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Comparative Fruit Anatomy and Morphology of Four Species Known as Cumin (Kimyon) in Turkey

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ABSTRACT

Herbs and spices have long been used to improve the flavor of food. Cumin, one of these spices, is widely used all over the world. However different species known as cumin are used for the same purpose. According to the data obtained from ethnobotanical studies in Turkey, four species are known and used as cumin (Kimyon) in the country; *Carum carvi* L., *Cuminum cyminum* L., *Laser trilobum* (L.) Borkh. and *Grammosciadium daucoides* DC. In this study, comparative fruit anatomy and morphology of species were studied. The purpose of this study was to have easier species identification by revealing the differences between their fruits. Considerable differences were observed in the fruit morphology with different shapes. Also, the fruit surface patterns of species showed important differences with the only similarities of their surfaces were being striated. *Carum carvi* and *Grammosciadium daucoides* had prominent striae, while *Cuminum cyminum* and *Laser trilobum* sustained slight striae. Species had different fruit anatomical shapes. The extent of costal channels and the presence of secondary and primary ribs were important differences. An identification key based on both morphological and anatomical characters were presented for the studied species.

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Türkiye'de Kimyon Olarak Kullanılan Dört Türün Karşılaştırmalı Meyve Anatomisi ve Morfolojisi

ÖZET

Baharatlar, yemeklere lezzet vermek için uzun zamandan beri kullanılmaktadır. Bu baharatlardan biri de tüm dünyada yaygın olarak kullanılan kimyondur. Kimyon olarak bilinen farklı türler aynı amaç için kullanılmaktadır. Türkiye'deki etnobotanik çalışmalardan elde edilen verilere göre Türkiye'de kimyon olarak kullanılan dört tür bilinmektedir. Bu türler; *Carum carvi* L., *Cuminum cyminum* L., *Laser trilobum* (L.) Borkh. ve *Grammosciadium daucoides* DC. Bu çalışmada kimyon olarak kullanılan türlerin karşılaştırmalı meyve anatomisi ve morfolojisi incelenmiştir. Bu çalışmanın amacı, meyveler arasındaki anatomik ve morfolojik farkları ortaya çıkararak türlerin birbirinden ayırt edilmesini kolaylaştırmaktır. Bu türlerin meyve morfolojisinde önemli farklılıklar gözlenmiştir. Ayrıca, türlerin meyve yüzeyinde yapılan mikromorfolojik çalışmalarda da belirgin farklılıklar ortaya konulmuştur. Kimyon olarak kullanılan türlerin meyve anatomisi incelendiğinde salgı kanalların yerleşimi ve primer veya sekonder kostaların varlığı gibi önemli farklılıklara rastlanmıştır. Çalışılan türler için hem morfolojik hem de anatomik karakterlere dayanan bir teşhis anahtarı sunulmuştur.

Araştırma Makalesi

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INTRODUCTION

Throughout history, various herbs and spices have been used all over the world to preserve or change the food flavor. People have been using these plants for very long times. Cumin, a popular spice and herb plant in ancient Egypt, was used as a pain killer for cough, digestive system and chest diseases, and for treating

rotten teeth (Chevallier, 2016). In terms of cooking, cumin is a material found in Indian and Middle Eastern recipes, especially in Chinese cuisine, particularly in curry and pickles. Also, cumin is being used in Central American and Mediterranean cuisines (Chevallier, 2016; Mete, 2017).

The Apiaceae commonly known as carrot or parsley family is one of the largest group among Angiosperm plants (Pimenov and Leonov, 1993; Hickey and King, 1997). There are 455 genera and 3600-3751 species belonging to the family in the world (Pimenov and Leonov 1993, 2004). The family of Apiaceae is represented by 101 genera and 451 species in Turkey and endemism ratio is about 33% (Özhatay et al., 2009). The morphological and anatomical characteristics of the fruit have important distinctive characteristics for the family (Kızılarslan and Akalın, 2017).

