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Diagnostic characteristics of fruits of some species of the Apiaceae family used in pharmacy: a comparative analysis

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Abstract: *the wide use of plants of the Apiaceae family is accompanied by difficulties in identification, since their fruits have similar morphological characteristics. During the analysis, it became clear that there is a lack of detailed descriptions and accessible information about this family. The fruits characteristic of the Apiaceae family are often similar to each other within different species, which can complicate the identification of medicinal plant materials. Macroscopic characteristics remain an important element in establishing the authenticity of medicinal plant raw materials. That is why a detailed morphological description of the fruits of the Apiaceae family is necessary for their correct use in pharmacy and medicine. Within the framework of the study, a comprehensive analysis of the morphological characteristics of the fruits of representatives of the Apiaceae family was carried out, which is of great importance for their identification and standardization in pharmaceutical practice. A comprehensive analysis of scientific literature, the educational and professional program in specialty 226 "Pharmacy, Industrial Pharmacy," integrated licensing exam programs (EDKI-1, KROK-2), and the methodological literature of Warsaw Medical University (WMU) to structure the data about the macroscopic features description of fruits of the Apiaceae family (Umbelliferae) representatives.*

A theoretical justification for the need for a unified approach to describing the fruits of this family has been provided. It has been established that the standardization of medicinal plant raw materials is a crucial stage in the production of medicinal products, as it involves the accurate identification and quality control of the raw materials. A review of the literature revealed discrepancies in the macroscopic description of the fruits of representatives of the family, which complicates the process of their reliable identification. Based on the analysis, the main morphological features of the fruits were determined. It can be used as criteria for classification and identification. It was found based on the studied sources and systematized materials, that the fruits of this family are characterized by the set of features. These features can be used as diagnostic markers for determining species affiliation. The generalization of the results made it possible to form a table of morphological features suitable for distinguishing between closely related species with similar fruits. This contributes to

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the reliability of the identification of medicinal plant raw materials and ensures the effectiveness of quality control of medicinal products. The practical value of the study lies in the prospect of applying the results obtained in the pharmaceutical field to the formation of pharmacopoeia standards, as well as in the field of pharmaceutical botany – for the classification and systematization of species of the Apiaceae family.

Keywords. Apiaceae; Medicinal Plant; Fruit; Monograph; Classifications.

Introduction

The Apiaceae (Umbelliferae) family is one of the most species-rich among flowering plants and includes over 400 genera and between 3,000–3,300 and almost 4,000 species. There are 74 genera and 161 species (including subspecies) of the family in Ukraine, with more than half of the genera (48) represented by only one species [1, 2-3]. Research on medicinal plants of this family, whose fruits have pharmacological significance, is widely covered in numerous textbooks, practical manuals, and photo catalogs. This indicates their important role in pharmaceutical practice and the educational process, which is confirmed by materials from pharmacognosy textbooks, methodological recommendations, and specialized photo atlases [2, 4-6, 7-12, 13-17, 19-22]. During the analysis of literary sources, either the absence of a complete description of individual structures of the fruit or discrepancies in characteristics, in particular regarding the number of ribs on the mericarps, their shape, etc., were revealed. Terminological inconsistencies can also be traced, for example: the "outer surface" is sometimes referred to as the "dorsal side," the "inner surface" as the "ventral side," and the terms "plates" and "spines" may be used interchangeably. Since the Apiaceae family is taxonomically complex, but the vast most species are economically important, and 11% of them are often used in medical practice, it was advisable to analyze, systematize, research, and identify priority diagnostic features. We have selected fruits from the Apiaceae family that are presented in the programs of Pharmacognosy and Pharmaceutical Botany.

Aim

The aim of our work was to conduct a morphological analysis of the fruits of some representatives of the Apiaceae family.

Materials and Methods

The study is based on materials collected by the authors over many years during field expeditions in various regions of Ukraine. The identification of objects was confirmed using herbarium samples stored in the National Herbarium of Ukraine (http://botany.kiev.ua/gerbary.htm). The fruits of the Apiaceae family were collected between 2020 and 2025. For morphological analysis of the fruits, ten samples of each species were studied.

