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The Essential Oil Compositions of *Teucrium* spp. Belonging to the Section *Polium* Schreb. (Lamiaceae) Growing in Cyprus

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Abstract: The genus *Teucrium* L., belonging to the family Lamiaceae, is divided in ten sections including *Polium* (Mill.) Schreb. In Cyprus, this section is represented by five endemic species: *T. micropodioides, T. cyprium, T. karpasiticum*, *T. kyreniae* and *T. salaminium*. Essential oils of the aerial parts of these species were separately obtained by hydrodistillation using a Clevenger-type apparatus. Chemical compositions of the obtained oils were analyzed by GC and GC/MS, simultaneously. The essential oil yields ranged between 0.03-0.75 (v/w). The major components of the essential oil of *T. kyreniae* were β-caryophyllene (21.2%), (*E*)-nerolidol (10.9%), carvone (8.8%) and α-humulene (7.9%). *T. salaminium* essential oil was dominated by β-caryophyllene (15.2%), caryophyllene oxide (13.9%), germacrene D (11.6%) and bicyclogermacrene (10.0%). Major components of the oil of *T. cyprium* were β-pinene (35.4%), α-pinene (10.6%) and spathulenol (8.4%). Major compounds of the oils of *T. micropodioides* samples, collected from two different locations, were (1) limonene (47.0%), β-pinene (16.0%) and β-caryophyllene (6.9%), (2) δ-cadinene (11.2%), 1-epi-cubenol (7.8%), cubebol (4.7%), cubenol (4.1%), respectively. Main constituents of the essential oil of *T. karpasiticum* were limonene (43.9%), β-pinene (16.0%), α-bisabolol oxide A (7.8%), β-caryophyllene (5.5%) and α-pinene (4.6%). The section *Polium*, is considered a complex and the diversity of oil compositions from the species belonging to this section provided additional proof to this consideration.

Keywords: Lamiaceae; section *Polium; Teucrium* spp.; Cyprus; endemic; essential oil.

1. Introduction

The genus *Teucrium* L., belonging to the family Lamiaceae, is a large and polymorphic genus which is represented mostly by perennial, bushy, or herbaceous plants [1, 2]. On the "Plant list database" 342 names have been accepted for the *Teucrium* taxa [3]. This genus has been divided into ten sections: *Teucropsis* Benth., *Teucrium* Benth., *Chamaedrys* (Mill.) Schreb., *Spinularia* Boiss., *Isotriodon* Boiss.,

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Pycnobotrys Benth., *Scorodonia* (Hill) Schreb., *Stachyobotrys* Benth., *Scordium* (Mill.) Benth., and *Polium* (Mill.) Schreb. [4]. The members of this genus are distributed in the Mediterranean and Southwestern Asian regions [1, 4-6].

In the flora of Cyprus, the taxa belonging to the genus *Teucrium* are classified under five different sections of which are *Teucrium, Scorodonia, Scordium, Chamaedrys* and *Polium* [4]. The two endemic species of *Teucrium* belonging to sect. *Polium* Schreb. are *T. micropodioides* Rouy and *T. cyprium* Boiss. The latter is represented by two subspecies, subsp. *cyprium* and subsp. *kyreniae* P.H. Davis [1]. However as a result of the revision of this section by Hadjikyriakou and Hand, 2008 [7] four endemic species were identified. The rank of two subspecies subsp. *cyprium* and subsp. *kyreniae* were lifted by him as species which are *T. kyreniae* and *T. cyprium,* and *T. micropodioides*, which is also endemic, remained at the same rank. In addition, a new endemic species, *T. karpasiticum* Hadjik.&Hand, was reported in the same publication, which shows a close relationship with *T. micropodioides*. It was also noted that the probability of a close relationship between *T. cyprium* and a Libyan species *T. davaeanum* may exist [7]. Later on, one more endemic species, *T. salaminium* Hadjik.&Hand was reported. This species shares many morphological characteristics with *T. micropodioides*, however, separated by different growth form, coloration of leaves and flowers and structure of inflorescences. All these five endemic species belong to the section *Polium* subsect. *Rotundifolia* Valdés Berm.&Sánchez-Crespo. [8].

The phytochemistry of both nonvolatile and volatile constituents of the genus *Teucrium* has been investigated and reviewed [9-15]. The *neo*-clerodane diterpenoids are considered as chemo-taxonomically important markers of the genus and also some other metabolites such as abietane diterpenes, sesquiterpenes, triterpenes, steroids, flavonoids, iridoids, and aromatic compounds have been reported [9-15]. The chemical compositions of the essential oils of the genus *Teucrium* have been summarized by Candela et al.[15].