Some species are known as cumin in Turkey; *Carum carvi* L., *Cuminum cyminum* L., *Laser trilobum* (L.) Borkh, *Grammosciadium daucoides* DC. These species have been used for both culinary and medicinal purposes (Baytop, 1999; Yeşil and Akalın, 2010; Bulut et. al., 2014; Doğan et. al., 2014; Özdemir and Kültür, 2017).

The genus *Carum* L. has five species in Turkey. *Carum carvi* is from tribe Apieae (Pimenov and Leonov, 1993). They are fragrant plants that carry essential oils (Hedge et al., 1972a; Tuzlacı, 2011; Menemen, 2012a). *Carum carvi* is known as caraway seed (Frenk Kimyonu) and used as a spice in Europe and Turkey (Baytop, 1999). Ethnobotanical studies show that *Carum carvi* is used in folk medicine as appetizer, digestive, aphrodisiac. (Bulut et. al., 2014)

Cuminum cyminum L. is the only *Cuminum* species in Turkey (Tuzlacı, 2011; Menemen, 2012b). *Cuminum cyminum* is from tribe Caucalideae (Pimenov and Leonov, 1993). There are 5 ribs easily seen on each mericarp of the schizocarp fruit. Its surface is slightly hairy (Baytop, 1999). Ethnobotanical studies show that *Cuminum cyminum* is used in folk medicine for the common cold treatments (Güneş et al.,2017).

Laser trilobum is the only species from this genus in Turkey (Hedge et al., 1972b; Tuzlacı, 2011; Menemen, 2012c). *Laser trilobum* is from tribe Peucedaneae (Pimenov and Leonov, 1993). It is common in Thrace and Anatolia. Due to its distribution, it is obtained from Kastamonu, Zonguldak, Eskişehir, Adana and Konya. In this species, there are 5 primary and 4 secondary rib in each mericarp (Baytop, 1999). It is used as spice in Adana, Çanakkale and Mersin (Tuzlacı, 2011). Ethnobotanical studies show that *Laser trilobum* is used in folk medicine for treatment of diabetic disease, abdominal pain, digestive and blood pressure therapy (Bulut et. al., 2014; Güneş et al.,2017).

Grammosciadium DC. has 6 species in Turkey. *Grammosciadium daucoides* is from tribe Scandiceae (Pimenov and Leonov, 1993). *Grammosciadium daucoides* known as "Kami" used as spice in Malatya (Hedge et al.,1972c; Yeşil and Akalın, 2010; Menemen, 2012d;). There are several anatomical and morphological studies about *Grammosciadium* (Bani et al., 2016a; Ulusoy et al., 2017).

This study aims to determine the detailed fruit anatomy and morphology of the species known as cumin in Turkey and thus, to reveal the differences between the fruits of these species used as spices.

MATERIALS and METHODS

Ripe fruits of *Carum carvi, Cuminum cyminum, Laser trilobum, Grammosciadium daucoides* were obtained from the voucher specimens. The species list, grid, city, altitude and herbarium number of Istanbul University Faculty of Pharmacy (ISTE) are given in Table 1. Anatomical research material was dried so firstly they were kept in distilled water then they were preserved in 70% ethanol. In this study, measurements were taken from at least 6 mature fruits of different herbarium samples of each of 4 species. The numbers and information of the herbarium samples studied are given in Table 1. All transverse sections were cut by hand from the middle of the mericarps using a blade. Samples were examined in Sartur reagent (a compound reagent of lactic acid, Sudan III, aniline, iodine, potassium iodide, alcohol, and water) (Çelebioğlu and Baytop, 1949). Photographs were taken via iPhone 6s and measurements of mericarps were made by KAMERAM© computer software. The fruit morphology and anatomy were described by using Botanical Latin (Stearn, 2005); Kızılarslan and Akalın (2017). The fruit micromorphology was described by Stearn (2005), Aksenov et al. (1972), Özcan (2004); Bani et al. (2016a, b); Liu and Downie (2017).

RESULTS

Macromorphological Characteristics of Fruits

General views of the fruits are shown in Figure 1. The macromorphological characteristics of fruits are listed in Table 2. *Carum carvi* fruits (Figure 1a) are 4-6 mm long and fruit shape is narrowly elliptic. Fruits are brown or bright yellowish brown in color and glabrous. It consists 5 light yellow colored dorsal ribs that are visible in each mericarp.

