Bangladesh J. Bot. **54**(3): 547-553, 2025 (September) DOI: https://doi.org/10.3329/bjb.v54i3.84365

ELEMENTAL CONTENT, ESSENTIAL OIL COMPONENTS AND USAGE AREAS OF THE COMPONENTS OF TWO *SALVIA* SPP.

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Keywords: Sage, GC/MS, Pyhtol, Nutrient, Heavy metal

Abstract

Salvia species contain very rich bioactive substances. In this study, the essential oil compositions of *Salvia dichroantha* Stapf (endemic) and *S. tomentosa* Mill. species collected from their natural area, and their essential oil composition and elemental substance (14 elements) contents were determined. The main components in the essential oils of *S. dichroantha* and *S. tomentosa* species were phytol (33.27%) and caryophyllene oxide (23.44%), respectively. It was recorded that the species had higher K and Ca contents from macronutrients and that their heavy metal contents were below the permitted limit values.

Introduction

Salvia is distributed across tropical and subtropical regions of the world. Some species in this genus are cultivated and exported. It is reported that there are approximately 1000 species in the *Salvia* genus (Turdiboev *et al*. 2022). Türkiye is an important gene center of the *Salvia* genus. There are a total of 114 taxa in the flora of Türkiye, 100 species, 8 subspecies and 6 varieties. 59 of these taxa are endemic (Cosge Senkal *et al*. 2019). *Salvia* taxa are known to exhibit a wide range of biological activities, including antibacterial, anti-viral, antifungal, antioxidant, antispasmodic, and analgesic effects.

Two *Salvia* species, one of which is endemic, were used in this study. Of these species, *S. dichroantha* Stapf (endemic) is a perennial, herbaceous structure, flowering between July and September. It is widespread in the northwestern, southwestern and central Anatolian regions of Türkiye at altitudes of 810-1800 m. Infusion prepared from the leaves of this species is used in folk medicine for wound treatment in Nigde province/TÜRKİYE and its surroundings (Eroz Poyraz and Koca 2006). The other species, *S. tomentosa* Mill., is a perennial, woody structure, flowering between April and August and can grow up to 1 m in length. It has violet-colored flowers. It grows naturally in the Mediterranean Region, Dalmatia and Italy, and is cultivated in Germany, Southern France and Hungary. It grows in the Western, Northern and Southern Anatolian regions of Türkiye. The leaves of this species are consumed as tea (infusion and decoction) (Demir *et al*. 2023).

This study aims to analyze the essential oil and mineral composition of the aerial parts of *S. dichroantha* and *S. tomentosa*, to assess their nutritional element profiles, and to evaluate the potential applications of the major essential oil constituents considering existing literature.

Materials and Methods

Aerial parts of the species were collected from Mudurnu/Bolu/TURKİYE (40^o 27'45" N, 31^o 12'43" E and altitude: 876 m) during the full flowering period. The collected plant samples were dried, and the samples were kept in a closet at room temperature in a paper bag. Species identification was made according to Flora of Turkey (Davis *et al*.1982).

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Hydro-distillation method was used to obtain essential oil from herbal material using clevenger type apparatus. Before distillation, the above-ground parts of the species were dried in the shade. After weighing 100 g of dried herbal material was placed in the volumetric flask containing 700 ml of distilled water. It was distilled for 3 hours and as three replications. The obtained essential oil was taken into viols and sodium sulfate was added. It was kept in the dark (+4^{o}C) until component analysis. The amount of essential oil was recorded. The chemical components of the essential oil obtained from the aerial parts of two *Salvia* species were determined by Shimadzu, QP2010 ULTRA brand GC/MS (Cosge Senkal *et al*. 2019). Essential oil components were defined by comparing their mass spectra and retention indices (RI) with values of reference samples, the FFNSC 1.2 mass spectral library, and the literature (Babushok *et al*. 2011).

Analysis of 14 elements (aluminum, cadmium, cobalt, chrome, nickel, phosphorus, potassium, calcium, iron, copper, zinc, manganese, boron and sodium) in the samples prepared in this way was carried out with iCAP-Qc ICP-MS spectrometer (Thermo Scientific). Calculations were made based on the dry weights of plant samples. The analysis was performed with 3 replications. Preparation of samples for analysis and the operating principle of the device were carried out as reported by Basaran *et al*. (2017).