For macromorphological analysis, we used a ULAB microscope equipped with a Canon EOS 550 digital microcamera (microphotographs x40) and a Philip Harris Levenhuk M 10000 PLUS stereomicroscope (microphotographs x10). The dimensions of the objects under study were determined using a measuring ruler with a millimeter scale.

A detailed description of the diagnostic structures of schizocarps was based on the works of national and foreign authors [4-12, 13-18, 19-22, 23-24].

The literature review was conducted using analytical-search, comparative-systematic, and classification-generalization methods.

Results

The fruits of the Apiaceae family are schizocarps and have similar morphological features, which makes it difficult to accurately identify medicinal plant materials (MPM). We analyzed educational sources, including the State Pharmacopoeia of Ukraine (SPhU) and the educational program of the Warsaw Medical University (WMU), with which we have close cooperation [19-21]. The results of the analysis of literary sources are presented in Table 1. It contains a list of sources – reference books, textbooks, and photo herbariums – that contain information about medicinal plants.

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Table 1. Analysis of literature for the presence of macroscopic species of representatives of the fruits of plants of the Apiaceae family

Literature */ Name of plants	[9]	[15]	[21]	[8]	[7]	[22-25]	[17]	[14]	[18-20]
1. *Ammi visnaga* (L.) Lam.	+	+	+	+	+		+		
2. *Anethum graveolens* L.	+	+	+		+	+	+	+	
3. *Angelica archangelica* L.		+	+				+	+	
4. *Apium graveolens* L.								+	+
5. *Carum carvi* L.	+	+	+	+	+	+	+	+	
6. *Cicuta virosa* L.							+	+	
7. *Conium maculatum* L.	+	+					+		
8. *Coriandrum sativum* L.	+	+	+	+	+		+	+	+
9. *Daucus carota* L.	+	+	+		+	+	+	+	
10. *Daucus carota subsp. sativus* (Hoffm.)							+	+	
11. *Foeniculum vulgare* Mill. subsp. *vulgare* var. *dulce* (Mill.) Batt. & Trab		+	+	+	+	+			+
12. *Foeniculum vulgare* Mill.	+	+	+	+	+	+	+	+	+
13. *Heracleum sphondylium* L.					+				
14. *Levisticum officinale* Koch.							+	+	+
15. *Pastinaca sativa* L.	+	+	+	+			+		
16. *Petroselinum crispum* (*satium*) (Mill.) Fuss	+	+					+	+	
17. *Pimpinella anisum* L.	+	+	+	+	+	+	+	+	+

**Note:* references in the table to the list of sources used.

For representatives of the Apiaceae family, publications are indicated in which the discription of their fruits is mentioned.

The study of scientific sources revealed certain inconsistencies in the macroscopic description of the fruits of the Apiaceae family, which may create difficulties in their identification. The main morphological features of schizocarps that are diagnostically significant for their recognition and systematization were identified. The standardization of medicinal plant materials is an integral part of the drug manufacturing process and requires reliable identification and proper quality control. Macroscopic features are decisive for its standardization, in particular when establishing identity. Inaccuracies in morphological analysis can lead to a decrease in the quality of both the raw materials themselves and the medicinal products produced from them.

After analyzing all the descriptions obtained and conducting our own microscopic studies, we systematized and supplemented the already published characteristics of the fruits of the Apiaceae family, identifying the diagnostic features used in the verification of medicinal plant materials.

The external appearance of the fruits and the characteristics of the dorsal and ventral surfaces are shown in Table 2.

For a detailed description of the schizocarps, attention was focused on the size and shape of the schizocarp and mericarps separately, the texture of the surface, the number of ribs and furrows between them, the shape of the stylodias and stylopodium, the presence or absence of calyx remnants at the base of the stylodias, as well as color, smell, and taste (Table 3).