Cuminum cyminum fruits (Figure 1b) are 5-6 mm long and spindle-shaped and yellowish brown colored granules. There are 5 dorsal ribs that are easily seen on each mericarp. The color between the rib is brown and fruit is sparse pubescent.

Laser trilobum fruits (Figure 1c) are 5-10 mm long and 2-4 mm wide, fruit shape is elliptic. Each mericarp has 5 primary and 4 secondary dorsal ribs.

Table 1. The list, city and collection numbers of the studied species

Species	Grid	City	Altitude	Collection Number
Carum carvi	A9	Kars	2000m	ISTE 59366
	A9	Kars	2000m	ISTE 18351
Cuminum cyminum	B3	Eskişehir	800 m	ISTE 56924
	C6	Gaziantep	-	ISTE 56938
Laser trilobum	A6	Samsun	-	ISTE 77603
	A1	Kırklareli	-	ISTE 29918
	A4	Çankırı	1700m	ISTE 35270
	A4	Zonguldak	-	ISTE 49146
	C3	Isparta	1300m	ISTE 103408
Grammosciadium daucoides	B9	Ağrı	2020 m	ISTE 42701
	A6	Sivas	1800m	ISTE 102054
	C6	Malatya	1550m	ISTE 101986
	B7	Erzincan	2100m	ISTE 74633

Figure 1. General view of the fruits; A *Carum carvi,* B *Cuminum cyminum,* C *Laser trilobum,* D *Grammosciadium daucoides*

Grammosciadium daucoides fruits (Figure 1d) are 7-11 mm in length, fruit shape is lorate and the calyx is persistent in the fruit. There are 5 dorsal ribs in each mericarp.

Fruit Micromorphology

The features of the mericarp surface are shown in Figure 2 and Figure 3. Distinguishing properties were observed on the fruits surfaces (Table 2).

1. *Carum carvi*

The ornamentation pattern is rugose-striate type. The fruit surface is very strongly striate on whole surface and it is rugose on the surface of ribs, it is more intensely rugose on the vallecular surface.

2. *Cuminum cyminum*

The surface pattern is striate type, while the fruit surface has micropapillae particularly on the surface of ribs, has few on the vallecular surface. Striae can be observed on the whole surface.

3. *Laser trilobum*

The ornamentation pattern is rugose-striate type with densely rugose on surfaces of ribs and slightly corrugated on vallecular surfaces. Striae can be observed on vallecular surfaces.

4. *Grammosciadium daucoides*

The ornamentation pattern is rugose-favulariate type on both surfaces of ribs. The surface has frequent and prominent striate.

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

Features	*Carum carvi*	*Cuminum cyminum*	*Laser trilobum*	*Grammosciadium daucoides*
Mericarp width Average (min-max)	1.58 mm (1.55-1.6)	1.84 mm (1.82- 1.86)	3.31 mm (3.21-3.42)	1.42 mm (1.35-1.44)
Mericarp length Average (min-max)	1.41 mm (1.39-1.42)	1.1 mm (1.08-1.14)	1.11 mm (0.98-1.24)	1.13 mm (1.12-1.15)
Ratio of width to length of mericarp	1.117	1.668	2.97	1.254
Vallecular vittae width Average (min-max)	0.18 mm (0.16-0.22)	0.19 mm (0.16-0.22)	0.29 mm (0.21- 0.34)	0.2 mm (0.16-0.23)
Vallecular vittae length Average (min-max)	0.045 mm (0.036-0.056)	0.046 mm (0.04-0.057)	0.097 mm (0.063-0.12)	0.052.9 mm (0.042-0.055)
Commissural vitae width Average (min-max)	0.115 mm (0.111-0.119)	0.227 mm (0.189-0.249)	0.3 mm (0.23-0.39)	0.2 mm (0.15-0.25)
Commissural vitae length Average (min-max)	0.035 mm (0.023-0.042)	0.044 mm (0.027-0.054)	0.059 mm (0.04-0.1)	0.045 mm (0.029-0.059)
Oil duct	rib	rib	rib (sparse)	rib (sparse)
Hypodermal collenchyma	single line	2-3 lines	single line	2-3 lines
Shape of mericarp in transversal section	latissime ovatus	depresse ovatus	transverse anguste elipticus	latissime ovatus
Surface of fruit	glabrous	sparsely pubescent	glabrous	glabrous
Length and shape of fruit	4-6 mm long, narrowly elliptic	5-6 mm long, spindle-shaped	5-10mm long, elliptic	7-11 mm long, elliptic
Number of dorsal ribs in each mericarp	5	5	5 primary and 4 secondary	5
The micromorphological properties of fruit surface	rugose-striate	striate	rugose-striate	rugose-favulariate

