomatic type.

In cross section, the leaf is flat, dorsal-ventral type, with undifferentiated mesophyll on columnar and spongy tissue (Fig. 4). On both sides, the leaf is surrounded by a single-layer epidermis, its cells are oval, covered with a layer of cuticle. Simple unicellular trichomes are clearly visible, especially in the area of the conducting bundles. The inner part is filled with loose mesophyll cells. The central and lateral conducting bundles are collateral, closed type, weakly sclerenchymatized. Around the bundles, there are rounded cavities of schizogenous origin; the shape is rounded.



Figure 4. Cross section of *Ferula varia* leaf, fragment in the area of the central vein. Staining iron chloride: 1 — upper epidermis, 2 — mesophyll, 3 — xylem, 4 — cavity, 5 — phloem, 6 — conducting bundle, 7 — lower epidermis, 8 — simple trichomes; dimensions in μm

A poorly differentiated mesophyll is also characteristic of other *Ferula* species, as is a small number of vessels.

The root in cross section is covered with a multilayered cork, its cells are dark brown, almost rectangular (Fig. 5). Under the bark lies a multilayered cortical parenchyma. The endoderm is single-layered and consists of oval-shaped cells. The central cylinder of the root consists of a complex radial-type bundle in which

xylem and phloem rays alternate. In some places, there are areas of pericycle. In the inner part of the root, there are numerous cavities of schizogenous origin, usually round in shape.

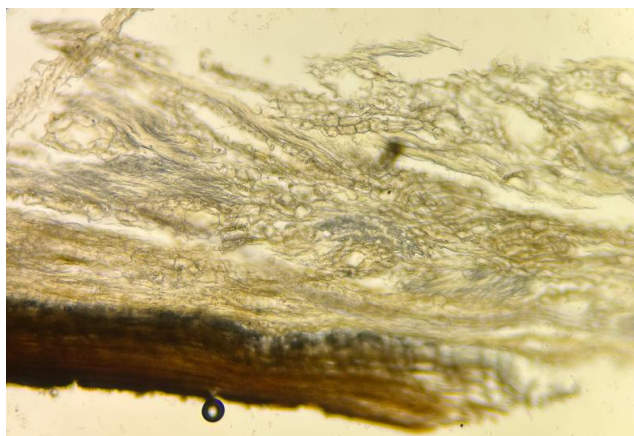


Figure 5. Cross section of the root of *Ferula varia*, fragment

The structure of the root of *Ferula varia* differs significantly from that of *Ferula foetida* [22], as it forms a denser structure that does not break down into separate fragments. The cavities in the underground organs have a similar structure to other species of ferula [20–22].

Analysis of microscopic indicators has made it possible to identify diagnostic features that can help in the identification of crushed raw materials:

- for the stem: the shape of the stem in cross section, the shape of the conducting bundles, areas of collenchyma, the rounded shape and different diameters of the vessels;
- for the root: the presence of rounded cavities of schizogenous origin;
- for the leaf: undifferentiated mesophyll, the shape of the conducting bundles, the presence of rounded vessels, dense pubescence on the underside of the leaf; the presence of simple trichomes.

Conclusion

Thus, based on the results of the studies, the morphological and anatomical features of the above-ground and underground organs of *Ferula varia* were determined. Characteristic features of the structure at the macroscopic level were noted for the shape of the leaves, the structure of the stem surface, and the shape of the secondary umbels.

The above-ground organs are characterized by the primary anatomical structure of the stem with the presence of peripheral collateral and medullary conducting bundles. The leaves are classified as dorsoventral with undifferentiated mesophyll and denser pubescence on the underside of the leaf blade. The root is characterized by a secondary structure, a thick layer of cork, and a radial arrangement of conducting elements. The presence of round-shaped schizogenous cavities was determined for all organs studied.

The obtained results made it possible to identify diagnostic features at the macro- and microscopic levels, which allows for species identification of both whole and crushed raw materials.

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Conflict of interest

The authors declare no conflict of interest.