In many countries, *Teucrium* sp. have been consumed mostly as herbal tea in order to treat various health problems such as common cold, pain, rheumatism and some digestive disorders [15]. The phytochemistry and some biological activities of some *Teucrium sp.* growing in Cyprus has earlier been reported [16-21]. According to ethnopharmacological research into medicinal plants of Cyprus, the species classified under the section *Polium* have been used against various health disorders. In a study, *T. micropodioides* was mentioned as probably the best known *Teucrium sp.* in Cyprus. It is used both internally and externally. For internal usage, the infusions of different parts of the plant have been utilized for different pharmacological activities e.g., an infusion of flowers is used as sedative, however, an infusion of leaves is used as stimulant and stomachic. For external usage, it is used as a bath or compress for anti-rheumatism, antipyretic and antiseptic effects [16]. In addition, flowers/inflorescences of the same species are used externally for treatment of catarrh and common cold, traditionally [22]. Moreover, the usage of the same species was reported for digestive and mental-nervous system disorders [23]. On the other hand, it was mentioned that the aerial parts of *T. cyprium* are used against fever and jaundice as an infusion and the juice of the fresh plant is topically used for healing, astringent and antipruritic effects [16].

The aim of this study was to analyze the essential oil compositions of the aerial parts of *Teucrium* sp. (*T. micropodioides, T. cyprium, T. karpasiticum, T. kyreniae* and *T. salaminium)* belonging to the section *Polium.* As far as we know the essential oil compositions of *T. cyprium* and *T. micropodioides* were reported previously [16] although the others are herein reported for the first time.

2. Materials and Methods

2.1. Plant Materials

The aerial parts of *Teucrium* sp. (*T. micropodioides, T. cyprium, T. karpasiticum, T. kyreniae* and *T. salaminium)* were collected during the flowering period and the voucher specimens are kept at the Near East University Herbarium (NEUN10264-10269). All plant materials were dried under shade at room temperature. The collection dates, locations and their specimen numbers could be seen at Table 1.

Table 1. The collection dates and locations, voucher specimen numbers of the *Teucrium sp.*

Species	**Locations / Collection Dates**	**Specimen Number**
T. cyprium	Lemessos - Troodos Mountains / 15.05.16	NEUN10269
T. karpasitium	Karpas - Dipkarpaz / 22.05.18	NEUN10264
T. kyreniae	Kyrenia - Alevkayası / 27.05.16	NEUN10265
T. micropodioides	Kyrenia - Buffavento Castle Road / 03.05.16	NEUN10266
	Karpas - Avtepe / 23.05.16	NEUN10267
T. salaminium	Famagusta - İncirli Cave / 23.06.16	NEUN10268

2.2. The Isolation of Essential Oils

100 g of the air dried aerial parts of each plant material were hydrodistilled with 1L distilled water for 3 hours using Clevenger-type apparatus. The resulting essential oils were stored at 4ºC until the analysis. The essential oil yields were calculated on a moisture free weight basis as v/w. All the studies were triplicate.

2.3. GC-MS Analysis

The GC-MS analysis was carried out with an Agilent 5975 GC-MSD system. Innowax FSC column (60 m x 0.25 mm, 0.25 mm film thickness) was used with helium as carrier gas (0.8 ml/min). GC oven temperature was kept at 60°C for 10 min and programmed to 220°C at a rate of 4°C/min, and kept constant at 220°C for 10 min and then programmed to 240°C at a rate of 1°C/min. Split ratio was adjusted at 40:1. The injector temperature was set at 250°C. Mass spectra were recorded at 70 eV. Mass range was from m/z 35 to 450.

2.4. GC Analysis

The GC analysis was carried out using an Agilent 6890N GC system. FID detector temperature was 300°C. To obtain the same elution order with GC-MS, simultaneous auto-injection was done on a duplicate of the same column applying the same operational conditions. Relative percentage amounts of the separated compounds were calculated from FID chromatograms.

Identification of the essential oil components were carried out by comparison of their relative retention times with those of authentic samples or by comparison of their linear retention index (LRI) to a series of *n*-alkanes. Computer matching against commercial (Wiley GC/MS Library, MassFinder 3 Library) [24, 25] and in-house "Başer Library of Essential Oil Constituents" built up by genuine compounds and components of known oils, as well as MS literature data [26], was used for the identification.

3. Results and Discussion

The essential oil compositions of *Teucrium sp.* growing in Cyprus belonging to the section *Polium* can be seen at Table 2. The six essential oils obtained from the aerial parts of five different species; *T. kyreniae, T. salaminium, T. cyprium, T. micropodioides* (two locations) and *T. karpasiticum* (Sample A-F, respectively) were analyzed by GC-FID and GC-MS, simultaneously.