Descriptive statistics parameters for the data obtained from laboratory analyses, mean and standard deviation values were prepared using the MINITAP statistics program (Evans 2009).

Results and Discussion

The amount and chemical composition of the essential oil obtained by hydro distillation from the flowering aerial parts of *S. dichroantha* and *S. tomentosa* species are presented in Table 1. The essential oil content of *S. dichroantha* was found to be considerably lower than that of *S. tomentosa*. Phytol was determined as the main component constituting more than 30% of the essential oil of *S. dichroantha*. This component was followed by caryophyllene oxide. While the main component in *S. tomentosa* essential oil was caryophyllene oxide and it was followed by isospathulenol, spathulenol and manool in lower amounts. In different studies, the essential oil yield and chemical composition of the aerial parts of *S. dichroantha* and *S. tomentosa* were determined. The essential oil content of *S. dichroantha* ranged from 0.01% to 0.19%, with the main constituents being caryophyllene oxide (10.98-65.8%), *β*-caryophyllene (23.11%), sabinyl acetate (21.87%), caryophyllend I (16.7%), caryophyllenol II (14.3-15.6%), spathulenol (11.55%), germacrene (7.29%) and phytol (5.6%). In *S. tomentosa*, the essential oil content ranged from 0.26% to 2.8%, and the dominant compounds included borneol (7.88-29.32%), *α*-pinene (5.73-24.65%), *β*-pinene (37.28-39.7%), camphor (9.7%), *β*-caryophyllene (6.74-11.2%), cyclofenchene (10.3%), *δ*-cadinene (6.7%), *γ*-muurolene (6.51%), *α*-humulene (19.32%), 13-epi-manool (18.14%), *α*-thujone (12.13%), viridiflorol (7.78%) and 1,8-cineole (5.42-17.4%) (Tepe *et al*. 2005, Kunduhoglu *et al*. 2011, Avci 2013, Kaya *et al*. 2017, Karik *et al*. 2018, Bardakci *et al*. 2019, Cosge Senkal *et al*. 2019). The amount of essential oil of *S. dichroantha* is within the limit values in the literature data. However, the phytol content determined in this study was recorded as lower in previous studies. Also, the amount of essential oil obtained in *S. tomentosa* species was higher than the literature data. It was observed that the main components detected in this species were different from the literature data. Approximately 80% of the *S. dichroantha* essential oil was composed of sesquiterpenes and diterpenes with similar values. The monoterpene ratio in the essential oil of this species was below 1%. Approximately 60% of the *S. tomentosa* essential oil was composed of sesquiterpenes. When compared to the *S. dichroantha* essential oil, the diterpene compound ratio in the essential oil of this species was found to be lower, while the value of monoterpenes was higher. It was observed that some of the findings obtained in terms of the volatile oil contents and chemical components of these two *Salvia* species differ from the literature data. These differences may be due to many factors such as genotype, ecological conditions, analysis methods.

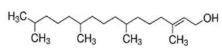
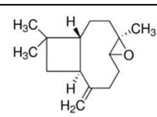
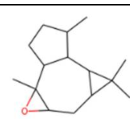
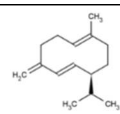
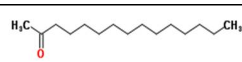
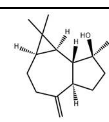
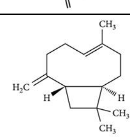
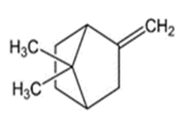
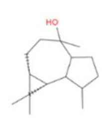
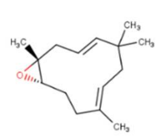
Table 1. GC/MS analysis result of *Salvia* spp. essential oils.

