

Comparative morphology and fruit anatomy of *Ferula szowitsiana* DC. and *Ferula caspica* M.Bieb.

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ABSTRACT: *Ferula caspica* and *Ferula szowitsiana* grow in the same area of Central Anatolia. According to Flora of Turkey, they can be easily confused for one another during the flowering time. In this study, morphological and anatomical features of these two species were examined in order to reveal their differences. Leaves, flowers and fruits of these two species were examined and necessary measurements were made. The proliferation in the inflorescence of *F. caspica*, was not observed in the species *F. szowitsiana*. There were distinct morphological differences in the fruits, also, the numbers of the secretory channels were different in the anatomical sections of mericarps. Morphological differences were observed in leaf lobes of these two species. As a result, the data that can be used to distinguish between these species are shown.

KEYWORDS: *Ferula caspica*; *Ferula szowitsiana*; anatomy; Apiaceae; morphology.

1. INTRODUCTION

The Apiaceae is a one of the largest group among Angiosperm [1, 2]. There are 455 genera and 3600-3751 species belonging to the family in the world. *Ferula* L. is one of the largest genera of the Apiaceae in Asia. The genus contains 180-185 species [2-4]. *Ferula* is represented by 23 taxa in flora of Turkey [5].

Ferula genus contains plants with medicinal value. *Ferula* species are used as aphrodisiac, galactagogue, cicatrizant in traditional medicine in Turkey [6]. On the other hand, studies have shown that some *Ferula* species have anticancer, anti-inflammatory, antimicrobial, antifungal, anti-HIV, antispasmodic and hypotensive effects [7-14]. *Ferula asafoetida* H.Karst. and *Ferula gummosa* Boiss. are widely used as herbal medicine in the world. The essential oil from *F. gummosa* seeds has antibacterial effects [15]. Stem, leaf and fruit extracts of *F. gummosa* have antioxidant and antihemolytic activities [16]. Ethanolic extract of the leaves and flowers of *F. gummosa* has anti-proliferative and apoptosis-inducing activities against the gastric cancer cells [17]. Gum extract of *F. asafoetida* has antispasmodic and hypotensive effects [11], antihyperglycemic effect [18], antimicrobial and antioxidant activities [19]. In traditional Iranian medicine, *F. szowitsiana* is used as a natural analgesic [20]. Study is promising for the pain-reducing effect of *F. szowitsiana* [21]. Another study is promising for the anticancer effect of *F. szowitsiana* [22].

F. szowitsiana is perennial plant among the *Ferula* species. Stems are erect, terete, weakly sulcate, glabrous, 30-70 cm. Basal leaves are 3-pinnate, setulose-puberulent, broadly ovate-triangular, 15-25(-35) x 15-30 cm in outline. Inflorescence is paniculate-corymbose, umbellules with 8-12 flowers. Shape of mericap is depressed elliptic, ribs are filiform, wings are well developed, dorsal vittae are 4-6 per vallecule, commissural vittae are 8-12. Flowering time is May-June. Fruiting time is June-July [23-26].

F. caspica is a perennial member of *Ferula* genus. Stems are single terete, superficially sulcate, 30-50 cm. Leaves are 3-4 pinnate, scabrous, obtuse triangular ovate in outline. Basal leaves are short-petiolate; blade is broadly ovate. Inflorescence paniculate-corymbose, umbels are sessile, in groups of 2-3; rays are 1-8, umbellules are 8-10 flowered. Mericarps are elliptic, plano-compressed, with narrow margin. Fruit is ellipsoid; lateral ribs are narrowly winged; vittae are 1 in each vallecule, 2 on commissure. Flowering time is May-June. Fruiting time is June-July [26, 27, 28].

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F. caspica and *F. szowitsiana* are eaten as raw food or cooked in Turkey (Sivas-Iğdır) [29]. *F. szowitsiana* is from subgenus *Merwia*, *F. caspica* is from subgenus *Dorematoides* [25, 28]. *F. caspica* and *F. szowitsiana* grow in the same area of Central Anatolia. According to Flora of Turkey, they can be easily mistaken for one another during the flowering time (Figure 1) [27]. The morphological and anatomical characteristics of the fruit have important distinctive characteristics for the family. Location, numbers and size of vittae are distinctive features for identification to species. Segmentation of leaves and size of ocrea are important characters for distinguish to species. Comparative morphological and anatomical study of *F. szowitsiana* and *F. caspica* are not been found in the literature. In this study, comparative morphology and fruit anatomies of *F. szowitsiana* and *F. caspica* were examined. Thus, this study allows for easier determination of these two taxa.