Fruit Anatomy

The fruits of all species consist of 2 homomorphic mericarps. Fruits were examined under separate headings. The transversal sections of mericarps are shown in Figure 4. Measurement and properties of the fruits of the examined species are given in Table 2.

1. *Carum carvi*

The shape of mericarp is latissime ovatus in transversal section (Figure 4A).

Exocarp: Cuticula is usually thin and smooth. Exocarp consists of single line, thick walled and isodiametric cells. A single line hypodermal collenchyma is seen. Exocarp continues towards the commissural area of 2 mericarps.

Mesocarp: Vascular bundles are placed in the 5 ribs but the valecular vittae are larger and vaguely elongated. Valecular vittae usually 4, commissural vittae 2. Commissural vittae smaller than valecular vittae. Each vascular bundle upper side is accompanied by some sclerenchymatous tissue. Trachea and tracheids are not distinguished from each other in xylem. Oil ducts are located in ribs.

Endocarp: Composed of single line, narrow-long and thin-walled cells. Endocarp was observed to be 2 lines under vallecular vittae. Endoderm cells are shortened between raphe (connecting seed to pericarp) and carpophore (connecting 2 mericarps to each other). Cell walls are lignified. Druse crystals are observed.

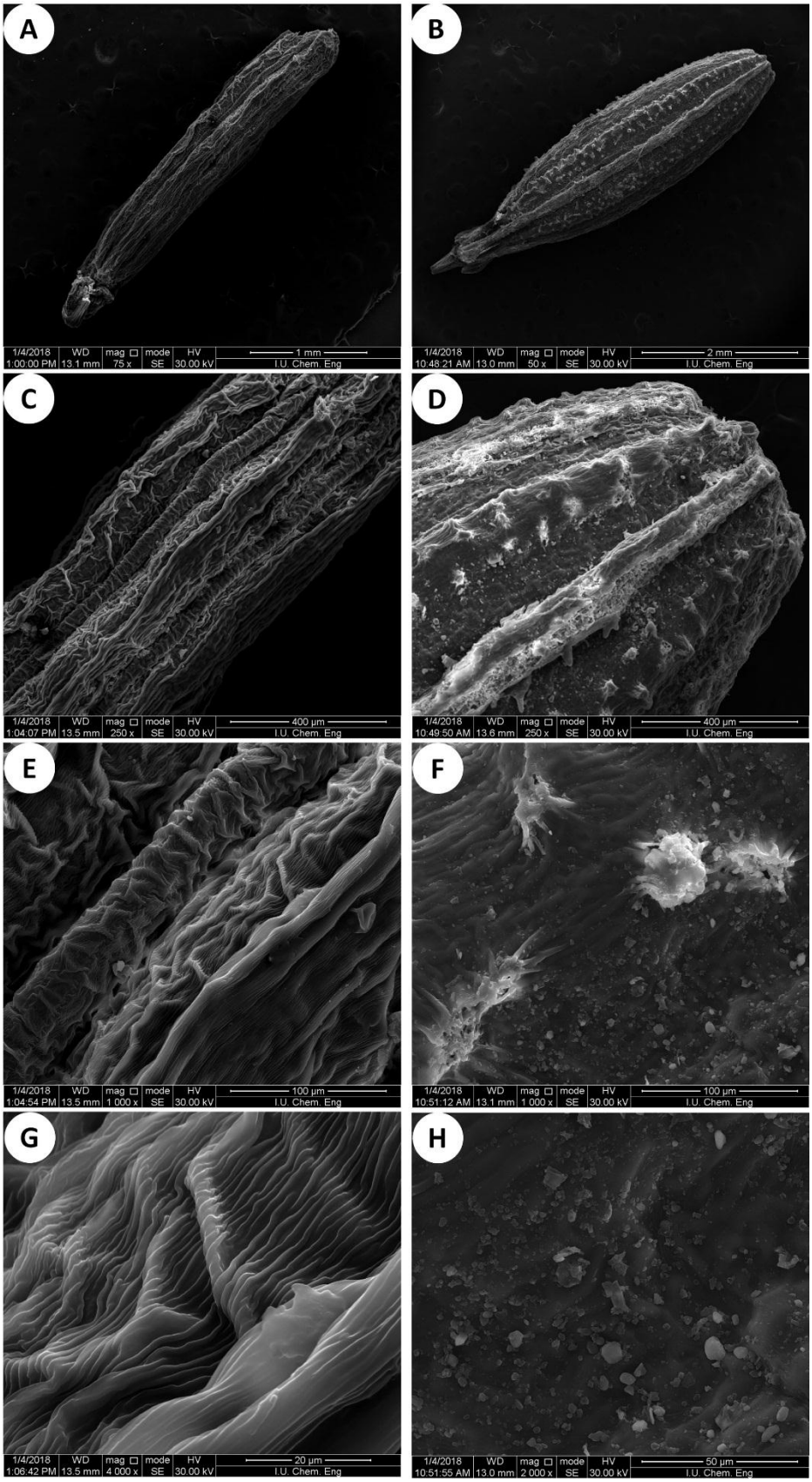

Figure 2. SEM micrographs of fruit surface in *Carum carvi* A, B, C, D; *Cuminum cyminum* E, F, G, H.

