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## Bazı Endemik *Linum* (Linaceae) Türlerinin Histo-Anatomik Özellikleri

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### **Öne Çıkanlar:**

- Ekonomik bitki
- Tıbbi bitki
- Bitki anatomisi

### **Anahtar Kelimeler:**

- *Linum*
- Linaceae
- Anatomi
- Endemik
- Keten

### **ÖZET:**

Bu çalışmada Kırşehir’de (Türkiye) yayılış gösteren *Linum* cinsine ait endemik iki taksonun anatomik özellikleri araştırılmıştır. *Linum flavum* subsp. *scabrinerve* (P.H.Davis) P.H. Davis kök enine kesitine göre en dış tabakası epidermis hücreleri kaplıdır. Gövde kesitinde ise iletim demetleri devamlı bir halka şeklinde olup üzerinde sklerankima hücreleri belirlenmiştir. Taksonun yaprak mezofili bifasiyaldir. Yaprığın alt yüzeyi 88, üst yüzeyi ise 51 stomaya sahiptir. Az miktarda glandüler tüy bulundurmaktadır. *Linum hirsutum* subsp. *pseudoanatolicum* P. H. Davis sekonder kök yapısına sahiptir. En dıştaki periderm hücreleri oval veya izodiyametik şekillidir. Gövde kesitinde vasküler demetler devamlı bir halka şeklindedir. Korteks tabakası, oval veya dikdörtgen şekilli 9-10 sıra parankimatik hücrelerden oluşur. Taksonun yaprak mezofili ekvisiyaldir. Yaprığın alt yüzeyi ve üst yüzeyi sırasıyla 48 ve 46 stomaya sahiptir. Epidermiste, glandüler veya glandüler olmayan tüyler bulunmaz. Sonuç olarak bu çalışma ile aynı cinsine ait iki farklı taksonun anatomik karşılaştırması yapılmıştır. Elde edilen bulgulara göre türlerin kök yapıları, gövdede sklerankima varlığı, yaprığın stoma büyüklükleri, mezofil tipleri ve glandular tüylerin varlığı gibi özellikleri birbirlerinden farklıdır.

## Histo-Anatomical Characteristics of Some Endemic Species of *Linum* (Linaceae)

### **Highlights:**

- Economic plant
- Medicinal plant
- Plant anatomy

### **Keywords:**

- *Linum*
- Linaceae
- Anatomy
- Endemic
- Flax

### **ABSTRACT:**

In this study, two endemic species belonging to the genus *Linum* distributed in Türkiye were investigated. The outermost layer of the *Linum flavum* subsp. *scabrinerve* (P.H.Davis) P.H.Davis root, according to its cross-section, is covered with epidermis cells. In the stem cross-section, the vascular bundles are in the form of a continuous ring, upon which are sclerenchyma cells. The leaf mesophyll of the taxon is bifacial. The lower surface and the upper surfaces of the leaf have 88 and 51 stomata in order of. Leaf has a few glandular hairs. The root of *Linum hirsutum* subsp. *pseudoanatolicum* P.H. Davis has secondary growth. Periderm cells on the outside are oval or isodiametric in shape. In the stem cross-section, vascular bundles are in the form of a continuous ring. The cortex layer consists of 9-10 rows of oval or rectangular-shaped parenchymatous cells. The leaf mesophyll of the taxon is equifacial. The lower surface and the upper surfaces of the leaf have 48 and 46 stomata, respectively. No glandular or non-glandular hairs are found on the epidermis. As a result, an anatomic comparison of two different taxa belonging to the same genus was made with this study. According to the results, the root structures of the species, the presence of sclerenchyma on the stem, the size of the stomata of the leaf, mesophyll types, and the presence of glandular hairs are different from each other.

