

Detailed Fruit Anatomy of the Genus *Grammosciadium* DC. (Apiaceae)

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Abstract: The genus *Grammosciadium* is a member of the family Apiaceae and has four taxa namely *G. daucooides*, *G. macrodon* subsp. *macrodon*, *G. macrodon* subsp. *nezaketiae* and *G. cornutum* distributed in Turkey. Because the fruit anatomical characters are distinctly important for the taxonomy of the family Apiaceae, this study includes the detailed anatomy of the fruits of the genus. Moreover, some measurements from the fruit anatomy are given. Besides the general anatomy of them, the taxa are evaluated by both qualitative characters such as mericarp types and clarity of ribs and quantitative characters such as number of vascular bundles, number of vittae, size of mericarp, vittae, endosperm and vascular bundles. All the data presented in this research study may be used as a basis for all possible research on the taxonomy of the family and the genus.

Grammosciadium DC. (Apiaceae) Cinsinin Detaylı Meyve Anatomisi

Anahtar Kelimeler

Anatomi,
Meyve,
Grammosciadium,
Apiaceae

Özet: *Grammosciadium* cinsi, Apiaceae ailesinin bir üyesidir ve Türkiye’de yayılış gösteren *G. daucooides*, *G. macrodon* subsp. *macrodon*, *G. macrodon* subsp. *nezaketiae* ve *G. cornutum* isimlerinde dört taksonla temsil edilmektedir. Meyve anatomik karakterleri Apiaceae ailesinin taksonomisinde oldukça önemli olduğu için, bu çalışma cinsin detaylı meyve anatomisini içermektedir. Ayrıca, çalışmada meyve anatomisinden bazı ölçümler de verilmiştir. Meyvelerin genel anatomilerinin yanısıra, taksonlar hem merikarp tipi ve rib belirginliği gibi kalitatif karakterler ve hem de iletim demetleri sayısı, vitta sayısı, merikarp, vitta, endosperm ve iletim demeti boyutları gibi kantitatif karakterler ile değerlendirilmiştir. Bu araştırma çalışmasında ortaya konan tüm veriler, familyanın ve cinsin taksonomisi ile ilgili yapılabilecek tüm araştırmalara temel oluşturabilecek niteliktedir.

1. Giriş

The anatomical characters of the genus *Grammosciadium* DC. were firstly discussed by Townsend [1], Tamamschian, and Vinogradova [2] who indicated the importance of fruit anatomy. There are also several current studies that explain the differences in the Apiaceae fruit anatomy [3-9]. For example, Ghahremaninejad et al. [10] studied 14 Iranian species of the genus *Bupleurum* L. and separate them into two groups according to the absence or presence of vallecular vittae in their fruits. In another study, Yılmaz et al. [11] show the importance of the presence of secretory ducts in the wings of the genus *Heptaptera* Marg. & Reuter. Moreover, according to Lee et al. [12], rib numbers and the shape of mericarp are diagnostic for the tribe

Selineae. Also, Zakharova et al. [8] studied with three taxa, one of which is *Carum piovanii* and they proposed a new combination as *Afroligusticum piovanii* because of some carpological similarities. In another study, Bani et al. [13] indicated detailed morphological and anatomical characters of genus *Grammosciadium* and made some taxonomical regulations by using statistical applications with these characters. Moreover, Zakharova et al. [14], used also fruit anatomy to support the molecular investigations to clarify the taxonomy of the genus *Hellenocarum* H.Wolff.

The genus *Grammosciadium* is a member of the family Apiaceae and has four taxa namely *G. daucooides* DC., *G. macrodon* Boiss. subsp. *macrodon*, *G. macrodon* Boiss. subsp. *nezaketiae* B.Bani and *G.*

cornutum (Nábělek) C.C.Towns. distributed in Turkey [15]. Based on the importance of the distinctive property of fruit anatomical characters in the Apiaceae family, detailed fruit anatomy of these 4 taxa belonging to the genus *Grammosciadium* is given in this study. Also, the characters that may be diagnostic have been identified.

2. Material and Method

The materials in Table 1, used for anatomical studies, were gathered from the taxa collected in 22 different localities [16]. All the fruits were sectioned from their middle part by modified Paraffin Sectioning Method [17] using Thermo Shandon Finesse325 microtome. The slices were dyed by applying safranin and fast green [18]. Images were obtained with a Leica

DFC295 camera attached to a Leica DM3000 microscope. The measurements given in Table 2, were performed from 10 different slices of three different fruits, and the average values were calculated from a minimum of 30 values for each character. The terminology for the characters has been written by using previous studies [2, 19, 20]. In this study, some data from a previous master's thesis were used [21].