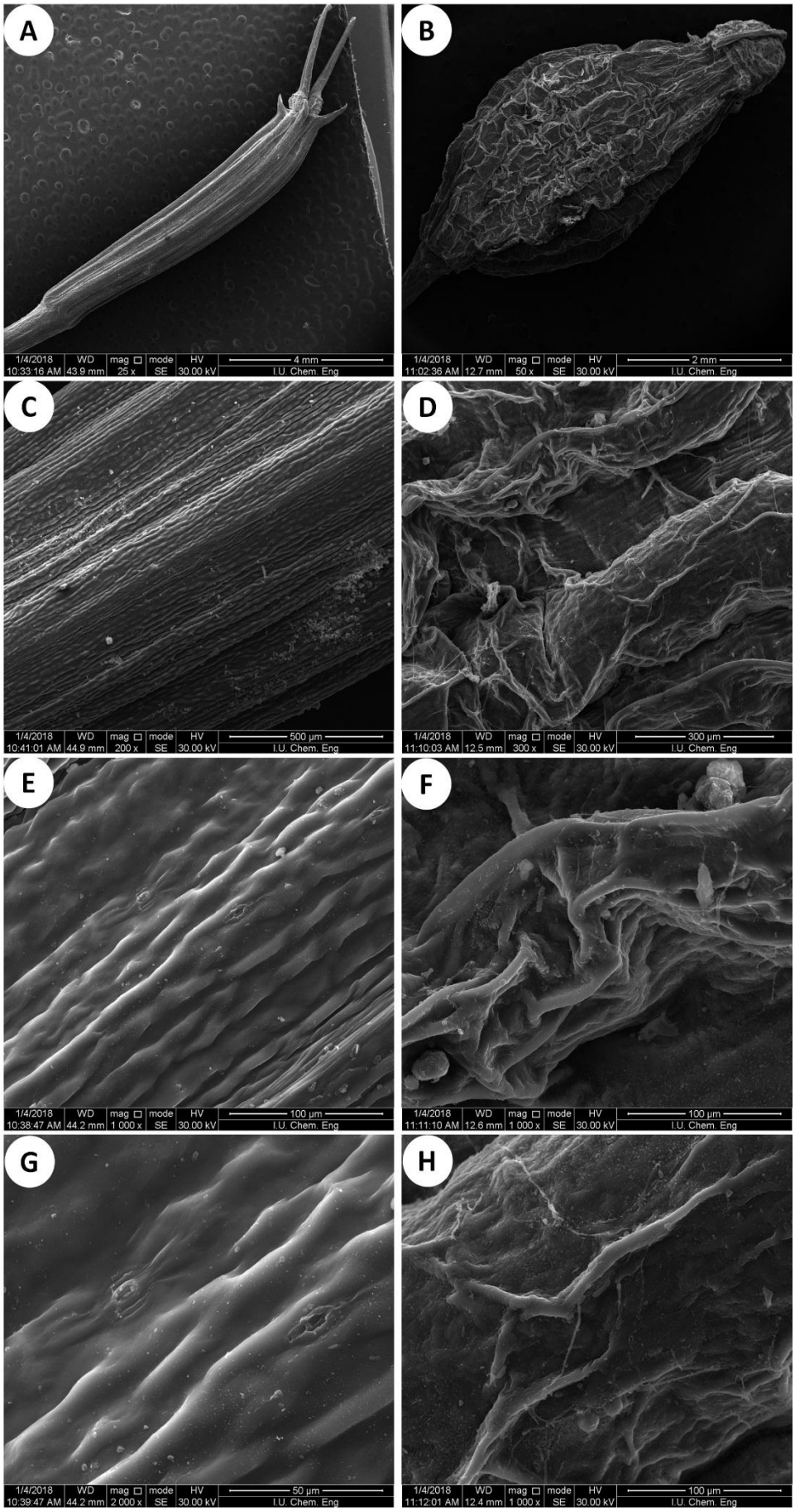

Figure 3.SEM micrographs of fruit surface in *Grammosciadium daucoides* A, B, C, D; *Laser trilobum* E, F, G, H.