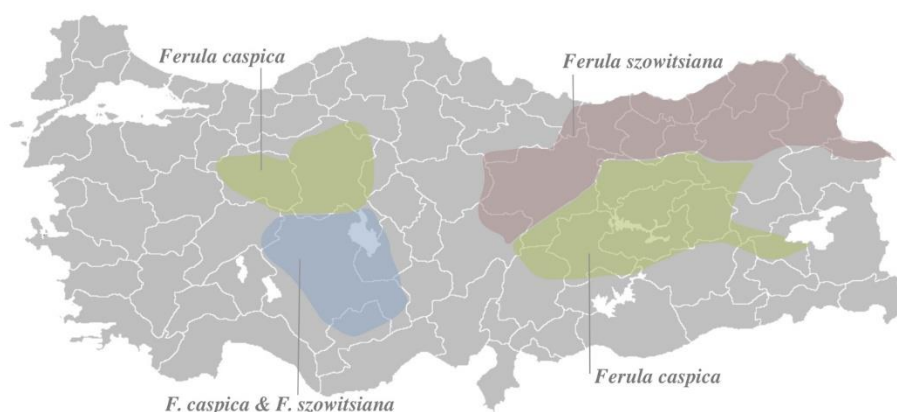


Figure 1. Distribution of *F. szowitsiana* and *F. caspica* species in Turkey.

2. RESULTS AND DISCUSSION

2.1. Morphological characteristics of leaf and flower

Basal leaves of *F. szowitsiana* are bigger than basal leaves of *F. caspica* (Table 1). Although leaves' ultimate segments are ovate in *F. szowitsiana*, leaves' ultimate segments are oblong in *F. caspica*. While *F. szowitsiana*'s lobes of leaves' ultimate segments are triangular-oblong, *F. caspica*'s lobes of leaves' ultimate segments are oblong-obtuse. Sheaths of *F. szowitsiana* are linear-oblong, chartaceous, glabrescent or puberulent, usually pinkish. Sheaths of *F. caspica* are linear, membranous, puberulent or glabrous, subamplexicaul. *F. szowitsiana*'s leaves are persistent and covered with messy hairs on both surfaces. *F. caspica*'s leaves are wilting, with scabrous surface, covered with short tough hairs. The leaves of *F. szowitsiana* and *F. caspica* are shown in Figure 2. General view of *F. szowitsiana* and *F. caspica* in Figure 3.

Inflorescence is paniculate-corymbose in both of two *Ferula* species. Although all umbels are proliferating in *F. caspica*, they are not proliferating in *F. szowitsiana* (Figure 4). Although petals of *F. szowitsiana* are hairy, petals of *F. caspica* are glabrous.

Table 1. Measurement and properties of the two *Ferula* species.

	<i>Ferula szowitsiana</i>	<i>Ferula caspica</i>
Leaves	3 pinnate, in outline 15-30 x 15-30 cm	3-4 pinnate, in outline 6-15 x 4-9 cm
Leaves lobes	triangular-oblong, 1-2 (-4) mm	oblong-obtuse, 1-3 x 0.5-1 mm
Sheaths	Linear-oblong	Linear
Rays	7-12	1-7(-8)
Petal surface	Hairy	Glabrous
Umbels	Not proliferating	Proliferating
Umbellules	8-12 Flowered	7-14 Flowered

2.2. Morphological characteristics of fruits

F. szowitsiana fruits (Figure 5A) are 11-13 mm long and fruit shape is wide elliptic. Fruits are bright yellowish brown in color and glabrous. It consists of 3 filiform dorsal ribs are visible in each mericarp.

