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

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Received: 05 October 2018 / Revised: 06 December 2018 / Accepted: 07 December 2018

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 these species are shown.

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

1. INTRODUCTION

The Apiaceae is 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 antihaemolytic 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 a 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 panicle-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 vallecula, comissural 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 panicle-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 vallecula, 2 on commissure. Flowering time is May-June. Fruiting time is June-July [26, 27, 28].
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.

### 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.

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

#### 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*. 
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.

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 vallecula, commissural vittae 6-14. Commisural 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.

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

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 reveals 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>
<thead>
<tr>
<th>Species</th>
<th>Grid</th>
<th>City</th>
<th>Location</th>
<th>Collector</th>
<th>Determination</th>
<th>Collection Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ferula szewitsiana</td>
<td>B4</td>
<td>Konya</td>
<td>Around Cihanbeyli Tuz Gölü. Yavşan memlehasi.</td>
<td>P.H. Davis</td>
<td>P.H. Davis</td>
<td>ISTE 21102</td>
</tr>
</tbody>
</table>

Acknowledgements: Thanks to Prof. Dr. Mahmud MİSKİ, Prof. Dr. Nur TAN and Fatma Memnune EruçAR for plant materials (F. caspica). Thanks to Fatma Memnune EruçAR for photo of F. caspica.


Conflict of interest statement: The authors declared no conflict of interest.

REFERENCES


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