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## INTRODUCTION

The Linaceae (Flaxaceae) family is represented by 22 genera. The best known of these is *Linum* L. (Flax). The genus *Linum* includes more than 200 species (Zeven and Wet, 1975). It distributes mainly around the Mediterranean, mostly in the northern hemisphere, the Middle East (Near East), Europe, temperate regions of Asia, North Africa, and North America (Zohary and Hopf, 1993; Vromans, 2006). There are 36 species of *Linum* (Flax) in Europe, eight species in Cyprus, nine species in Israel, 13 species in Iraq, 45 species in Russia, 15 species in Iran, and 39 species in Türkiye. The Balkan Peninsula and Anatolia are among the most important distribution areas and diversity centers of *Linum* in the world. The high rate of endemism and the high number of subspecies and varieties indicate that Anatolia is one of the gene centers of this genus (Yılmaz et al., 2003).

In the western regions of Eurasia, flax is mostly grown for its fiber, and in the eastern regions, it is grown for its oil (Gill, 1987; Sankari 2000; Vromans, 2006). The agricultural history of flax dates back to the Stone Age. It is known that flax was cultivated 6000-8000 years ago in Egypt and Sumer-Mesopotamia, together with the oldest agricultural plants, barley and wheat (Hayward, 1948; Zohary and Hopf, 1993; Şahin, 2020).

Flax can be evaluated in many ways in terms of usage areas and benefits. In addition to being used in the production of linen fabric and the production of edible or non-edible industrial oil, it is used in ship rope and sail, tent cloth, hose production, gas mask, linoleum production, paint, the lacquer and varnish industry, hard plywood, paper, vegetable oil, oil puree and resin production, and heat insulation material production (Delorit et al., 1984; Schuster, 1992; Carter, 1993; Kurt, 1996). It has been determined that flax reduces some heart diseases, burns, cough, and asthma (Jhala and Hall, 2010; Ahmada et al., 2018). In addition, the ground seeds of flax, which are known by local names such as Zeyrek or Cimit among the people in Central Anatolia, are also used externally as a folk medicine with the effect of healing open wounds or ripening boils (Ezer and Avcı, 2004). In recent years, podophyllotoxin isolated from various flax species has been determined to have antibacterial, antiviral, and anticarcinogenic properties (Yılmaz, 2003).

This study aimed to reveal the anatomic similarities and differences between some endemic *Linum* species distributed around Kırşehir. Determining the differences between two species that are distributed in the same ecologic conditions will be important in distinguishing the species. In addition, anatomic studies on *Linum* are limited. For this reason, this research will be a source for future studies on the genus *Linum*.

## MATERIALS AND METHODS

In this study, the taxa belonging to the genus *Linum* were examined. Specimens of the species used in the research were collected from Kırşehir (Türkiye) and its surroundings from the edges of fields and open fields between April and September 2020, when the plants were in bloom (Table 1).

**Table 1.** Information about the studied taxa

Taxa	Locality	Altitude (m)	Voucher, Date	Alcohol stock number
<i>Linum flavum</i> subsp. <i>scabrinerve</i> (P.H.Davis) P.H.Davis	Akçakent-Kırşehir	1415	Sulcay60, 2019.06.13	A141
<i>Linum hirsutum</i> subsp. <i>pseudoanatolicum</i> P.H.Davis	Kırşehir-Province	1037	Sulcay60, 2019.05.30	A86

Plant samples were identified according to Flora of Turkey (Davis, 1967). Some of the collected materials were stored as herbarium samples in Kırşehir Ahi Evran University, Faculty of Agriculture, Field Crops Laboratory, and some of them were fixed in 70% alcohol.