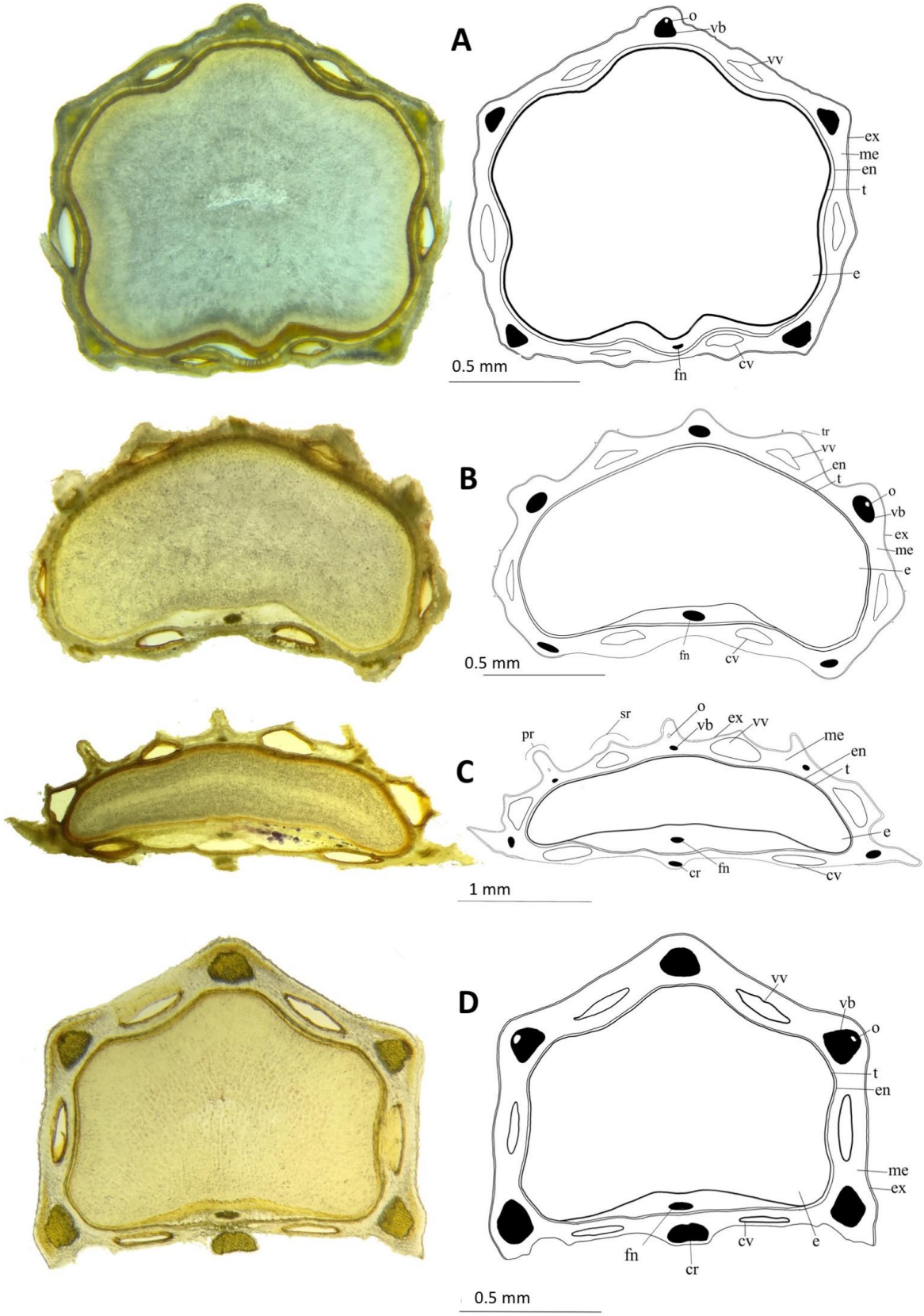

Figure 4. The transversal section of mericarps; A *Carum carvi*, B *Cuminum cyminum*, C *Laser trilobum*, D *Grammosciadium daucoides*. cr carpophore, cv commissural vittae, e endosperma, en endocarp, ex exocarp, fn funicle, me mesocarp, o oil duct, pr primary rib, sr secondary rib, t testa, tr trichome, vb vascular bundle, vv vallecular vittae.

2. *Cuminum cyminum*

The shape of mericarp is depressed ovatus in transversal section (Figure 4B).

Exocarp: Cuticula is usually thin and smooth. 2-3 line hypodermal collenchyma is seen. Exocarp continues towards the commissural area of 2 mericarps.

Mesocarp: Vascular bundles are placed in the 5 ribs. Valecular vittae usually 4, commissural vittae 2. Commissural vittae is bigger than valecular vittae. Oil ducts are located in ribs. Sclerenchymatous tissue around the vascular bundles was observed to be minimal.

Endocarp: Composed of single line, narrow-long and thick-walled cells. Druse crystals are observed.

3. *Laser trilobum*

The shape of mericarp is transverse anguste elipticus in transversal section (Figure 4C).

Exocarp: Cuticula is usually thin and smooth. Exocarp consists of single line, thick walled and isodiametric cells. A single line hypodermal collenchyma is seen.

Mesocarp: Vascular bundles are placed in the 5 primary ribs. Valecular vittae usually 4, commissural vittae 2. Valecular vittaes are placed in the 4 secondary ribs. Commissural vittae is bigger than valecular vittae. Oil ducts are rarely located in ribs. Sclerenchymatous tissue around the vascular bundles was observed to be minimal.

Endocarp: Composed of single line, narrow-long and thick-walled cells. Testa has the thick layer. Druse crystals are observed.

4. *Grammosciadium daucoides*

The shape of mericarp is transverse latissime ovatus in transversal section (Figure 4D).

Exocarp: Cuticula is usually thin and smooth. Exocarp consists of single line, thick walled and isodiametric cells. 2-3 lines hypodermal collenchyma is seen. Exocarp continues towards the commissural area of 2 mericarps.