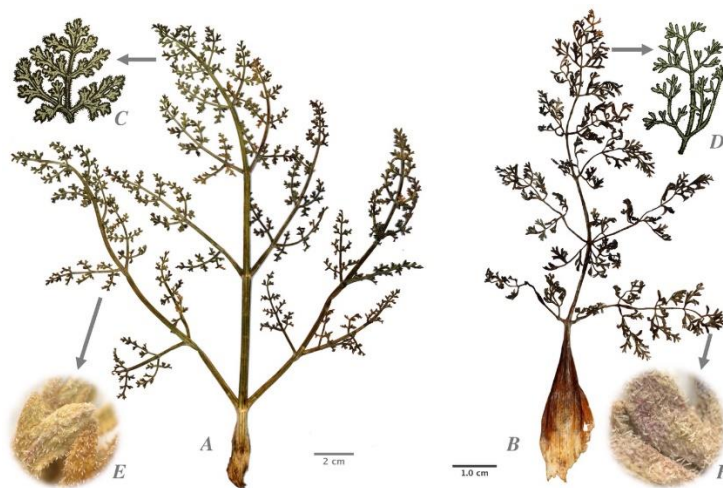


Figure 2. General view of the leaves; A-C *F. szowitsiana*, B-D *F. caspica*, E Surface of leaf *F. szowitsiana*, F Surface of leaf *F. caspica* (C-D: [30]).



Figure 3. General view of plants; A *F. szowitsiana*, B *F. caspica*.



Figure 4. General view of umbels; A *F. szowitsiana*, B *F. caspica*.



Figure 5. General view of fruits; A *F. szowitsiana*, B *F. caspica*.

F. caspica fruits (Figure 5B) are 7-9 mm long and fruit shape is narrow elliptic. Fruits are dark brown in color and glabrous. It consists of 3 dorsal ribs in each mericarp.

2.3. Anatomical characteristics of fruits

The fruits of all species consist of 2 homomorphic mericarps. The transversal section of mericarps are shown in Figure 6. Measurement and properties of the fruits of the examined species are given in Table 2.

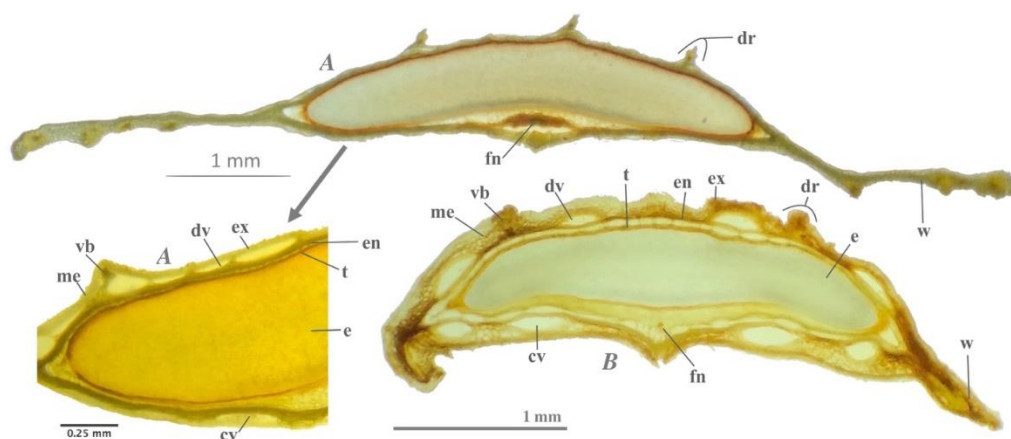


Figure 6. The transversal section of mericarps; A *F. szowitsiana*, B *F. caspica*. cv commissural vittae, dr dorsal rib, dv dorsal vittae, e endosperma, en endocarp, ex exocarp, fn funicle, me mesocarp, t testa, vb vascular bundle, w wing.

2.3.1. *Ferula szowitsiana*

The shape of mericarp is narrow long elliptical in transversal section. Cuticula is usually thin and smooth. Exocarp consists of single line, thick walled and isodiametric cells. Exocarp continues towards the commissural area of 2 mericarps. Vascular bundles are placed in the 3 ribs. Dorsal vittae are 3-4 per vallecule, commissural vittae 6-14. Commissural vittae are smaller than vallecular vittae. Each vascular bundle upper side is accompanied by some sclerenchymatous tissue. Trachea and tracheids are not distinguished from each other in xylem. Endocarp composed of single line, narrow-long and thin-walled cells. Cell walls are lignified. The results of fruit anatomy of *F. szowitsiana* supports the Ashena et al.'s [31] study.