To determine the anatomic characteristics, first, parts of the plant such as the root, stem, and leaf were divided into small parts. Sections were taken by hand. Glycerin was used as the examination medium in the sections. Semi-permanent preparations were prepared by sealing the edges of the preparations using glycerin-gelatin (Vardar, 1987) and photographs were taken with an Amscope MU1803-HS camera attached to a Nikon microscope. In addition, an average of 25 anatomic measurements were made from tissues such as the epidermis, parenchyma, collenchyma, and trachea seen in the sections (Table 2)

## RESULTS AND DISCUSSION

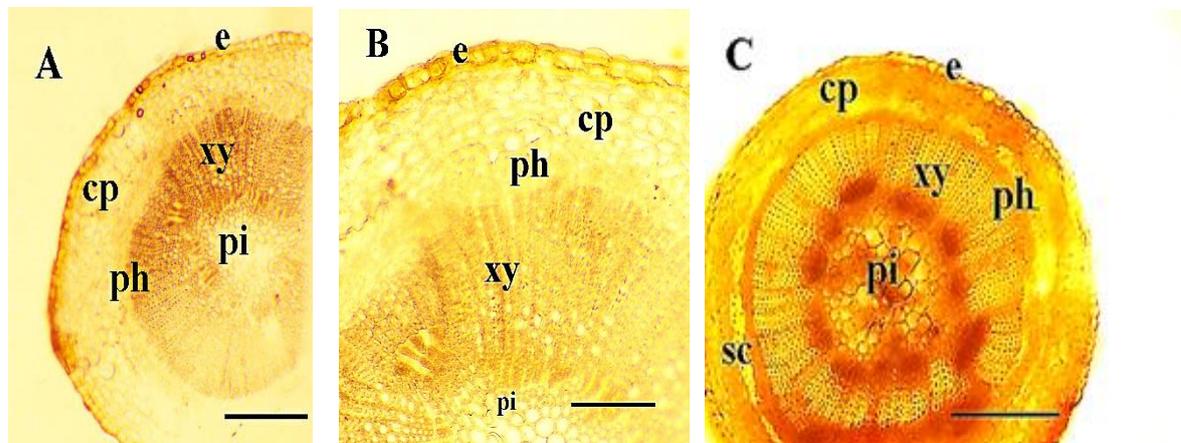
### *Linum flavum* subsp. *scabrinerve* (P.H. Davis) P.H. Davis.

