Original Article

Istanbul J Pharm 48 (1): 6-11
DOI: 10.5152/IstanbulJPharm.2018.374759

Leaf indumentum in some Turkish species of *Teucrium* (Lamiaceae)

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Cite this article as: Ecevit-Genç G, Özcan T, Dirmenci T. Leaf indumentum in some Turkish species of *Teucrium* (Lamiaceae). Istanbul J Pharm 48 (1): 6-11.

ABSTRACT

Trichome micromorphology can be used as a discriminating character in the separation of species and subspecies. The micromorphological characteristics of foliar trichomes from five *Teucrium* taxa (*T. scordium* subsp. *scordium*, *T. sirnakense*, *T. chasmophyticum*, *T. andrusi* and *T. spinosum*) were investigated by scanning electron microscope. Seven types of trichomes were identified, including glandular and non-glandular. The glandular trichomes were recorded in three types; short clavate, long clavate, and subsessile. The non-glandular trichomes were identified with four types; unicellular thin-walled, 2(5)-celled thin-walled, 3–7(11)-celled flexuose, elongated thin-walled and 2-celled thick-walled trichomes. Generally, the trichome types were similar on both sides of the leaves, except in *T. spinosum*. Subsessile glandular trichomes were the most common type and were occurred in all the investigated species. Also clavate glandular trichomes were found in all the species, except *T. scordium* subsp. *scordium*. All trichomes were distinctively thick-walled, whereas thin-walled trichomes were observed in only *T. chasmophyticum* species. The leaf micromorphology of *T. sirnakense* and *T. chasmophyticum* has also been reported in detail for the first time in this study.

Keywords: Teucrium, Lamiaceae, trichome, micromorphology, SEM, leaf indumentum

INTRODUCTION

Teucrium L. belong to the Lamiaceae family is a well-known, wide-distributed and also one of the largest genus with more than 260 species distributed all around the world. (Kastner 1989; Abu-Assab and Cantino 1993). Mediterranean region, the center of diversity of the genus, has about 96% of all taxa (Cantino et al. 1992; Navarro and El Oualidi 2000).

Teucrium species have been divided into ten sections all over the world regarding their calyx shapes and the inflorescence structures (McClintock and Epling 1946; Tutin and Wood 1972). These are the sections: sect. *Teucriopsis* Benth., sect. *Teucrium*, sect. *Chamaedrys* Miller Schreber, sect. *Polium* Miller Schreber, sect. *Isotriodon* Boissier, sect. *Pycnobotrys* Bentham, sect. *Scorodonia* (Hill) Schreber, sect. *Stachyobotrys* Bentham, sect. *Scordium* Reichenbach, and sect. *Spinularia* Boissier. The species of the Teucriopsis and Pycnobotrys sections are not distributed in Turkey. (Ekim 1982). The eight sections of the genus, consist of 49 taxa (36 species) and 18 of them endemic are naturally grown in Turkey (Govaerts 1999; Duman 2000; Dönmez 2006; Parolly and Eren 2007; Dönmez et al. 2010; Dinç et al. 2011, Dirmenci 2012; Özcan et al. 2015; Vural et al. 2015; Dinç and Doğu 2016).

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Received: 04.01.2018
Accepted: 05.03.2018

Teucrium sirnakense Özcan and Dirmenci (endemic) and *T. scordium* L. subsp. *scordium* (Sect. *Scordium*), *T. andrusi* Post (endemic) and *T. chasmophyticum* Rech. f. (Sect. Isotriodon and *T. spinosum* L. (Sect. *Spinularia*) were examined in this study. Sect. *Scordium* has toothed leaves, rectangular stems, subgibbous calyces and subequal calyx teeth, and Sect. *Isotriodon* has dentate or entire leaves, terete stems, gibbous and bilabiate calyces. Sect. *Spinularia* is quite different than these two sections. *T. spinosum* is the only annual species in the Turkish *Teucrium*, and has resupinate corolla according to Flora of Turkey (Ekim 1982).

Teucrium species has traditionally been used in Turkey for abdominal pain, antidiabetic, antipyretic, stomachache, common cold, high fever and rheumatic pain (Aksoy-Sagirli et al. 2015).

Plant trichomes are important to descriptive and experimental botanists and data about them and their indumenta are routinely included in many studies. Many authors, such as Behnke (1984); Navarro and El Oualidi (2000); Beyrouthy et al. (2009); Moon et al. (2009); Kaya et al. 2012; Khalik and Hassan (2012); Osman (2012); Ecevit-Genç et al. (2017); Genç et al. (2017); Zareh et al. (2017) emphasize the importance of trichomes in taxonomy.