The essential oil yields and the characterized compound numbers are *T. kyreniae*: 0.16% (41), *T. salaminium*: 0.6% (51), *T. cyprium*: 0.75% (37), *T. micropodioides*-Karpas region: 0.03% (43), *T. micropodioides*-Kyrenia region: 0.195% (71) and *T. karpasiticum*: 0.05% (34).

The major compounds characterized in *T. kyreniae* oil were β-caryophyllene (21.2%), (*E*)-nerolidol (10.9%), carvone (8.8%) and α-humulene (7.9%). The major compounds of *T. salaminium* oil were β-caryophyllene (15.2%), caryophyllene oxide (13.9%), germacrene D (11.6%) and bicyclogermacrene (10.0%).

The main constituents of the *T. cyprium* oil were β-pinene (35.4%), α-pinene (10.6%) and spathulenol (8.4%). However it was reported that the essential oils of different parts (leaves, flowers+leaves and stems) of the same species were dominated by sabinene (21.2-11.9%) while cadinene (δ-cadinene; 11.4-8.1% and α-cadinene; 8.4-2.4%) and caryophyllene (β-caryophyllene; 7.1-2.5%, caryophyllene oxide; 2.6-2.1% and α-caryophyllene; 2.9-1.7%) derivatives were found in minor concentrations. In addition, α-pinene and β-pinene, the major compounds in the present study, were reported as minor compounds of leaves (3.3 and 0.9%), flowers+leaves (5.5 and 1.5%) essential oils and were absent in the stem oil. Moreover, spathulenol was completely missing in all essential oils obtained from different parts [16].

On the other hand, the major compounds of the *T. micropodioides* oils which were collected from different locations showed significant differences. In the oil of *T. micropodioides*-Karpas region, limonene (47.0%), β-pinene (16.0%) and β-caryophyllene (6.9%) were found as the major compounds, however, δ-cadinene (11.2%), 1-*epi*-cubenol (7.8%), cubebol (4.7%) and cubenol (4.1%) were detected in the oil of *T. micropodioides*-Kyrenia region. In a previous study, the essential oil compositions of the different plant parts of the same species from three locations also showed significant differences not only with each other but also within our results, they were dominated by volatile terpenes which comprised 33% of total oil. The authors did not specify the percentages of any individual terpenoids [16]. Nevertheless, the oil of *T. micropodioides*-Karpas region was rich in monoterpenes while the other sample was rich in sesquiterpenes. Those differences in the essential oil compositions of the same species collected from different or even close locations may be due to the "Polium Complex " phenomenon which can be seen in section *Polium* members' essential oil compositions [26].

Moreover, the oil of *T. karpasiticum* showed limonene (43.9%), β-pinene (16.0%), α-bisabolol oxide A (7.8%), β-caryophyllene (5.5%) and α-pinene (4.6%) as main constituents. The essential oil compositions of the oils of *T. micropodioides*-Karpas region and *T. karpasiticum* were quite similar to each other even though they are different species. Close relationship of these two species has been mentioned by Hadjikyriakou and Hand, 2008 [7].

The essential oil compositions of *Teucrium sp.*, belonging to the different sections including section *Polium*, have been intensively reviewed by Candela et al., 2020 [15]. It was reported that the essential oil compositions of the taxa could be classified under two categories (1) rich in sesquiterpene(s) and (2) rich in monoterpene(s) [15]. In the present study, the majority of the oils analyzed were detected as sesquiterpene-rich, however, the oils of *T. micropodioides*-Karpas region and *T. karpasiticum* were monoterpene-rich.

There are few literature information on the compositions of the essential oils of the section *Polium* members growing in Turkey which were *T. antitauricum* [28], *T. montanum* [29] and *T. polium* [6, 30-33]. The main components of the essential oil of *T. montanum* were reported as sabinene (11.3), δ-cadinene (6.3), germacrene D (5.8), α-copaene (5.7), (*E*)-β-farnesene (5.5), τ-cadinol (5.4), α-pinene (5.2), linalool (3.2), β-pinene (3.1) while the ones detected in *T. antitauricum* essential oil were germacrene D (28.2), β-caryophyllene (27.6), caryophyllene oxide (7.5), bicyclogermacrene (5.5), α-humulene (4.2), aromadendrene (3.6) [28, 29].