Table 2. Measurement and properties of the fruits of the examined species.

Features	<i>Ferula szowitsiana</i>	<i>Ferula caspica</i>
Shape of Mericarp in transversal section	Narrow long elliptical	Narrow elliptical
Mericarp Width	11 mm (8.15 - 11.87 mm)	3.95 mm (3.35 - 4.45 mm)
Mericarp Length (Average)	1.18 mm	1.05 mm
Wing Length	2.191 mm (1.971 - 2.273 mm)	0.48mm (0.372 - 0.600 mm)
Vallecular vittae width	0.361 mm (0.260 - 0.528 mm)	0.258 mm (0.157 - 0.380 mm)
Commissural vittae width	0.248 mm (0.128 - 0.351 mm)	0.270 mm (0.138 - 0.442 mm)
Surface of fruits	Glabrous	Glabrous
Surface of basal leaves	Setulose- puberulent	Densely puberulent

2.3.1. *Ferula caspica*

The shape of mericarp is elliptical in transversal section. Cuticula is thin. Exocarp consists of single line, thick walled and isodiametric cells. Exocarp continues towards the commissural area of 2 mericarps. Vascular bundles are placed in the 3 ribs. Dorsal vittae usually 4, commissural vittae 4. Widths of commissural vittae and vallecular vittae are same. Each vascular bundle upper side is accompanied by some sclerenchymatous tissue. Trachea and tracheids are not distinguished from each other in xylem. Endocarp composed of single line, narrow-long and thin-walled cells. Cell walls are lignified.

4. CONCLUSION

Although *F. szowitsiana* and *F. caspica* can be easily mistaken for each other, this study reveal the significant differences between them. The important factors in the misidentification of these two species may that they grown in nearby localities, and the necessity of full leaf, flower and fruit in the identification of Apiaceae species. Even if they are collected in different periods of vegetation, it is possible to determine these two *Ferula* species with differences of inflorescence, fruit morphology and fruit anatomy. When these two *Ferula* species are examined, it is seen that they belong to two different subgenera. *F. szowitsiana* is from subgenus *Merwia*, *F. caspica* is from subgenus *Dorematoides* [25,28]. There is no other species belong to subgenera of *Merwia* and *Dorematoides* besides *F. szowitsiana* and *F. caspica* in Turkey .

We believe that this study will make it easier to work with the right plant in studies related to the genus *Ferula* which has a medically important value. Due to the presence of the *Ferula* species with cytotoxic effects, it is important to reach the right plant by both the people who use it and the researchers who will research it. The morphological and anatomical results will allow correct identification of two *Ferula* species easily.

5. MATERIALS AND METHODS

The study materials, ripe fruits of *F. szowitsiana* and *F. caspica*, were obtained from the voucher specimens. The species' grid, city, location, altitude and Herbarium number of Istanbul University Faculty of Pharmacy (ISTE) are given in Table 3. Anatomical research material was dried so firstly they were stayed in distillate water then they were preserved in 70% ethanol. In this study at least 6 mature fruits of each of 2 species were analyzed. All transverse sections were cutted by hand from the middle of the mericarps using a blade. Samples were examined in Sartur reagent [32]. Photographs were taken with iPhone X. Measurements of mericarps were made by program of ImageJ©. The fruit morphology and anatomy were described by using Botanical Latin [33].

Table 3. Grid, city, location, collector and collection numbers of the studied species.

Species	Grid	City	Location	Collector	Determination	Collection Number
<i>Ferula szowitsiana</i>	B4	Konya	Around Cihanbeyli Tuz Gölü. Yavşan memlehası.	P.H.Davis	P.H.Davis	ISTE 21102
<i>Ferula caspica</i>	B4	Konya	Konya, Karatay, Çatalhöyük - Erler roadside. Near to big garbage dump.	Mahmut Miski, Nur Tan, Memnune Eruçar.	H.Onur Tuncay Bülent Olcay	ISTE 115841

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