In many genera of Lamiaceae, the trichome morphology is very useful for the classification of all taxonomic levels (Marin et al. 1994; Navarro and El Oualidi 2000; Moon et al. 2009; Salmaki et al. 2009; Ecevit-Genç et al. 2015, 2017).

Trichomes are widely distributed over the different parts of the Lamiaceae genus and they are generally distinguished as glandular and non-glandular trichomes. Micromorphological features, especially trichomes, are avaiable taxonomic characters in *Teucrium*. Trichomes have an important role in the infrageneric classification of the genus. There have been many studies on the trichomes of *Teucrium* species in recent years (Navarro and El Oualidi 2000; Grubesic et al. 2007; Dinç et al. 2011; Eshratifar et al. 2011; Doğu et al. 2013, Ecevit et al. 2015, 2017).

The main purposes of this paper are to provide a detailed description of the leaf micromorphology of five *Teucrium* species belonging to three different sections.

MATERIALS AND METHODS

The material was collected from different localities in Turkey by the authors. Voucher specimens have been deposited in the ISTE. A list of taxa included in the study was given in Table 1.

For the micromorphological study, the materials were obtained from collected specimens and micromorphological investigations were conducted using scanning electron microscope (SEM). For SEM analysis, leaves parts were mounted on the stubs and coated with gold layer. They were studied with a scanning electron microscope (FEI Quanta 450 FEG-EDS). All leaves were scanned from adaxial and abaxial surfaces. Terminology of the indumenta on leaves were based on Navarro and El Oualidi (2000), (Table 2).

RESULTS

The micromorphological characteristics and distribution of the trichomes on leaves of five *Teucrium* taxa were examined in this study. Different type of indumentum shows considerable among species (Table 3). SEM micrographs of all indumentum types are presented in Figure 1.

In the sect. Scordium, *T. scordium* subsp. *scordium* leaves have sparsely B, C1 and C2 trichome types on both surface, although *T. sirnakense* leaves have A1, A2, B type glandular trichomes and C2 and C3 non-glandular trichomes on the adaxial and abaxial surface. Dense indumentum appears on the abaxial surface than the adaxial surface of this species leaves (Figure 1).

In the Sect. *Isotriodon*, *T. chasmophyticum* has A1, B, D trichome types on both surface of the leaves. The lower surface of the leaf has a much denser indumentum than the upper surface (Figure 1). *T. andrusi* has A1, A2, B, C2, C3 trichome types adaxial and abaxial surface of the leaves. Dense indumentum appears on both surface of the leaves (Figure 1). *Teucrium spinosum* belongs the sect. Spinularia, A2, B, C2 trichome types are observed at the abaxial surface of leaves; A2, B, C3 trichome types were found on the adaxial surface of leaves (Figure 1).

Table 1. Collection data of *Teucrium* taxa studied.

Taxon	Collection data
T. scordium subsp. scordium	Edirne, İpsala border gate, 01.viii.2014, T.Dirmenci, ISTE 101 691
T. sirnakense	Şırnak, Taşdelen village, rocky slopes, 10.vi.2013, T.Dirmenci, E.Akçiçek, Ö.Güner, ISTE 101 694
T. chasmophyticum	Siirt, Between Eruh-Gölgelikonak village, 11.vi.2013, T.Dirmenci, E.Akçiçek, Ö.Güner, ISTE 101 711
T. andrusi	Mardin, Bakırkırı hill, cliffs, 23.vi.2013, T.Özcan, M.Açar, ISTE 101 712
T. spinosum	Diyarbakır, Diyarbakır–Ergani roadsides, 09.vi.2014, T.Dirmenci, E.Akçiçek, Ö.Güner, ISTE 101 719

ISTE: Herbarium of the Faculty of Pharmacy of İstanbul University

Table 2. Trichome types (Navarro and El Oualidi 2000)

	Glandular trichomes
A	Clavate glandular trichomes
A1	Short clavate glandular trichomes. Generally with two, large and thin stalk cells.
A2	Long clavate glandular trichomes. Generally with long 3-5 stalk cells.
B	Subsessile glandular trichomes, peltate trichomes
	Non-glandular trichomes
C	Thin-walled trichomes
C1	Triangular, large and very thin –walled unicellular hairs.
C2	Large, thin-walled, 2(5)-celled trichomes which are acute apical cell. Internodes have ridges or marked.
C3	Flexuose and elongated, 3-7(11)-celled trichomes, with internodes distinct, the apical cell acute with micro-papillae.
D	Short and slightly conical, generally 2-celled thick-walled trichomes which are pointed short or elongated apical cell, erect or sometimes slightly curved.