3. Results

3.1. *Grammosciadium daucoides*

In the cross-section of the fruits, a thin cuticle at the outermost and just below single-layered epidermis cells are established. There are 5 primary vascular

Table 1. Taxon Locality, collection date and collection number [16]

<i>G. daucoides</i>	B7 Erzincan: 1357 m, 04 June 2012, B.B.6816 A9 Kars: 2050 m, 05 June 2012, B.B.6821 B9 Muş: 1580 m, 09 June 2012, B.B.6826 B9 Ağrı: 1650 m, 04 July 2012, B.B.6871 A8 Bayburt: 2380 m, 04 July 2012, B.B.6876 A8 Bayburt: 1870 m, 05 July 2012, B.B.6877 C6 Kahramanmaraş: 1500 m, 19 May 2014, B.B.6959 B6 Sivas: 1700 m, 21 May 2014, B.B.6963 C4 Konya: 1500 m, 22 May 2014, B.B.6964 B7 Tunceli: 1250 m, 13 June 2014, B.B.6978 B6 Sivas: 1926 m, 02 July 2014, B.B.6984 B9 Bitlis: 2263 m, 09 July 2014, B.B.6998
<i>G. macrodon</i> subsp. <i>macrodon</i>	C7 Adıyaman: 1250 m, 02 May 2013, B.B. 6908 B9 Diyarbakır: 1240 m, 06 May 2013, B.B.6917 B7 Elazığ: 1345 m, 03 May 2013, B.B.6915 C6 Kahramanmaraş: 2000 m, 19 May 2014, B.B.6958 B8 Bingöl: 1600 m, 09 July 2014, B.B.7000
<i>G. macrodon</i> subsp. <i>nezaketiae</i>	B9 Bitlis: 1350 m, 13 June 2012, B.B.6844 B9 Van: 2300 m, 09 July 2014, B.B.6995 B9 Van: 2000 m, 10 June 2012, B.B.6837 B9 Van: 1450 m, 10 June 2012, B.B.6832
<i>G. cornutum</i>	B10 Hakkari: 2200 m, 20 June 2012, B.B.6857

Table 2. Fruit measurements of the taxa (mm)

Characters	<i>G. daucoides</i>	<i>G. macrodon</i> subsp. <i>macrodon</i>	<i>G. macrodon</i> subsp. <i>nezaketiae</i>	<i>G. cornutum</i>
Mericaip length	1.05 ± 0.187	0.98 ± 0.420	1.60 ± 0.525	1.55 ± 0.032
Mericaip width (Commissure area)	1.62 ± 0.356	1.68 ± 0.740	1.72 ± 0.254	2.33 ± 0.013
Mericaip length/width ratio	0.6	0.5	0.9	0.6
Commissure length	0.14 ± 0.051	0.13 ± 0.039	0.20 ± 0.196	0.14 ± 0.027
Endosperm width	1.08 ± 0.352	1.12 ± 0.416	1.03 ± 0.295	1.63 ± 0.017
Endosperm length	0.68 ± 0.155	0.65 ± 0.259	0.68 ± 0.131	0.88 ± 0.051
Integument thickness	0.03 ± 0.010	0.02 ± 0.013	0.03 ± 0.009	0.02 ± 0.004
Number of vascular bundles	5	5	5	9
Distance between dorsal vittae	0.59 ± 0.129	0.55 ± 0.165	0.59 ± 0.076	0.25 ± 0.005
Distance between primary bundles	0.42 ± 0.122	0.92 ± 0.067	0.11 ± 0.093	0.91 ± 0.063
Dorsal vittae (oil duct) length	0.03 ± 0.010	0.06 ± 0.043	0.05 ± 0.084	0.04 ± 0.009
Dorsal vittae (oil duct) width	0.02 ± 0.008	0.03 ± 0.021	0.03 ± 0.008	0.02 ± 0.005
Vallecular vittae length	0.03 ± 0.140	0.03 ± 0.013	0.03 ± 0.015	0.02 ± 0.004
Vallecular vittae width	0.18 ± 0.072	0.04 ± 0.016	0.05 ± 0.024	0.09 ± 0.015
Vallecula length (with vittae)	0.17 ± 0.033	0.21 ± 0.082	0.29 ± 0.110	0.11 ± 0.021
Dorsal bundle width	0.15 ± 0.034	0.38 ± 0.134	0.43 ± 0.056	0.27 ± 0.011
Dorsal bundle length	0.09 ± 0.025	0.06 ± 0.015	0.09 ± 0.016	0.16 ± 0.012
Lateral bundle length	0.14 ± 0.026	0.29 ± 0.090	0.38 ± 0.090	0.29 ± 0.009
Lateral bundle width	0.10 ± 0.018	0.06 ± 0.022	0.84 ± 0.011	0.16 ± 0.013