#### Roots

In the outermost part of the root, there is a single layer of epidermis. The cortex is highly narrowed and consists of multiple rows of parenchymatous cells. Sclerenchymatous cells are formed on the phloem, which is in 4-5 rows. The xylem is in 9-10 rows towards the center. The pith region consists of circular-shaped parenchymatous cells (Figure 1 A, B).

#### Stem

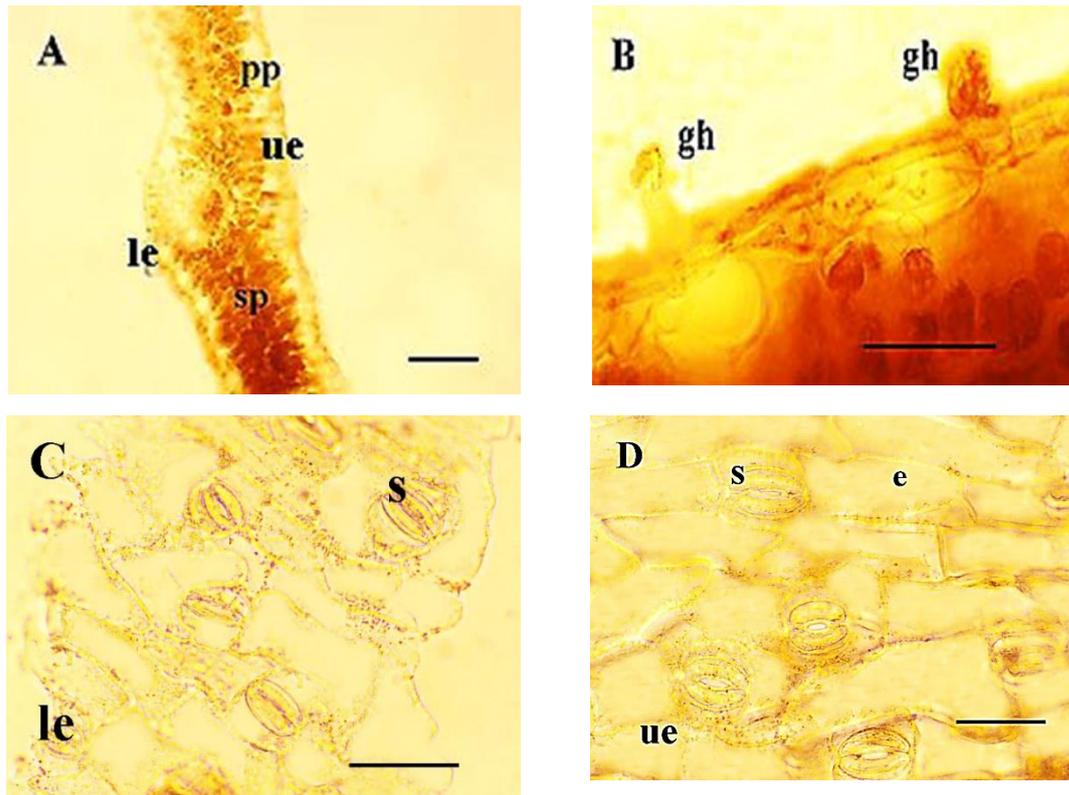
In cross-sections of the stem, there is a single layer of epidermis in the outermost layer. Epidermis cells are thick-walled and oval-shaped. The cortex layer is formed by oval or rectangular parenchyma cells. Vascular bundles are in the form of a continuous ring. Phloem occupies a narrower area than the xylem. The cambium is indistinct. Sclerenchyma cells are formed on the vascular elements. Pith is composed of parenchyma cells and the size of the parenchyma cells increases towards the center (Figure 2 C).