Table 2. The essential oil compositions of the *Teucrium sp.* growing in Cyprus belonging to the *Polium* section

KI[a]	LRI[b]	Compound Name	Relative Percentage Amounts					
			A	B	C	D	E	F
1008-1039 [c]	1032	α-Pinene	-	1.5	10.6	4.8	0.9	4.6
1012-1039 [c]	1035	α-Thujene	-	0.2	-	-	0.2	0.1
1043-1086[c]	1076	Camphene	-	0.1	-	-	t	0.1
1085-1130 [d]	1118	β-Pinene	0.2	4.0	35.4	16.0	2.5	16.0
1098-1140 [c]	1132	Sabinene	-	2.5	-	1.1	2.6	0.7
1140-1175 [c]	1174	Myrcene	-	0.3	0.8	5.6	0.1	2.4
1154-1195[c]	1188	α-Terpinene	-	-	-	0.1	0.2	-
1178-1219 [e]	1203	Limonene	5.0	5.5	3.9	47.0	0.4	43.9
1188-1233[c]	1218	β-Phellandrene	-	-	0.4	0.4	0.1	0.2
1211-1251[c]	1246	(*Z*)-β-Ocimene	-	-	-	0.1	-	-
1222-1266[c]	1255	γ-Terpinene	0.2	-	-	0.2	0.5	-
1232-1267[c]	1266	(*E*)-β-Ocimene	-	-	-	0.6	-	-
1246-1291[e]	1280	*p*-Cymene	0.4	0.4	-	0.1	0.9	-
1261-1300[c]	1290	Terpinolene	-	-	-	0.2	0.2	-
NA	1386	1-Octenyl acetate	0.5	0.7	-	0.1	0.4	-
1370-1414[c]	1400	Nonanal	0.6	-	-	-	-	-
1429-1481[c]	1450	*trans*-Linalool oxide (*Furanoid*)	0.1	-	-	-	-	-
NA	1452	α,*p*-Dimethylstyrene	0.1	-	-	-	-	-
NA	1452	1-Octen-3-ol	-	0.8	-	-	-	0.2
1438-1480[c]	1466	α-Cubebene	-	-	-	-	0.3	-
1461[c]	1468	*trans*-1,2-Limonene epoxide	-	-	-	0.1	-	-
1526-1565[e]	1474	*trans*-Sabinene hydrate	-	-	-	-	0.2	-
1445-1549[c]	1492	Cyclosativene	-	-	-	-	0.1	-

Table 2 continued..

1471-1495[c]	1495	Bicycloelemene	0.1	-	-	-	-	-
1462-1522[c]	1497	α-Copaene	-	-	0.4	0.3	0.8	0.2
1499[f]	1499	α-Campholene aldehyde	-	-	0.4	-	-	-
1481-1537[c]	1532	Camphor	-	-	0.3	-	-	-
1496-1546[c]	1535	β-Bourbonene	-	0.4	0.8	0.1	-	-
1481-1555[c]	1541	Benzaldehyde	0.4	-	-	-	-	-
1509-1569[c]	1548	(*E*)-2-Nonenal	0.1	-	-	-	-	-
1518-1560[c]	1549	β-Cubebene	-	-	-	-	0.4	-
1507-1564[c]	1553	Linalool	0.2	-	0.2	0.1	0.6	-
1425-1478[c]	1556	*cis*-Sabinene hydrate	0.1	-	-	0.4	-	-
NA	1568	1-Methyl-4-acetylcyclohex-1-ene*	-	0.4	-	-	-	-
1557-1625[c]	1571	*trans*-*p*-Menth-2-en-1-ol	-		-	-	0.3	-
1545-1590[c]	1586	Pinocarvone	-	0.2	1.4	-	1.0	0.7
1549-1597[c]	1591	Bornyl acetate	-	0.4	0.7	0.1	0.5	-
1545-1601[c]	1601	Nopinone	-	0.4	-	-	0.4	0.3
NA	1602	6-Methyl-3,5-heptadien-2-one	0.3	-	-	-	-	-
1564-1630[c]	1611	Terpinen-4-ol	-	0.1	-	-	4.0	-
1570-1685[c]	1612	β-Caryophyllene	21.2	15.2	3.5	6.9	0.1	5.5
1600-1650[c]	1624	*trans*-Dihydrocarvone	0.3	-	-	-	-	-
1555-1645[c]	1638	*cis*-*p*-Menth-2-en-1-ol	-	-	-	-	0.3	-
1611-1688[c]	1639	*trans*-*p*-Mentha-2,8-dien-1-ol	-	-	-	0.3	-	-
NA	1642	Thuj-3-en10-al	-	-	-	-	0.2	-
1645[e]	1645	*cis*-Isodihydrocarvone	0.2	-	-	-	-	-
1597-1648[c]	1648	Myrtenal	-	1.0	4.0	0.6	2.4	0.8
1606-1683[c]	1651	Sabina ketone	-	-	-	-	1.2	-
1647-1668[c]	1663	*cis*-Verbenol	-	-	-	-	0.2	-

Table 2 continued..