Table 3. Trichome types and distribution on the adaxial–abaxial leaf surfaces of studied *Teucrium* taxa

Section	Taxon	Leaves trichomes (According toNavarro & El Oualidi 2000)	
		Adaxial surface	Abaxial surface
Scordium	*T. scordium subsp. scordium*	B, C1, C2	B, C1, C2
	T. sirnakense	A1, A2, B, C2, C3	A1, A2, B, C2, C3
Isotrion	*T. chasmophyticum*	A1, B, D	A1, B, D
	T. andrusi	A1, A2, B, C2, C3	A1, A2, B, C2, C3
Spinularia	*T. spinosum*	A2, B, C2	A2, B, C3

DISCUSSION

Trichome morphology is the useful taxonomic markers in some genera of Lamiaceae. Their absence or presence can be used as taxonomic characters in the infrageneric classification of some genera (Metcalfe and Chalk 1950; Navarro and El Oualidi 2000; Moon et al. 2009). For the classification of trichome in *Teucrium*, distinction into thin and thick-walled provides taxonomic support to the delimitation of the species, could be regarded as a valid taxonomic character (Navarro and El Oualidi; Eshratifar et al. 2011; Ecevit-Genç et al. 2015, Ecevit-Genç et al. 2017).

As a result of our work, seven trichome types were observed in five species belong to three different section of Teucrium (Table 2). The trichome types located on the adaxial and abaxial sides of leaves are same except *T. spinosum*. Among them subsessile glandular trichomes are most widespread in all taxa examined. Clavate glandular trichomes are generally found all of the species except *T. scordium* subsp. *scordium*. 2-celled thick-wall non-glandular trichomes are common trichome types but only T. *chasmophyticum* have thin-wall non-glandular trichome. In this work, the leaves trichome micromorphology of *T. sirnakense, T. chasmophytum* are reported in detail by SEM for the first time.

Many studies have been presented about leaves indumentum of *Teucrium* species. For example, 56 *Teucrium* species related to the nine sections were investigated by Navarro and El Oualidi (2000). The authors analyzed five species of the sect. *Spinularia* including *T. spinosum* and they found different trichome types between species. According to their results, *T. spinosum* has flexuose and elongated thin-walled non-glandular trichomes and subsessile glandular trichomes. In addition to this species, long clavate glandular and large thin-walled non-glandular trichome types were identified in this study. The authors have investigated four species of sect. *Isotriodon*. Thick-walled non-glandular and long clavate glandular trichomes are most common trichomes and flexuose and elongated thin-walled trichome types are less frequent in this section according to Navorro and El Oualidi (2000). But elongated 5-7(8)-celled thick-wall non-glandular trichomes was not observed on any taxa of studied in this study. Also long clavate glandular trichomes were not observed on *T. chasmophytum*.

We have observed subsessile glandular trichomes and large thin-walled non-glandular trichomes on *T. scordium* subsp. *scordium* leaves. The other subspecies of *T. scordium* subsp. *scordioides* leaves indumentum was investigated in many previous studies and long clavate glandular trichomes, subsessile glandular trichomes and flexuose and elongated thin-walled

non-glandular trichomes were found by Navorro and El Oualidi (2000) and Ecevit-Genç et al. (2017). Peltate, capitate acicular and flagelliform trichome types were found by Jurišic Grubešic et al. (2007). According to all these findings trichome types are show some differences between two subspecies.

T. scordium investigated morpho-anatomically by Lakusic et al. (2010) from Balkan peninsula and they found glandular (peltate, unicellular capitate, multicellular capitate), and non-glandular (unicellular unbranched, multicellular unbranched) trichomes on the leaves of this species. But the unicellular trichomes were not observed on the leaves of *T. scordium* subsp. *scordium* in this study.

Clavate glandular trichomes are ordinarily observed on the leaves of taxa of sect. *Isotriodon* by our team's previous paper (Ecevit-Genç et al. 2017). The results of this study about the species of the sect. *Isotriodon* are overlapped with the previous study of our team. *T. andrusi* leaves were examined by Dinç et al. (2011) and their results are corresponding to our results.