It can be noted that some characteristics such as size, color, and shape showed significant variability even within the same species. Meanwhile, the number of ribs on the dorsal side of the mericarps, the shape of the stylodias, the presence or absence of a calyx at their base, smell, and taste are stable characteristics that should be used to identify species.

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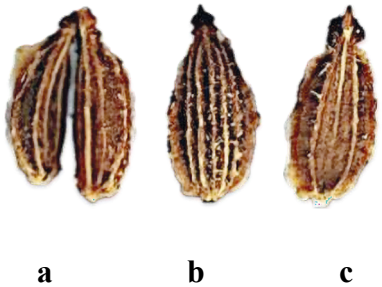
Table 2. Morphological structure of fruits from selected representatives of Apiaceae

 a b c	 a b c	 a b c
A. *Ammi visnaga* (L.) Lam.	**B.** *Anethum graveolens* L.	**C.** *Angelica archangelica* L.*
 a b c	 a b c	 a b c
D. *Apium graveolens* L. *	**E.** *Carum carvi* L.	**F.** *Cicuta virosa* L.*
 a b c	 a b c	 a b c
G. *Conium maculatum* L.*	**H.** *Coriandrum sativum* L.	**I.** *Daucus carota* L.*
 a b c	 a b c	 a b c
J. *Daucus carota subsp. sativus* (Hoffm.)	**K.** *Foeniculum vulgare* Mill. subsp. *vulgare* var. *dulce* (Mill.) Batt. & Trab	**L.** *Foeniculum vulgare* Mill.

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a b c

M. *Heracleum sphondylium* L.*

a b c

N. *Levisticum officinale* Koch.

a b c

O. *Pastinaca sativa* L.

a b c

P. *Petroselinum crispum* (Mill.) Fuss.

a b c

Q. *Pimpinella anisum* L.

Note: a – external view of the schizocarp, b – dorsal side, c – ventral side.
*Images taken at 40x magnification.

Table 3. Morphological characteristics of fruits of selected representatives of Apiaceae family

Name of species	Morphological characteristics
1	2
Ammi visnaga **(Table. 2A)**	**Shape (a):** egg-shaped, pointed at one end. **Size:** length (L) –1.9–3 mm; width (W) – 0.9–1.2 mm. **Color:** light brown. **Dorsal side (b):** convex, smooth, with 5 pale brown, slightly protruding ribs between which there are essential-oil canals. **Ventral side (c):** flat, with 2 light yellow lateral ribs. In the center there is a clearly visible remnant of the carpophore, which divides the mericarps into two equal parts. **Stylodia:** short, bent towards the dorsal side of the mericarps, with remnants of the calyx at their base. **Taste:** bitter. **Smell:** weak.
Anethum graveolens **(Table.2 B)**	**Shape (a):** oval, compressed from the back, flat. **Size:** L – 3-7 mm; W – 1.5-4 mm. **Color:** grayish brown. **Dorsal side (b):** convex, bare, with 5 thread-like pale brown ribs, essential-oil canals in the furrows between them. **Ventral side (c):** flat, with two wings on the sides of the semi- fruit up to 0.5 mm and a remnant of the carpophore in the center. It has two dark essential-oil canals. **Stylodia:** short and flat. **Taste:** sweet, peppery. **Smell:** strong, aromatic.