1643-1671[c]	1670	*trans*-Pinocarveol	-	1.7	5.5	0.6	3.2	0.9
1627-1668[c]	1675	(*Z*)-β-farnesene	-	-	-	-	-	0.4
1688[e]	1677	*epi*-Zonarene	-	-	-	-	1.0	-
1620-1678[c]	1678	*cis*-*p*-Mentha-2,8-dien-1-ol	-	-	-	0.2	-	-
1665-1691[c]	1683	*trans*-Verbenol	-	0.9	2.2	0.2	1.4	-
1637-1689[c]	1687	α-Humulene	7.9	4.7	-	1.8	0.1	1.5
1662-1717[c]	1700	*p*-Mentha-1,8-dien-4-ol (=*Limonen-4-ol*)	0.2	-	-	0.2	-	-
1677-1704[c]	1704	Myrtenyl acetate	-	-	0.5	0.2	-	-
1659-1724 [c]	1706	α-Terpineol	0.5	0.2	0.7	0.3	0.6	0.5
1672-1718[c]	1709	α-Terpinyl acetate	-	-	-	-	1.0	-
1708-1720[c]	1720	*trans*-Sabinol	-	-	-	-	0.6	-
1720[c]	1725	Verbenone	-	0.2	-	-	0.4	-
1676-1726[c]	1726	Germacrene D	-	11.6	4.4	4.0	0.8	1.1
NA	1729	α-Methyl cinnamaldehyde	0.3	-	-	-	-	-
NA	1733	γ-Amorphene	0.2	-	-	-	-	-
1688-1761[c]	1740	Valencene	-	-	0.4	-	-	-
1686-1753 [c]	1740	α-Muurolene	-	0.4	0.8	-	0.5	-
1687-1765[c]	1747	*trans*-Carvyl acetate	0.2	-	-	-	-	-
1699-1751[c]	1751	Carvone	8.8	1.7	0.4	0.8	-	1.3
1692-1757[c]	1755	Bicyclogermacrene	-	10.0	0.5	1.3	-	-
1668-1771[c]	1758	*cis*-Piperitol	0.3	-	-	0.2	-	-
1722-1774[c]	1773	δ-Cadinene	-	0.6	0.3	0.3	11.2	0.1
1763-1786[c]	1784	(*E*)-α-Bisabolene	-	0.3	-	-	0.3	-
1754-1775[c]	1785	7-*epi*-α-Selinene	-	-	0.7	-	-	-
1739-1797[c]	1797	*p*-Methylacetophenone	0.5	0.5	-	0.4	-	-
1742-1811 [g]	1799	Cadina-1,4-diene (=*Cubenene*)	-	-	-	-	0.6	-

Table 2 continued..

1747-1805[c]	1802	Cuminaldehyde	-	0.1	-	-	0.7	-
1743-1808[c]	1804	Myrtenol	0.3	0.9	3.3	0.3	2.2	0.5
1774-1821[c]	1811	*trans*-*p*-Mentha-1(7),8-dien-2-ol	0.7	0.2	-	-	-	-
NA	1814	*p*-Mentha-1,5-dien-7-ol	-	-	-	-	0.3	-
1789-1842[c]	1838	(*E*)-β-Damascenone	0.2	-	-	-	-	-
1805-1850[c]	1845	*trans*-Carveol	3.9	1.4	0.5	1.0	0.6	-
1836-1837[e]	1849	Calamenene	-	-	-	-	1.4	-
NA	1856	Carvon-1,2-oxide	0.5	0.2	-	-	-	-
1813-1865[c]	1864	*p*-Cymen-8-ol	-	-	-	-	0.3	-
1818-1882[c]	1882	*cis*-Carveol	0.5	0.2	-	0.3	-	-
1863-1903[c]	1896	*cis*-*p*-Mentha-1(7),8-diene-2-ol	0.6	-	-	-	-	-
1854-1928[c]	1900	*epi*-Cubebol	-	-	-	-	3.0	-
1893-1941[c]	1941	α-Calacorene	-	-	-	-	2.1	-
1884-1964[c]	1957	Cubebol	-	-	-	-	4.7	-
NA	1984	γ-Calacorene	-	-	-	-	0.3	-
NA	1988	Nerolidol oxide-I	0.5	-	-	-	-	-
NA	2001	Isocaryophyllene oxide	-	0.5	0.6	-	-	-
1936-2023[c]	2008	Caryophyllene oxide	2.6	13.9	2.6	1.4	2.6	-
NA	2016	Nerolidol oxide-II	4.9	-	-	-	-	-
2006[c]	2029	Perilla alcohol	-	0.4	0.6	-	0.3	1.3
NA	2046	Norbourbonone	-	-	0.3	-	-	-
1995-2055[c]	2050	(*E*)-Nerolidol	10.9	-	-	-	-	-
2008-2054[c]	2051	Gleenol	-	-	-	-	1.0	-
2014-2062[c]	2057	Ledol	-	-	-	-	0.3	-
2003-2071[c]	2071	Humulene epoxide-II	-	2.7	0.4	0.3	-	0.2
2065-2073[g]	2073	*p*-Mentha-1,4-dien-7-ol	-	-	-	-	2.4	-
2019-2090[c]	2080	Cubenol	-	-	-	-	4.1	-
2026-2090[c]	2088	1-*epi*-Cubenol	-	-	-	-	7.8	-