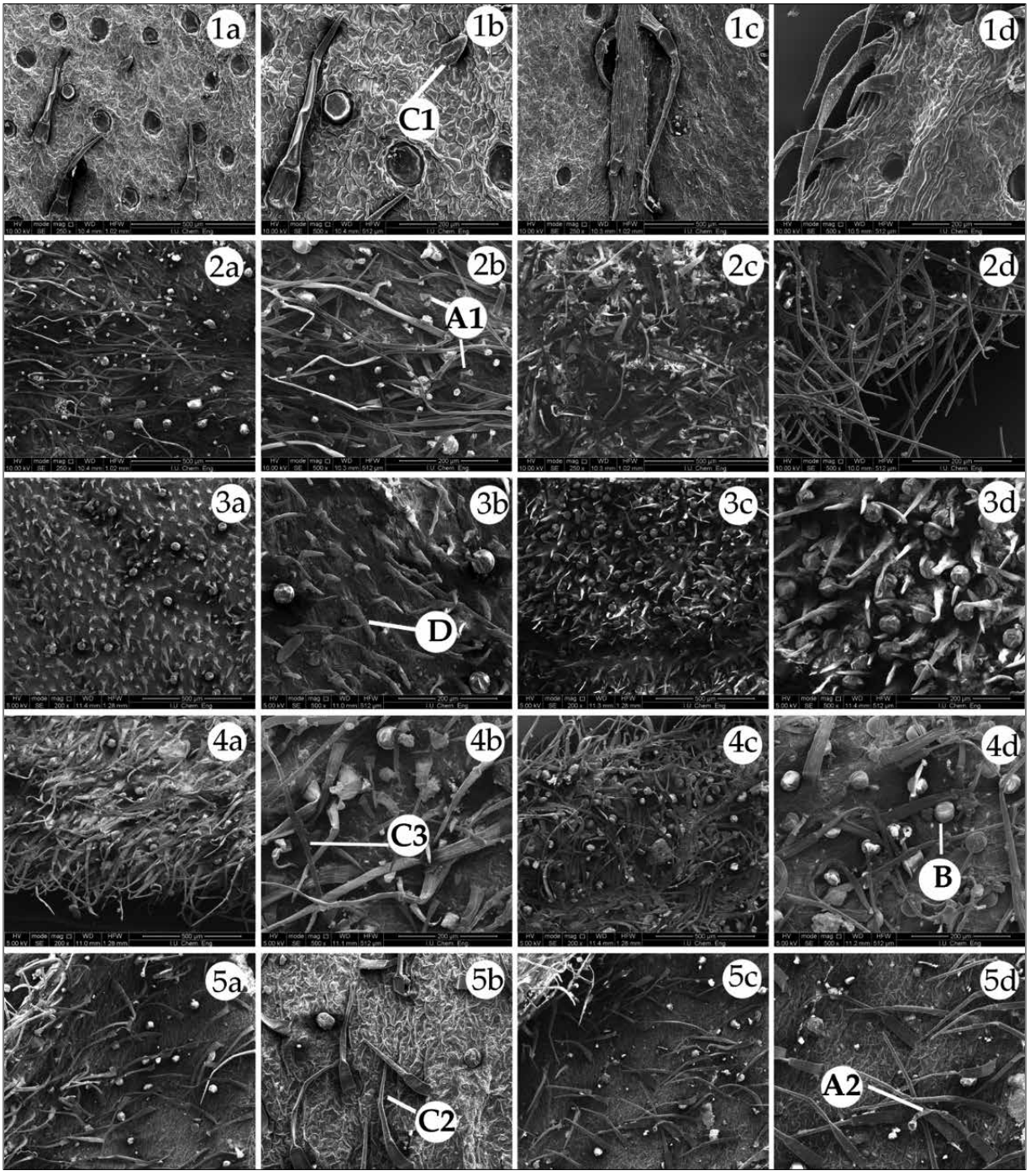


Figure 1. a-d. SEM micrographs of leaves of *Teucrium*. Adaxial surface (a, b), abaxial surface (c, d). *T. scordium subsp. scordium* (1), *T. sirnakense* (2), *T. chasmophytum* (3), *T. andrusi* (4), *T. spinosum* (5). (scale bars: a, c =500 micrometer (μm); b, d =200 μm).

This paper gives detailed information on the micromorphological features of the *T. spinosum, T. scordium* subsp. *scordium, T. sirnakense, T. chasmophytum* and *T. andrusi* species. We concluded that trichome types are useful for specific delimitation of *Teucrium* species. However, micromorphological features must be supported by other morphological, molecular, biogeographical characters.

Acknowledgements

This work was supported by the Research Fund of Istanbul University (Project number 31081) and Research Fund of Balıkesir University (Project number 2012/8).

Conflict of Interest: The authors have no conflict of interest to declare.

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