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Name of species	Morphological characteristics
1	2
Angelica archangelica **(Table.2 C)**	**Shape (a):** ellipsoidal, hemispherical. **Size:** L – 7-8 mm; W – 4-5 mm. **Color:** light brown. **Dorsal side (b):** convex, bare, with three clustered ribs, two lateral ones are larger and wing-like. **Ventral side (c):** flat, without visible furrows. **Stylodia:** short. **Taste:** bitter. **Smell:** slight.
Apium graveolens **(Table.2 D)**	**Shape (a):** rounded, egg-shaped, slightly compressed on the sides. **Size:** L – 1.5-2 mm; W – 1.3-2 mm. **Color:** brownish-gray. **Dorsal side (b):** convex, bare, with 5 ribs protruding above the surface of the fruit, between which there are depressions containing essential-oil canals. **Ventral side (c):** flat, with two essential-oil canals. In the center is the remnant of the carpophore. **Stylodia:** short, cushion-like, remnants of the calyx are absent. **Taste:** spicy. **Smell:** slight, specific.
Carum carvi **(Table.2 E)**	**Shape (a):** elongated, arched, narrow. **Size:** L – 3–6.5 mm; W – 1–1.5 mm. **Color:** brown. **Dorsal side (b):** convex, bare, with 5 light yellow ribs protruding above the surface of the fruit and 4 brown furrows between them. **Ventral side (c):** flat, with two essential-oil canals and a carpophore in the center. **Stylodia:** short, slightly bent towards the dorsal side of the mericarps, without sepals. **Taste:** bitter, spicy, peppery. **Smell:** strong, reminiscent of carvone.
Cicuta virosa **(Table.2 F)**	**Shape (a):** rounded. **Size:** L – 2-4.5 mm; W – 1-1.5 mm. **Color:** brown (reddish brown). **Dorsal side (b):** strongly convex, bare, with 5 broad, rounded ribs between which there are dark brown, broad essential-oil canals. **Ventral side (c):** flat, with 2 essential-oil canals with a longitudinal furrow and 2 lateral light gray protruding ribs. **Stylodia:** large, cushion-shaped with a conical tip. **Taste:** poisonous plant NB! **Smell:** specific, slight.
Conium maculatum **(Table.2 G)**	**Shape (a):** broadly ovate. **Size:** L – 2.5–4 mm; W – 1.5–2 mm. **Color:** grayish brown. **Dorsal side (b):** convex, bare, with 5 cartilaginous, light brown ribs. Essential-oil canals are not found in mature fruitlets. **Ventral side (c):** flat with a thin longitudinal furrow and 2 lateral dark gray protruding ribs. **Stylodia:** short-conical, bent towards the dorsal side of the mericarps, at the base of which there are remnants of the calyx. **Taste:** poisonous plant NB! **Smell:** specific - mouse-like, unpleasant.

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Name of species	Morphological characteristics
1	2
Coriandrum sativum **(Table.2 H)**	**Shape (a):** spherical, elongated-rounded. **Size:** L – 5-4.3 mm; W – 2.5-3.6 mm, diameter (D) – 1.5-5 mm. **Color:** yellow-gray (light brown). **Dorsal side (b):** convex, slightly longitudinally wrinkled, with 5 sinuous ribs alternating with 5 straight ones. **Ventral side (c):** flat, narrowly fringed at the edge. It has 2 essential-oil canals located in the furrows. In the center there is a clearly visible, light-yellow remnant of the carpophore. **Stylodia:** short. **Taste:** spicy. **Smell:** strong.
Daucus carota **(Table.2 I)**	**Shape (a):** egg-shaped or elliptical. **Size:** L – 2.5-4 mm; W – 1.5-2.5 mm. **Color:** light brown. The ribs and hairs are significantly lighter with a grayish tint. **Dorsal side (b):** convex, spiny, three primary ribs not prominent, slightly bristly; secondary four ribs winged with light yellow hooked spines (with 10-12 spines on each rib) **Ventral side (c):** concave, with two slightly protruding ribs with light yellow hooked spines. In the center is a light-yellow remnant of the carpophore and with two light-yellow ribs without spines. **Stylodia:** short, cushion-shaped. **Taste:** bitter, spicy. **Smell:** aromatic, intensifies when rubbed.
Daucus carota subsp. sativus **(Table.2 J)**	**Shape (a):** egg-shaped or elliptical. **Size:** L – 2.5-4 mm; W – 1.5-2.5 mm. **Color:** brown, the ribs are lighter with a grayish tint. **Dorsal side (b):** convex, three primary ribs not prominent, slightly bristly; secondary four ribs covered with remnants of hooked spines lost during mechanized harvesting **Ventral side (c):** concave, with two slightly protruding ribs covered with remnants of hooked spines lost during mechanized harvesting. In the center is a light-yellow remnant of the carpophore and with two light-yellow ribs without spines. **Stylodia:** short, cushion-shaped. Remnants of the calyx are absent. **Taste:** bitter, spicy. **Smell:** aromatic, intensifies when rubbed.
Foeniculum vulgare **subsp. *vulgare* var. *dulce*** **(Table.2 K)**	**Shape (a):** cylindrical (with a rounded base and narrowed top). **Size:** L – 4-12 mm; W – 2-4 mm. **Color:** pale yellowish brown. **Dorsal side (b):** convex, bare, with 5 light yellow, clearly visible ribs, between which there are 4 dark brown essential oil ducts. **Ventral side (c):** flat, with 2 lateral light-yellow ribs and 2 dark brown essential oil canals between them in furrows. **Stylodia:** large, cushion-shaped with a conical tip, no calyx remnants. **Taste:** sweet, spicy. **Smell:** aromatic, reminiscent of anise.
Foeniculum vulgare **(Table.2 L)**	**Shape (a):** cylindrical (with a rounded base and narrowed top). **Size:** L – 3-8 mm; W – 1.5-3 mm. **Color:** brown. **Dorsal side (b):** convex, bare, with 3 light yellow, clearly visible ribs between which there are 4 dark brown essential-oil canals.