Table 2 continued..

2049-2104[c]	2098	Globulol	-	0.3	-	-	0.5	-
2041-2110[c]	2104	Viridiflorol	-	0.3	-	-	-	-
2068-2115[g]	2113	Cumin alcohol	-	0.3	-	-	2.1	-
2089-2131[g]	2131	Hexahydrofarnesyl acetone	-	-	0.6	-	-	0.2
2074-2150[c]	2144	Spathulenol	-	3.5	8.4	0.2	-	0.2
2168[g]	2161	Muurola-4,10(14)-dien-1-ol	-	-	-	-	0.6	-
2090-2189[c]	2170	β-Bisabolol	0.7	-	-	-	-	-
NA	2179	nor-Copaonone	-	-	-	-	0.3	-
2134-2191[g]	2187	*T*-Cadinol	-	-	-	-	0.6	-
2143-2230[g]	2209	*T*-Muurolol	-	0.3	-	-	1.7	-
NA	2211	Clovenol	-	0.3	-	-	-	-
NA	2212	Betulenal	-	-	-	-	-	0.2
2135-2219[c]	2219	δ-Cadinol (=α-muurolol)	-	-	-	-	1.5	-
NA	2220	Bisabolene oxide A	-	-	-	-	-	2.4
NA	2236	4-*epi*-α-Bisabolol	-	-	-	-	-	0.3
2241-2247[g]	2247	*trans*-α-Bergamotol	-	-	0.6	-	-	-
2180–2255[c]	2255	α-Cadinol	-	1.0	1.0	-	0.7	-
2146-2256[c]	2256	Cadalene	-	-	-	-	1.6	-
2300[e]	2300	Tricosane	-	-	-	-	-	0.3
2316-2320[g]	2316	Caryophylla-2(12),6(13)-dien-5β-ol (=*Caryophylladienol I*)	-	0.2	-	-	-	-
NA	2324	Caryophylla-2(12),6(13)-dien-5α-ol (=*Caryophylladienol II*)	0.3	0.7	-	-	-	-
NA	2272	14-Acetoxy-β-caryophyllene	-	-	-	0.2	-	-
NA	2357	14-Hydroxy-β-caryophyllene	0.6	-	-	0.6	-	1.2

Table 2 continued..

NA	2376	10-Hydroxy calamenene		-	-	-	1.0	-
NA	2389	Caryophylla-2(12),6-dien-5α-ol (=*Caryophyllenol I*)	0.3	1.2	-	-	-	-
2392–2396[c]	2392	Caryophylla-2(12),6-dien-5β-ol (=*Caryophyllenol II*)	0.4	1.8	-	-	-	-
2407-2419[g]	2411	4-Isopropyl-6-methyl-1-tetralone	-	-	-	-	1.4	-
NA	2450	α-Bisabolol oxide A	-	-	-	-	-	7.8
2500[e]	2500	Pentacosane	-	-	-	-	-	0.7
2862-2945[c]	2931	Hexadecanoic acid	-	-	1.0	-	-	-
	Total		76.8	97.3	99.1	100.0	89.8	96.9

A: *T. kyreniae* **B**: *T. salaminium* **C:** *T. cyprium* **D:** *T. micropodioides*-Karpas region **E:** *T. micropodioides*-Kyrenia region **F:** *T. karpasiticum*. [a]KI from literature (34[c], 35[d], 36[e], 37[f], 38[g]), [b]LRI: Relative retention indices calculated against *n*-alkanes; % calculated from FID data; t: Trace (< 0.1 %), NA: Not available in current literature.

In conclusion, our results showed that there could be significant chemical differences among the essential oils obtained from the same species which were collected at the same developmental stage and/or from different or close locations. This fact reveals the necessity of researching more samples of the same species not only collected from different geographical regions but also collected from different plant materials growing in the same region. Further studies in this respect could give information on whether chemical variations are due to their chemotypecity or not.