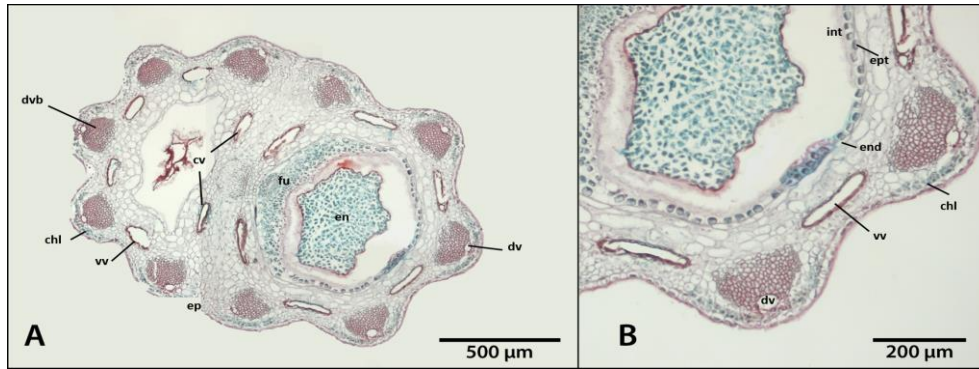


Figure 1. *G. daucoides* fruit cross section. A) General view (4X), B) Close view (10X); **chl**: chlorenchyma, **cv**: commissural vittae, **dv**: dorsal vittae, **dvb**: dorsal vascular bundle, **en**: endosperm, **end**: endepidermis, **ep**: epidermis, **ept**: epitegma, **fu**: funiculus, **int**: integument, **vv**: vallecular vittae

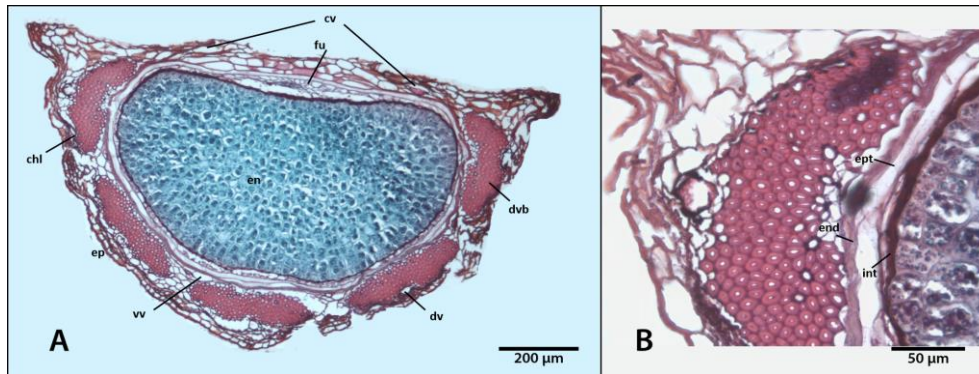


Figure 2. *G. macrodon* subsp. *macrodon* fruit cross section. A) General view (4X), B) Close view (10X); **chl**: chlorenchyma, **cv**: commissural vittae, **dv**: dorsal vittae, **dvb**: dorsal vascular bundle, **en**: endosperm, **end**: endepidermis, **ep**: epidermis, **ept**: epitegma, **fu**: funiculus, **int**: integument, **vv**: vallecular vittae