**Figure 1.** Cross-sections of *L. flavum* subsp. *scabrinerve* (A-B) Root cross-section, (C) Stem cross-section, cp: cortex parenchyma, e; epidermis, ph; phloem, pi; pith, xy; xylem (Scale 100  $\mu$ m)

#### Leaf

The upper and lower surfaces of the leaf are surrounded by a single-layered epidermis. Glandular hairs are scant on the upper and lower surfaces of leaves. The mesophyll layer is of bifacial type and consists of 1-2 layers of spongy parenchyma and 1-2 layers of palisade parenchyma. Paracytic-type stomata are scattered on both the lower and upper surfaces. The lower surface and the upper surface of the leaf have 88 and 51 stomata, respectively (Figure 2 C, D).



**Figure 2.** Cross-sections (A, B) and superficial of *L. flavum* subsp. *scabrinerve* (C, D). e; epidermis, gh; glandular hair, le; lower epidermis, s; stomata, ue; upper epidermis (Scale 100  $\mu$ m)

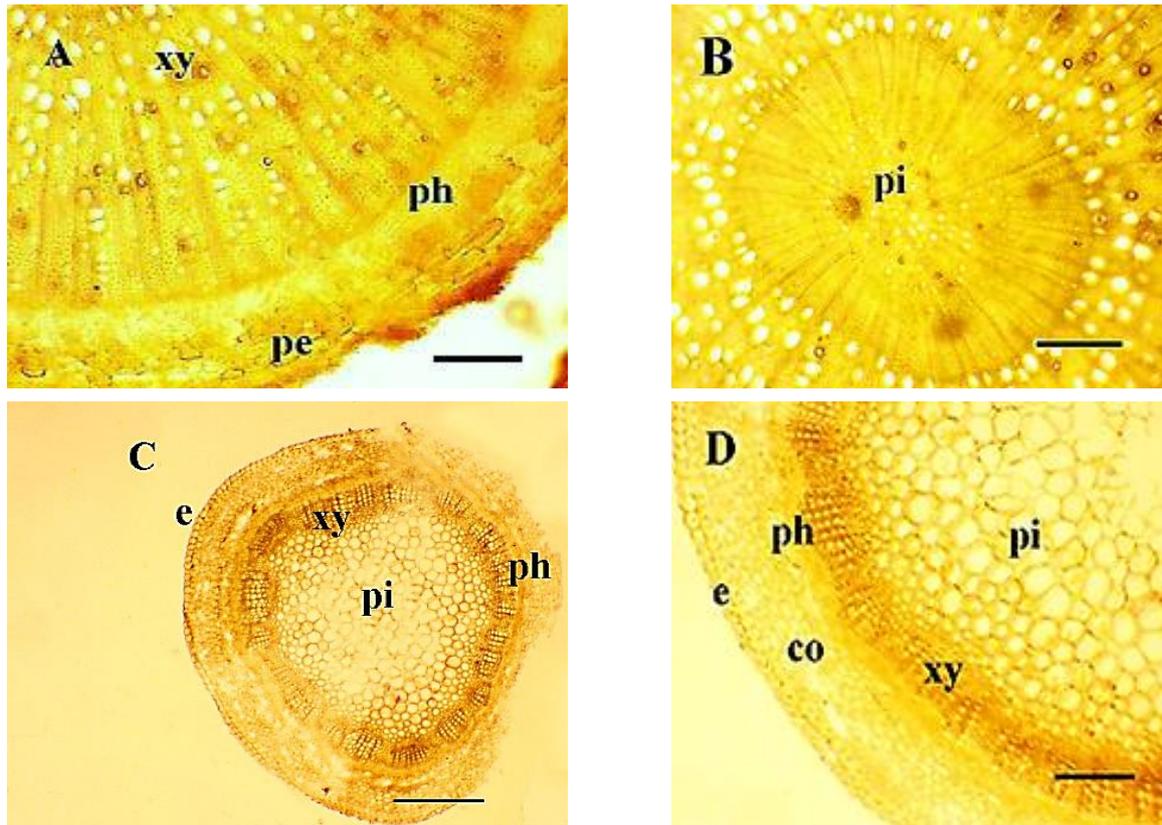
### *Linum hirsutum* subsp. *pseudoanatolicum* P. H. Davis

#### Roots

The root is a secondary structure. Periderm cells on the outside are oval or isodiametric in shape. Phellem elements are dark in color and fragmented in places. Cortex parenchyma cells are cylindrical and 6-7 layered. Phloem covers a narrow area. The secondary xylem has 9-10 layers. Secondary xylem elements are quite prominent and cover a large area (Figure 3 A, B).

#### Stem

In the cross-section of the stem of the taxon, there are oval and rectangular epidermis cells arranged in a single row on the outer surface. The cortex layer consists of 9-10 rows of oval or rectangular-shaped parenchymatous cells. In the vascular bundles, the xylem occupies a larger area than the phloem, and the vascular elements form a continuous ring. The cambium is not prominent. There is a parenchymatous pith in the center. Parenchyma cells increase in size towards the center (Figure 3 C, D).