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References

[1] R.D. Meikle (1985). Flora of Cyprus, Vol 2, The Bentham-Moxon Trust.
[2] WFO (2022): *Teucrium* L. Published on the Internet; http://www.worldfloraonline.org/taxon/wfo-4000038030 Accessed on: 10 Feb 2022.
[3] Royal Botanic Gardens, Kew and Missouri Botanical Garden. The Plant List. www.theplantlist.org Accessed on 10 Feb 2022

[4] N. Arnold, M. El Beyrouthy, B. de Foucault and F. Dupont (2010). Observations morpho-anatomiques et histochimiques sur les *Teucrium* de Chypre: *T. kotschyanum* Poech, *T. divaricatum* Heldr. subsp. *canescens* (Čelak.) Holmboe, *T. cyprium* Boiss. subsp. *cyprium* et *T. micropodioides* Rouy., *Acta bot. gallica*, **157**(**3**), 525-538.

[5] M. Khazaei, S. N. Nematollahi-Mahani, T. Mokhtari and F. Sheikhbahaei (2018). Review on *Teucrium polium* biological activities and medical characteristics against different pathologic situations, *J. Contemp. Med. Sci.*, 1**4**(**1**)**,** 1-16.

[6] G. Gülsoy Toplan, F. Göger, T. Taşkın, G. Ecevit-Genç, A. Civaş, G. İşcan, M. Kürkçüoğlu, A. Mat, K. H. C. Başer (2022). Phytochemical composition and pharmacological activities of *Teucrium polium* L. collected from eastern Turkey, *Turk. J. Chem.*, **46**, 269-282.

[7] G. Hadjikyriakou and R. Hand (2008). Notes on *Teucrium* sect. *Polium* (Lamiaceae) in Cyprus, *Willdenowia*, **38**(**1**), 111-125.

[8] G. Hadjikyriakou and R. Hand (2011). *Teucrium salaminium* Hadjik. & Hand (Lamiaceae, *Teucrium* sect. *Polium*), a new species from Cyprus, *Candollea*, **66**(**2**), 341-351.

[9] F. Piozzi (1981). The diterpenoids of *Teucrium* species, *Heterocycles* **15**, 1489–1503.

[10] F. Piozzi, B. Rodriguez and G. Savona (1987). Advances in the chemistry of the furanoditerpenoids from *Teucrium* species, *Heterocycles* **25**, 807-841.

[11] F. Piozzi (1994). Further research on the furoclerodaness from *Teucrium* species, *Heterocycles* **37**, 603–626.

[12] F. Piozzi, M. Bruno and S. Rosselli (1998). Further furoneoclerodanes from *Teucrium* genus, *Heterocycles* **48**, 2185–2203.

[13] F. Piozzi, M. Bruno, S. Rosselli and A. Maggio (2005). Advances in the chemistry of furano-diterpenoids from *Teucrium* genus, *Heterocycles* **65,** 1221–1234.

[14] A. Ulubelen, G. Topçu and U. Sönmez (2000). Chemical and biological evaluation of genus *Teucrium*, *Stud. Nat. Prod. Chem.* **23**, 591–648.

[15] R. G. Candela, S. Rosselli, M. Bruno and G. Fontana (2021). A review of the phytochemistry, traditional uses and biological activities of the essential oils of genus *Teucrium, Planta Med.* **87**(**6**), 432-479.

[16] N. Arnold, B. Bellomaria, G. Valentini and S. M. Rafaiani (1991). Comparative study on essential oil of some *Teucrium* species from Cyprus, *J. Ethnopharmacol.* **35**(**2**), 105-113.

[17] G. Valentini, B. Bellomaria and N. Arnold (1997). Essential oil of *Teucrium creticum* L. from Cyprus, *J. Essent. Oil Res.* **9**(**6**), 649-652.

[18] I. Kunter, N. Oztinen, B. Atli, E. Ak, A. Babri and M. Kosar (2019). Cytotoxic activities of different extracts of *Teucrium divaricatum* Kotschy ssp. *canescens* (Celak.) from Cyprus, *Proceedings* **40**(**1**), 33. doi: 10.3390/proceedings2019040033

[19] A. Hanoğlu, D. Yiğit Hanoğlu, N. Demirel, H. S. Yusufoğlu, and İ. Çalış (2021). Secondary metabolites from *Teucrium creticum* L., *Rec. Nat. Prod.*,**15**(**6**), 487-502.

[20] E. M. Galati, M. R. Mondello, A. D'Aquino, N. Miceli, R. Sanogo, O. Tzakou and M. T. Monforte (2000). Effects of *Teucrium divaricatum* Heldr. ssp. *divaricatum* decoction on experimental ulcer in rats, *J. Ethnopharmacol.* **72**(**1-2**), 337-342.