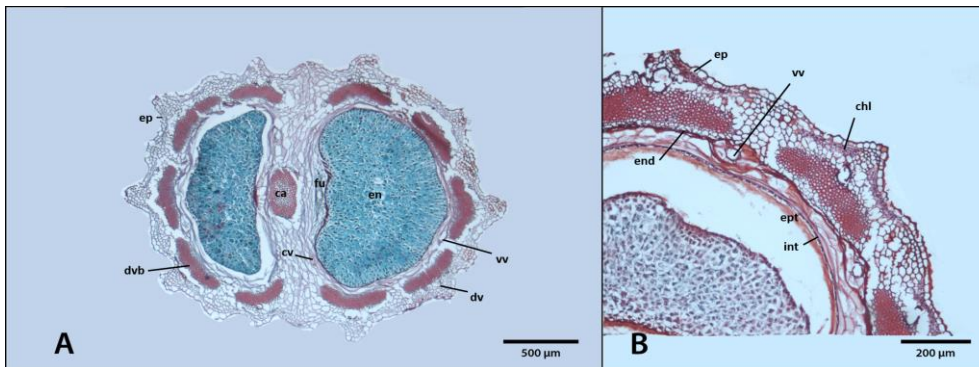


Figure 3. *G. macrodon* subsp. *nezaketiae* fruit cross section. A) General view (4X), B) Close view (10X); **ca**: carpophore, **chl**: chlorenchyma, **cv**: commissural vittae, **dv**: dorsal vittae, **dvb**: dorsal vascular bundle, **en**: endosperm, **end**: endepidermis, **ep**: epidermis, **ept**: epitegma, **fu**: funiculus, **int**: fragmented integument, **vv**: vallecular vittae

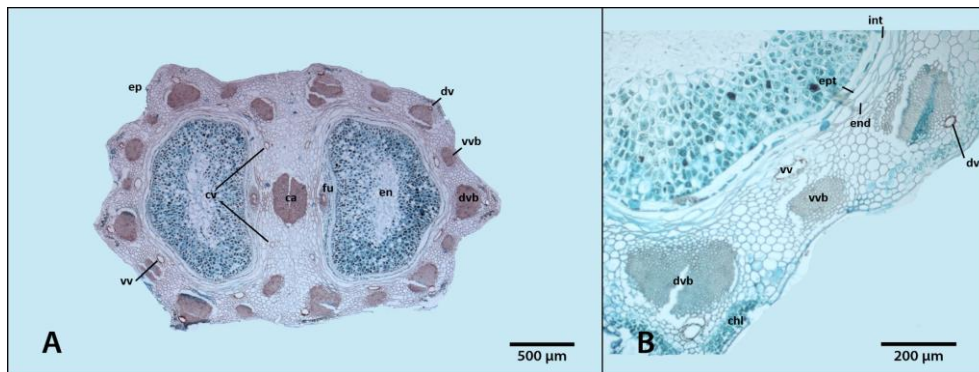


Figure 4. *G. cornutum* fruit cross section. A) General view (4X), B) Close view (10X); **ca**: carpophore, **chl**: chlorenchyma, **cv**: commissural vittae, **dv**: dorsal vittae, **dvb**: dorsal vascular bundle, **en**: endosperm, **end**: endepidermis, **ep**: epidermis, **ept**: epitegma, **fu**: funiculus, **int**: fragmented integument, **vv**: vallecular vittae, **vvb**: vallecular vascular bundle

bundles, making ribs, in a single mericarp, 3 of which are dorsal and 2 of which are lateral (Figure 1.). There is one orbicular rib oil duct (named as dorsal vittae) on each of the bundles and a large, elliptical vallecular vitta between the bundles. Also, there are 2 elliptical-shaped, wide commissural vittae. The pericarp ends with a single row of endepidermis cells innermost. Around the endosperm, there is an epitegma and a fragmented integument.

3.2. *Grammosciadium macrodon* subsp. *macrodon*

In the cross-section of the fruits, the outermost layer is a thin cuticle and below this cuticle a single layered epidermis is observed (Figure 2.). In one mericarp, 3 dorsal and 2 lateral vascular bundles have formed inconspicuous ribs. There is one rib orbicular oil duct in the upper part of the vascular bundles. There are 2 commissural vittae and 4 vallecular vittae in each mericarp of the fruit. The pericarp layer ends with a single row of endepidermis cells innermost. At the outermost part of the seed attached to the pericarp and the epitegma and the fragmented integument layer surround the endosperm as mentioned in Tamamschian and Vinogradova [2].