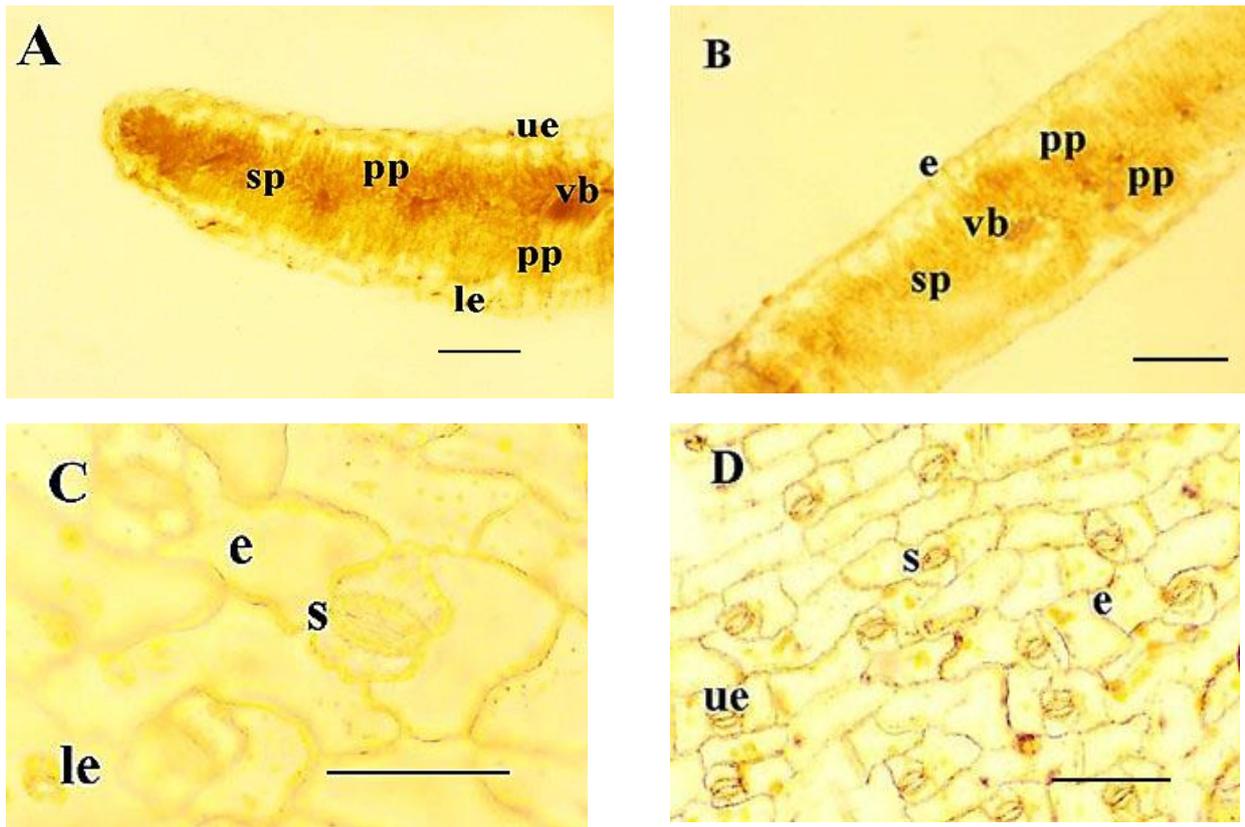


**Figure 3.** Cross-sections of *L. flavum* subsp. *scabrinerve* (A, B) Root cross-section (C, D) Stem cross-section co; cortex parenchyma, e; epidermis, pe; periderm, ph; phloem, pi; pith, xy; xylem (Scale 100  $\mu$ m)

### Leaf

The epidermis on the lower and upper surfaces of the leaf of the taxon is single-layered and the walls are undulating. No glandular or non-glandular hairs are found on the epidermis. The mesophyll layer is of equifacial type and consists of 1-2 layers of palisade parenchyma and 2-3 layers of spongy parenchyma (Figure 4 A, B). Stomata are scattered on both surfaces of the leaf. There are paracytic-type stomata on the upper and lower surfaces of the leaves. The lower surface and the upper surface of the leaf have 48 and 46 stomata, respectively (Figure 4 C, D).

In this study, the anatomic features of two species belonging to the genus *Linum*, which are medically and economically valuable in Kırşehir and its surroundings, were examined. The root structures of the species are different from each other. According to the sections taken from the roots of the species, the outermost layer of the root is the epidermis in the *L. flavum* subsp. *scabrinerve* and is the periderm in the *L. hirsutum* subsp. *pseudoanatolicum*. The outermost layer of *Linum nervosum* Waldst. is the periderm (Serebryanaya et al. 2014). In both species, xylem components cover a larger area than phloem components, and the pith is filled with xylem elements. The pith region of the root of the *Linum luteolum* M.Bieb. is filled with xylem elements (Serebryanaya et al. 2014). The species are similar to each other in that the vascular bundles form a continuous ring. Findings related to the root anatomy of the species are presented for the first time in this study.