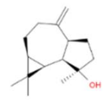
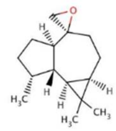
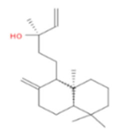
Compounds	Empirical formula	RI[1]	*S. dichroantha*	*S. tomentosa*
α-Pinene	$C_{10}H_{16}$	933	-	0.39
α-Fenchene	$C_{10}H_{16}$	949	-	4.51
Limonene	$C_{10}H_{16}$	1030	-	0.28
Eucalyptol (1,8-Cineole)	$C_{10}H_{18}O$	1032	-	0.59
Linalool	$C_{10}H_{18}O$	1106	0.42	-
Pinocarveol	$C_{10}H_{16}O$	1141	-	0.53
Pinocarvone	$C_{10}H_{14}O$	1164	-	0.36
α-Terpineol	$C_{10}H_{18}O$	1198	-	0.74
Myrtenol	$C_{10}H_{16}O$	1202	-	0.67
α-Copaene	$C_{15}H_{24}$	1375	0.20	-
β-Caryophyllene	$C_{15}H_{24}$	1438	3.47	6.19
β-Farnesene	$C_{15}H_{24}$	1452	0.50	1.11
α-Humulene	$C_{15}H_{24}$	1458	0.31	1.73
Germacrene-D	$C_{15}H_{24}$	1478	4.59	2.51
β-Selinene	$C_{15}H_{24}$	1482	-	1.53
Bicylogermacrene	$C_{15}H_{24}$	1498	1.41	2.72
γ-Cadinene	$C_{15}H_{24}$	1513	-	1.01
δ-Cadinene	$C_{15}H_{24}$	1523	1.18	-
Cadinene	$C_{15}H_{26}$	1529	-	0.69
Selina-3,7(11)-diene	$C_{15}H_{24}$	1538	-	0.42
Germacrene D-4-ol	$C_{15}H_{26}O$	1574	-	1.03
Spathulenol	$C_{15}H_{24}O$	1576	3.91	7.76
Caryophyllene oxide	$C_{15}H_{24}O$	1578	13.30	**23.44**
β-Copaen-4- *α*-ol	$C_{15}H_{24}O$	1588	1.81	2.71
Viridiflorol	$C_{15}H_{26}O$	1590	1.24	3.74
α-Humulene epoxide	$C_{15}H_{24}O$	1610	0.96	5.86
Isoaromadendrene epoxide	$C_{15}H_{24}O$	1612	5.36	-
Isospathulenol	$C_{15}H_{24}O$	1633	2.69	9.81
α-Cadinol	$C_{15}H_{26}O$	1652	1.22	-
2-Pentadecanone	$C_{15}H_{30}O$	1680	4.08	0.41
Aromadendrene oxide-(2)	$C_{15}H_{24}O$	1721	-	3.70
Sclareol oxide (*cis-B/C*)	$C_{18}H_{30}O$	1931	2.80	-
Manoyl oxide	$C_{20}H_{34}O$	1992	1.03	-
Manool	$C_{20}H_{34}O$	2026	2.10	7.02
Phytol	$C_{20}H_{40}O$	2106	**33.27**	0.71
Humulane-1,6-dien-3-ol	$C_{15}H_{26}O$	1616	-	1.14
Docosane	$C_{22}H_{46}$	2192	0.51	-
Tetracosane	$C_{24}H_{50}$	2407	0.20	-
Pentacosane	$C_{25}H_{52}$	2494	1.84	0.35
Octacosane	$C_{28}H_{58}$	2773	0.89	-
Squalene	$C_{30}H_{50}$	3066	0.60	-
Nonacosane	$C_{29}H_{60}$	3119	0.96	-
	Monoterpene		0,42	8,07
	Sesquiterpene		38,36	61,43
	Epoxide		0,96	5,86
	Ketone		4,08	0,41
	Diterpene		39,2	7,73
	Alkane		4,4	0,35
	Triterpene		0,60	0
Total			90.85	91.33
Total Number of Components			27	30
Essential Oil (%)			0.031 ± 0.009	0.35 ± 0.11

[1]Retention index

The potential usage of chemical compounds detected in *S. dichroantha* and *S. tomentosa* essential oils in medicine, food, cosmetics, agriculture etc. and their effects/activities were examined with literature data (Chowdhury and Ghosh 2012, Kadhim *et al*. 2016, Pavithra *et al*. 2018, Francomano *et al*. 2019, Abd-ElGawad *et al.* 2020, Nicolella *et al*. 2021, Akiel *et al*. 2022,) and outlined in Table 2.