Author contribution

The manuscript was written through contributions from all authors. All authors have given approval to the final version of the manuscript: **Sabiyeva A.** — conceptualization, data analysis, investigation; **Smagulov M.K.** — plant material collecting, writing draft, data curation; **Atazhanova G.A.** — methodology, morphological investigation; **Turdiyeva Zh.A.** — anatomical investigation, data analysis.

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Қарағанды облысында (Орталық Қазақстан) өсетін *Ferula varia* өсімдігінің анатомиялық және морфологиялық ерекшеліктері

Өсімдіктердің құрылысын зерттеу олардың түрлік тиесілігін анықтау және биологиялық ерекшеліктерін түсіну үшін қажет болатын өзіне тән белгілерін айқындауға мүмкіндік береді. Потенциалды дәрілік өсімдік шикізаты үшін морфологиялық-анатомиялық зерттеулер жүргізу фармакогностикалық талдаудың міндетті компоненті. Зерттеудің мақсаты халық медицинасында қолданылатын *Ferula varia* өсімдігінің жерүсті және жерасты мүшелерінің құрылымдық ерекшеліктерін макро- және микроскопиялық деңгейде зерттеу. Зерттеулер кептірілген және ұнтақталған шикізатқа бояу әдістерін қолдану және уақытша микропрепараттар дайындау арқылы жүргізілді. Нәтижелер сабақ пен жапырақ тақтасының пішіні мен беткі құрылымын, гүл шоғырларының құрылымдық ерекшеліктерін, сондай-ақ тамыр бөліктерінің анатомиялық сипаттамаларын анықтауға мүмкіндік берді. Сабақтың сирек түкті екендігі, ал жапырақ тақтасының төменгі жағында түктенудің анағұрлым тығыз екендігі анықталды. Микроскопиялық деңгейде жапырақ эпидермисі тіндерінің құрылысы мен орналасу ерекшеліктері, сондай-ақ тамырдың, жапырақтың және сабақтың көлденең кесінділерінің анатомиялық сипаттамалары анықталды. Алынған нәтижелер макро- және микроскопиялық деңгейде диагностикалық белгілерді айқындауға мүмкіндік берді, бұл бүтін және ұнтақталған шикізаттың түрлік сәйкестендірілуін жүргізуге жағдай жасайды. Жиналған деректер *Ferula varia* өсімдік шикізатына арналған нормативтік құжаттар жобасын әзірлеуде пайдаланылуы мүмкін.

Кілт сөздер: *Ferula varia*, жерүсті және жерасты мүшелер, дәрілік өсімдік шикізаты, макро- және микроскопия, диагностикалық белгілер

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Анатомические и морфологические особенности *Ferula varia*, произрастающей в Карагандинской области (Центральный Казахстан)

Изучение строения растений позволяет выделять характерные признаки, что необходимо для идентификации видовой принадлежности и понимания биологических особенностей. Для потенциального лекарственного растительного сырья проведение морфолого-анатомических исследований является обязательным компонентом фармакогностического анализа. Цель настоящего исследования — провести изучение особенностей строения надземных и подземных органов *Ferula varia*, применяемой в народной медицине, на макро- и микроскопическом уровне. Исследования проводили для высушенного измельченного сырья с применением окрашивания и приготовления временных препаратов. Результаты позволили описать форму и структуру поверхности стебля и листовой пластины, особенности строения соцветий и фрагментов корня. Определено наличие редкого опушения стебля, более густого — на нижней стороне листовой пластины. На микроскопическом уровне установлены особенности строения и расположения тканей эпидермиса листа, поперечных срезов корня, листа и стебля. Полученные результаты позволили выделить диагностические признаки на макро- и микроскопическом уровне, что позволяет проводить видовую идентификацию как цельного, так и измельченного сырья. Полученные данные могут войти в проект нормативных документов на растительное сырье *Ferula varia*.

Ключевые слова: *Ferula varia*, надземные и подземные органы, лекарственное растительное сырье, макро- и микроскопия, диагностические признаки

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