**Figure 4.** Cross-sections (A, B) and superficial of the leaf of *L. hirsutum* subsp. *pseudoanatolicum* (C, D). e; epidermis, le; lower epidermis, s; stomata, ue; upper epidermis (Scale 100  $\mu$ m)

**Table 2.** Anatomic measurements obtained from *Linum* species

Characters	<i>L. flavum</i> subsp. <i>scabrinerve</i>		<i>L. hirsutum</i> subsp. <i>pseudoanatolicum</i>	
	Width ( $\mu$ m)- Mean $\pm$ Se	Length ( $\mu$ m)- Mean $\pm$ SE	Width ( $\mu$ m)- Mean $\pm$ SE	Length ( $\mu$ m)- Mean $\pm$ SD
<b>Root</b>	Epidermis	54.39 $\pm$ 1.59	76.03 $\pm$ 1.79	
	Periderm			62.81 $\pm$ 0.93
	Pith parenchyma	44.10 $\pm$ 18.36		132.50 $\pm$ 11.43
	Cortex parenchyma	33.47 $\pm$ 2.56	88.52 $\pm$ 17.50	45.73 $\pm$ 3.95
<b>Stem</b>	Xylem	22.42 $\pm$ 7.61		40.79 $\pm$ 13.28
	Epidermis	26.87 $\pm$ 0.65	57.40 $\pm$ 0.45	42.16 $\pm$ 2.30
	Pith parenchyma	57.40 $\pm$ 3.45		69.70 $\pm$ 3.89
	Cortex parenchyma	26.05 $\pm$ 0.43	36.9629 $\pm$ 2.29	36.96 $\pm$ 2.29
	Xylem	33.68 $\pm$ 1.67		27.12 $\pm$ 4.42
<b>Leaf</b>	Epidermis	43.47 $\pm$ 13.50	44.62 $\pm$ 4.63	80.72 $\pm$ 14.00
	Palisade parenchyma	29.01 $\pm$ 2.62	67.9975 $\pm$ 9.12	45.60 $\pm$ 2.36
	Spongy parenchyma	32.01 $\pm$ 3.34		85.59 $\pm$ 2.32
	Lower surface stomata	41.68 $\pm$ 3.59	56.31 $\pm$ 6.25	71.39 $\pm$ 6.86
	Upper surface stomata	55.02 $\pm$ 2.51	82.31 $\pm$ 2.43	51.49 $\pm$ 1.60

Metcalf and Chalk (1950) reported that *Linum* stem and leaf anatomy were important in plant taxonomy. The stem cross-sections of the species differ from each other in shape. The stem cross-section of the *L. flavum* subsp. *scabrinerve* is a complete circle, whereas the cross-section shape of *L. hirsutum* subsp. *pseudoanatolicum* is not a regular circle. The stem shapes of *Linum album* Ky.ex Boiss. and *L. mucronatum* Bertol. subsp. *mucronatum* are polygonal (Talebi et al. 2015). The mesophyll of *L. hirsutum* subsp. *pseudoanatolicum* is equifacial (isolateral). The leaves of *L. nervosum* var. *nervosum*, *L. nervosum* var. *bungei*, *L. strictum* var. *strictum*, *L. strictum* var. *spicatum*, *L. glaucum*, *L. mucronatum* subsp. *mucronatum*, *L. usitatissimum* var. *usitatissimum* and *L. corymbulosum* are isobilateral (Talebi et al. 2015). The stomata width and length measurements on both the lower and upper surfaces of *L. hirsutum* subsp. *pseudoanatolicum* are higher.

## CONCLUSION

As a result, with this study, the anatomic features of two endemic taxa of the same genus distributed in the same ecological conditions were compared. According to the findings, the root structures of the species, the presence of sclerenchyma on the stem, the size of the leaf stomata, and the presence of glandular hairs and mesophyll types are different from each other.

## Conflict of Interest

The article authors declare that there is no conflict of interest between them.

## Author's Contributions

The authors declare that they have contributed equally to the article.

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