[21] C. Maria, B. Rodriguez, M. Bruno, G. Savona, F. Piozzi and O. Servettaz (1988). Neo-clerodane diterpenoids from *Teucrium micropodioides*, *Phytochemistry* **27**(**1**), 213-216.

[22] A. Lardos (2006). The botanical materia medica of the Iatrosophikon-a collection of prescriptions from a monastery in Cyprus, *J. Ethnopharmacol.* **104**(**3**), 387-406.

[23] M. R. González-Tejero, M. Casares-Porcel, C. P. Sánchez-Rojas, J. M. Ramiro-Gutiérrez, J. Molero-Mesa, A. Pieroni, M.E. Giusti, E. Censorii, C. de pasquale, A. Della, D., Paraskeva-Hadijchambi, A., Hadjichambis, Z. Houmani, M. El-Demerdash, M. El-Zayat, M.Hmamouchi and S. ElJohrig (2008). Medicinal plants in the Mediterranean area: synthesis of the results of the project Rubia, *J. Ethnopharmacol.* **116**(**2**), 341-357.

[24] F.W. McLafferty and D.B. Stauffer (1989). The Wiley/NBS registry of mass spectral data, J. Wiley and Sons, New York.

[25] W.A. Koenig and D. Joulain (2004). Terpenoids and related constituents of essential oils, MassFinder 3, Hamburg, Germany.

[26] D. Joulain and W.A. Koenig (1998). The atlas of spectral data of sesquiterpene hydrocarbons, EB-Verlag, Hamburg.

[27] N. Djabou, A. Muselli, H. Allali, M. E. A. Dib, B. Tabti, L. Varesi and Costa, J. (2012). Chemical and genetic diversity of two Mediterranean subspecies of *Teucrium polium* L., *Phytochemistry*, **83**, 51-62.

[28] K. H. C. Baser, B. Demirci, H. Duman and Z. Aytac (1999). Composition of the essential oil of *Teucrium antitauricum* T.Ekim., *J. Essent. Oil Res.* **11**(**1**), 61-62.

[29] K. H. C. Baser, B. Demircakmak and H. Duman (1997). Composition of the essential oils of three *Teucrium* species from Turkey, *J. Essent. Oil Res.* **9**(**5**), 545-549.
[30] A. Cakir, M. E. Duru, M. Harmandar, R. Ciriminna and S. Passannanti (1998). Volatile constituents of *Teucrium polium* L. from Turkey, *J. Essent. Oil Res.* **10**(**1**), 113-115.
[31] E. Sevindik, Z. T. Abacı, C. Yamaner and M. Ayvaz (2016). Determination of the chemical composition and antimicrobial activity of the essential oils of *Teucrium polium* and *Achillea millefolium* grown under North Anatolian ecological conditions, *Biotechnol. Biotechnol. Equip.* **30**(**2**), 375-380.
[32] Ş. Hayta, A. Yazgın and E. Bağcı (2017). Constituents of the volatile oils of two *Teucrium* species from Turkey, *Bitlis Eren Univ. J. Sci. Technol*, **7**(**2**), 140-144.
[33] S. Al-Massarani, A. El-Shaibany, N. Tabanca, A. Ali, A. S. Estep, J. J. Becnel, F. Goger, B. Demirci, A. El-Gamal, K. H. C. Baser (2019). Assessment of selected Saudi and Yemeni plants for mosquitocidal activities against the yellow fever mosquito *Aedes aegypti*, *Saudi Pharm. J.* **27**(**7**), 930-938.
[34] V. I. Babushok, P. J. Linstrom and I. G Zenkevich (2011). Retention indices for frequently reported compounds of plant essential oils, *J. Phys. Chem. Ref. Data* **40**, 1-47.
[35] A. Abdelwahed, N. Hayder, S. Kilani, A. Mahmoud, J. Chibani, M. Hammami, L. Chekir-Ghedira and K. Ghedira (2006). Chemical composition and antimicrobial activity of essential oils from Tunisian *Pituranthos tortuosus* (Coss.) *Maire.*, *Flavour. Fragr. J.* **21**, 129–133.
[36] http://www.pherobase.com/database/kovats/kovatsdetailsulcatone.php
[37] A. M. Viljoen, G. P. P. Kamatou, Z. H. Coovadia, T. Ozek and K. H. C. Baser (2010). Rare sesquiterpenes from South African *Pteronia* species, *South Afr. J. Bot.* **76**, 146-152
[38] https://pubchem.ncbi.nlm.nih.gov/compound/