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Name of species	Morphological characteristics
1	**2**
	Ventral side (c): flat, with 2 light yellow lateral ribs and 2 dark brown essential-oil canals between them in furrows. **Stylodia:** large, cushion-shaped with a conical tip. **Taste:** spicy. **Smell:** aromatic, reminiscent of anise.
Heracleum sphondylium **(Table.2 M)**	**Shape (a)**: broadly elliptical. **Size:** L – 5.6–6.4 mm; W – 4.7–5.3 mm. **Color:** greenish-straw. **Dorsal side (b):** flat, bare, three dorsal intermediate ribs thread-like, two lateral ribs – broadly winged. Essential-oil canals are blackish-brown, reaching more than 3/5 of the mericarp. **Ventral side (c):** flat with two essential-oil canals in the center, reaching more than half of the mericarp. **Stylodia:** short. **Taste:** spicy, sweetish. **Smell:** strong, aromatic.
Levisticum officinale **(Table.2N)**	**Shape (a):** cylindrical (with a flat base and narrowed top). **Size:** L – 5-7 mm; W – 3-4 mm. **Color:** light brown. **Dorsal side (b):** convex, bare, with 5 wavy light-yellow ribs between which there are essential oil canals. **Ventral side (c):** flat, with two essential-oil canals on the ventral side, located in furrows. In the center is the remnant of the carpophore. **Stylodia:** short, conical with remnants of the calyx at the base. **Taste:** spicy. **Smell:** strong, aromatic, specific.
Pastinaca sativa **(Table.2 O)**	**Shape (a):** elliptical, lentil-shaped, flattened. **Size:** L – 4-8 mm; W – 3-6 mm. **Color:** light straw. **Dorsal side (b):** slightly convex with five main ribs: three narrow, thin thread-like and two extreme ones, transitioning into a flat, slightly thickened rim. **Ventral side (c):** concave, flat with a longitudinal suture and two essential-oil canals located in the furrows. **Stylodia:** short, flat. **Taste:** spicy, slightly pungent. **Smell:** weak, specific.
Petroselinum crispum **(Table.2 P)**	**Shape (a):** egg-shaped, slightly compressed. **Size:** L – 2-5 mm; W – 1-1.5 mm. **Color:** brownish-reddish. **Dorsal side (b):** convex, bare, with 5 wavy light-yellow ribs protruding above the surface of the fruit, furrows – dark brown. **Ventral side (c):** flat, with two essential oil canals. In the center is the remnant of the carpophore. **Stylodia:** short, conical. **Taste:** spicy, sweetish. **Smell:** strong, aromatic, reminiscent of anethole.
Pimpinella anisum **(Table.2Q)**	**Shape (a):** egg-shaped or pear-shaped. **Size:** L – 3-5 mm; W – 1.5-2 mm. **Color:** brownish-gray.