Mesocarp: Vascular bundles are placed in the 5 ribs. Valecular vittae usually 4, commissural vittae 2. The dimension of vallecular vittae and commissural vittae are approximately the same. Each vascular bundle is accompanied by some sclerenchymatous tissue. Sclerenchymatous tissue is thick especially underside of vascular bundle. Trachea and tracheids are not distinguished from each other in xylem. Oil ducts are rarely located in ribs.

Endocarp: Composed of single line, narrow-long and thick-walled cells. Testa is thick layer especially at commissural surface. Druse crystals are observed.

DISCUSSION

This study includes 4 species used as cumin in the Apiaceae family in Turkey. When these species are examined, it is seen that they belong to different tribes (Pimenov and Leonov, 1993). Although these species are from different tribes, they have a common purpose of use. Significant differences have been observed in the fruit anatomy and morphology of these plants.

Firstly, the differences in the shape of the fruit can be specified. Shapes of fruits are narrowly eliptic in *Carum carvi*, spindle-shaped in *Cuminum cyminum*, eliptic in *Laser trilobum*, lorate in *Grammosciadium daucoides*. In addition, the fruit sizes are also different. Among these species only surface of *Cuminum cyminum* is sparsely pubescent. Each mericarp has 5 primary ribs. Only *Laser trilobum* has 4 secondary ribs.

Fruits' micromorphological characteristics are very important for the classification of the Apiaceae family (Özcan, 2004; Liu and Downie, 2017; Ostroumova et al., 2010). The fruit surfaces of species show distinct differences, the only similarities of their surfaces are being striated. However, *Carum carvi* and *Grammosciadium daucoides* have prominent striae, *Cuminum cyminum* and *Laser trilobum* have slight striae. Also, *Carum carvi*, *Cuminum cyminum* and *Laser trilobum* have different surface patterns at primary and secondary ribs. But *Grammosciadium daucoides* contains only one kind of rib, so it does not have different surface pattern. The results of fruit surface of *Grammosciadium daucoides* supports the Bani et al.'s (2016b) study.

There are also differences in shape of fruit transversal sections. Shape of mericarp in transversal section; *Carum carvi* latissime ovatus, *Cuminum cyminum* depressed ovatus, *Laser trilobum* transverse anguste elipticus, *Grammosciadium daucoides* transverse latissime ovatus. Hypodermal collenchyma is single line in exocarp of *Carum carvi* and *Laser trilobum* while hypodermal collenchyma is multi lines (2-3) in exocarp of *Cuminum cyminum* and *Grammosciadium daucoides*.

Oil ducts are located in ribs. Oil ducts are more common in *Carum carvi* and *Cuminum cyminum* than in *Laser trilobum* and *Grammosciadium daucoides.* Width of vallecular vittae and commissural vittae are much bigger in *Laser trilobum* than others 3 species. The endoderm cells are shortened and lignified especially on the commissural surface in *Carum carvi.* Druse crystals are observed in all species which are examined. The results of fruit anatomy of *Carum carvi* supports the Zakharova's (2010) study.

Identification Key for Species Known as Cumin in Turkey

This key has been prepared based on morphological and anatomical characteris Cumunumtics of the fruit of the species.

1. Fruit hairy and shape of mericarp depressed ovatus ***Cuminum cyminum***
1. Fruit not hairy and shape of mericarp not depressed ovatus **2.**
2. Mericarp consists of 5 primers and 4 secondary ribs ***Laser trilobum***
2. Mericarp consists of 5 ribs **3.**
3. Commissural vittae width 0.2 mm (0.15-0.25) ***Grammosciadium daucoides***
3. Commissural vittae width 0.115 mm (0.111-0.119) ***Carum carvi***

CONCLUSION

There are many species that are used as spices in the Apiaceae family. The parts of these plants that are used are usually fruit. This study includes some species used as cumin in the Apiaceae family in Turkey. Fruit anatomy and morphology of these species were compared. Thus, differences between these species have been revealed. Fruit anatomy and morphology are very important in distinguishing these species. The detailed anatomical and morphological results will allow separation of these species easily. This study will allow identification of the species from the fruit sample.

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CONFLICTS of INTEREST

The authors declared no conflict of interest.

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