3.3. *Grammosciadium macrodon* subsp. *nezaketiae*

In the cross-section of the fruits, below a thick cuticle at the outermost layer, there is a single layer of epidermis cells is seen. There are 5 primary vascular bundles, 3 of which are dorsal and 2 of which are lateral, that have formed obvious ribs in the pericarp (Figure 3). In the upper part of each bundle, towards the epidermis, there is one orbicular oil duct and there are several layers of chlorenchyma and parenchyma between this vitta and the epidermis. The vallecula has a multilayered crushed elliptical-shaped vitta close to the endepidermis. The pericarp ends with a single-layered endepidermis cells innermost. Epitegma and fragmented integument layers surround the endosperm on the outermost part of the seed attached to the pericarp. In addition, there are 2 commissural vittae close to the lateral bundles.

3.4. *Grammosciadium cornutum*

In the cross-sections of the fruits, the cuticle surrounds the single-layered epidermis cells. There are 9 primary vascular bundles in the pericarp, 3 of which are dorsal, 2 are lateral, and 4 are vallecular. There are 1 orbicular rib oil duct in the upper part of each dorsal and lateral bundle and a few layers of chlorenchyma and parenchyma tissue over these vittae protrudes outward (Figure 4). There are also vallecular vittae under the vallecular bundles, independently of each other. The pericarp layer ends with a single layer of endepidermis cells innermost. Epitegma and fragmented integument layer surround the endosperm. In addition, there are 2 commissural vittae.

4. Discussion and Conclusion

Because of the presence of the vallecular vascular bundles, the mericarps of *G. cornutum* have 9 vascular bundles. However, the other taxa have 5 vascular bundles in their mericarps. Moreover, fruit primary ridges are generally prominent. However, *G. macrodon* subsp. *macrodon* seems to have obscure primary ridges. Tuncay and Yeşil [22] studied the fruit anatomy of *G. daucooides* and mentioned that there are 4 vallecular and 2 commissural vittae in its mericarps. Although not as distinct as in *G. daucooides* mericarp, there are 4 vallecular and 2 commissural vittae in the mericarps of all the taxa. Also, *G. daucooides* has the widest vallecular vittae, measured as 0.18 ± 0.072 mm. According to Zakharova et al. [8], morphological similarity including the obtuse-keeled ribs and winged-marginal ribs can be used as a diagnostic character. From this point of view, in the mericarps of *G. macrodon* subsp. *macrodon* the primary ribs seem to be inconspicuous. However, the other taxa have prominent primary ribs in their mericarps. On the other hand, subsp. *macrodon* only has prominent marginal ribs. Bani et al. [23] distinguished *G. macrodon* subsp. *nezaketiae* from the other taxa, with its tuberculate-striate type of fruit surface. It is also seen from the anatomical slices that, *G. macrodon* subsp. *nezaketiae* has wing-like small striate on the dorsal side primary ribs.

Wojewódzka et al. [24] used several quantitative characters such as mericarp length to width ratio, and dorsal bundle thickness to width ratio to show the evolutionary shift in tribe *Scandiceae* of the family. Also, there are many measurements made in this study that is similar to the previous study. In this research, measurements gathered from the fruits, shown in Table 2. According to these measurements, the fruits of *G. cornutum* have the widest mericarp measured from the commissure area. Also, the length of the dorsal bundle and the size of the endosperm have the highest values. However, in some measurements such as distance between dorsal vittae, length of vallecula the species has the smallest values (Table 2). Moreover, in the fruits of *G. macrodon* subsp. *nezaketiae* the distance between two primary bundles has the shortest value. On the other hand, the fruits of the taxon have the highest values within the measurements as the width of dorsal and lateral bundles and length of commissure and vallecular area. These findings support the previous studies that justified the large vascular bundles of the fruits of *G. macrodon* subsp. *nezaketiae* [15, 25].

In conclusion, the general anatomy of taxa has 4 vallecular and 2 commissural vittae. However, there are differences between the measurements of these that, *G. daucooides* has the widest vallecular vittae. Moreover, only *G. cornutum* has 9 vascular bundles and the other taxa have 5 vascular bundles. And *G.*

macrodon subsp. *nezaketiae* has the widest vascular bundles located both dorsally and laterally. Also, all the taxa have prominent primary ribs, while *G. macrodon* subsp. *macrodon* has just marginal prominent ribs.

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Declaration of Ethical Code

In this study, we undertake that all the rules required to be followed within the scope of the "Higher Education Institutions Scientific Research and Publication Ethics Directive" are complied with, and that none of the actions stated under the heading "Actions Against Scientific Research and Publication Ethics" are not carried out.

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