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Name of species	Morphological characteristics
1	2
	Dorsal side (b): convex, rough, covered with short warty trichoms, with 3 light yellow ribs. **Ventral side (c):** flat with 2 lateral light-yellow ribs that do not protrude. The remnant of the carpophore is located in the center. **Stylodia:** short, bent towards the dorsal side of the mericarps. **Taste:** spicy, sweetish. **Smell:** strong, aromatic, reminiscent of anethole.

Conclusions

The generalization of the obtained results made it possible to form a systematic table of morphological characteristics, which can serve as a tool for distinguishing between species with similar characteristics. This, in turn, increases the efficiency of identifying medicinal plant raw materials, which is a main factor in ensuring their quality and safety in the production of medicines.

The practical value of the study lies in the possibility of applying its results in the pharmaceutical field, for the development of pharmacopeial standards. In addition, it contributes to the systematization of plants of the Apiaceae family within pharmaceutical botany. The study highlighted the relevance of further analysis of the morphology of the fruits of the Apiaceae family to improve approaches to standardization and quality of medicinal plant raw materials.

The results obtained may also be useful in studying the classification, systematic position, and ecological characteristics of representatives of this family.

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Consent to publication

All authors of the article are acquainted with the final version of the manuscript and have no objections to its publication. The article does not use personal data and information about patients.

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Діагностична характеристика плодів деяких видів родини Apiaceae, що використовуються у фармації: порівняльний аналіз

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Анотація: *широке використання рослин родини Селерові супроводжується труднощами ідентифікації, адже їх плоди мають подібні морфологічні ознаки. У процесі аналізу з'ясувалося, що бракує детальних описів і доступної інформації щодо цієї родини. Вислоплідники, характерні для Селерових, часто подібні між собою в межах різних видів, що може ускладнювати розпізнавання лікарської рослинної сировини. Макроскопічні характеристики залишаються важливим елементом встановлення автентичності ЛРС. Саме тому докладний морфологічний опис плодів представників родини Селерові є необхідним для їх правильного використання у фармації та медицині. У межах проведеного дослідження здійснено всебічний аналіз морфологічних характеристик плодів представників родини Apiaceae (Селерові), що має вагоме значення для їх ідентифікації та стандартизації у фармацевтичній практиці. Було здійснено комплексний аналіз наукової літератури, освітньо-професійної програми зі спеціальності 226 «Фармація, промислова фармація», програм інтегрованих ліцензійних іспитів (ЄДКІ – 1, КРОК – 2), а також методичну літературу Варшавського медичного університету з метою структурування даних щодо опису макроскопічних ознак плодів представників родини Apiaceae (Селерові). Проведено теоретичне обґрунтування необхідності уніфікованого підходу до опису плодів цієї родини. Встановлено, що стандартизація лікарської рослинної сировини є ключовим етапом у виробництві лікарських засобів, оскільки передбачає точну ідентифікацію та якісний контроль вихідної сировини. Огляд літератури виявив існування розбіжностей у макроскопічному описі плодів представників родини, що ускладнює процес їх достовірної ідентифікації. На основі аналізу визначено головні морфологічні ознаки плодів, які можуть бути використані як критерії класифікації та ідентифікації. На основі вивчених джерел та систематизованих матеріалів з'ясовано, що плоди цієї родини відзначаються характерним набором ознак, які можуть бути використані як діагностичні маркери для встановлення видової належності. Узагальнення результатів дозволило сформувати таблицю морфологічних ознак, придатну для розмежування близьких видів зі схожими плодами. Це сприяє підвищенню достовірності ідентифікації лікарської рослинної сировини та забезпечує ефективність контролю якості лікарських препаратів. Практична цінність виконаного дослідження полягає у перспективі застосування отриманих результатів у фармацевтичній сфері для стандартизації рослинної сировини, а також у галузі фармацевтичної ботаніки – для впорядкування та систематизації видів родини Apiaceae.*

Ключові слова: Apiaceae, medicinal plant, fruit, Monograph, classifications.