Table 2. Potential uses of the main components in the *Salvia dichroantha* Stapf and *S. tomentosa* Mill. essential oils.

Compound name	Chemical structure	Molecular weight (g/ mol)	Potential for use in medicine, food, cosmetics etc. and effects[1]
Phytol		296.5	Food additive, antioxidant and antimicrobial activity, antiallergic and anti-inflammatory effects, and antinociceptive activity.
Caryophyllene oxide		220.35	Preservatives in food and cosmetics, anticarcinogenic, anti-inflammatory, skin healer, and flavoring.
Isoaromadendrene epoxide		220.35	Antimicrobial, antioxidant and anti-inflamatory activity.
Germacrene-D		204.35	Insecticidal and repellent activity.
2-Pentadecanone		226.40	Food additive and flavor.
Spathulenol		220.35	Antiproliferative, anti-inflammatory, antimicrobial, anticancer activity. Repellent and larvicidal activity.
β-Caryophyllene		204.35	Neuroprotective, Anti-inflammatory Antioxidant activity. Sedative effect Antitumor activity.
α-Fenchene		136.23	Analgesic, anticancer, anti-inflammatory and antioxidant activity. Insecticidal activity.
Viridiflorol		222.37	Anticancer, antibacterial, anti-inflammatory, and antioxidant activity. Personal care products. Feeding deterrent.
α-Humulene epoxide		220.35	Anti-inflammatory and antioxidant activity.

Isospathulenol		220.35	Antibacterial activity.
Aromadendrene oxide-(2)		220.35	Anticancer activity.
Manool		306.5	Antibacterial, antifungal, anti-inflammatory, antimicrobial, antispasmodic, antigenotoxic and anticarcinogenic effects.

[1]Chowdhury and Ghosh 2012, Kadhim *et al.* 2016, Francomano *et al.* 2019, Abd-ElGawad *et al.* 2020, Pavithra *et al*. 2018, Nicolella *et al.* 2021, Akiel *et al*. 2022.

Ash content is an important parameter as it represents the total mineral content of plants. Ash content of *S. dichroantha* and *S. tomentosa* species was determined as 11.05% and 9.70%, respectively. The ppm values of 14 elements investigated in the aerial parts of *S. dichroantha* and *S. tomentosa* species collected during the full flowering period are given in Table 3. *Salvia* species are mostly consumed as herbal tea and spices. Mineral contents of *Salvia* species exhibited a very wide variation. It was recorded that K value was the highest, followed by Ca and P. While the Ca value was higher than the literature data, P and K values were within the limits specified in the literature data. It is generally consistent with the literature data in terms of other elements and is close to the minimum values specified in the literature. In addition, *S. dichroantha* species had higher values than *S. tomentosa* species in terms of other elements, except for B and Na content (Table 3). The element content of two Salvia species was within the limit values reported by both WHO (World Health Organization) and other countries (Er *et al*. 2013, Ekin 2022).

Table 3. Analyzed element values of *Salvia* spp.

Elements	*S. dichronatha*	*S. tomentosa*
Ca[1]	127.814 ± 1.1082	112.05 ± 0.4433
K	390.373 ± 4.6842	385.84 ± 1.0818
P	30.298 ± 0.5459	26.307 ± 0.1814
Fe	5.892 ± 0.0840	1.484 ± 0.0094
Mn	0.468 ± 0.0073	0.289 ± 0.0018
Zn	1.348 ± 0.0087	1.039 ± 0.0043
Cu	0.206 ± 0.0013	0.171 ± 0.0011
B	0.585 ± 0.0077	0.630 ± 0.0058
Na	3.548 ± 0.0229	3.770 ± 0.0194
Al	5.76767 ± 0.03549	1.06528 ± 0.01545
Cd	0.00048 ± 0.00005	0.00036 ± 0.00012
Co	0.00436 ± 0.00005	0.00147 ± 0.00001
Cr	0.03841 ± 0.00059	0.00597 ± 0.00034
Ni	0.03208 ± 0.00161	0.01469 ± 0.00036

[1]Calcium, Potassium, Phosphorus, Iron, Manganese, Zinc, Copper, Boron, Sodium, Aluminum, Cadmium, Cobalt, Chrome, Nickel

This study revealed that *S. dichroantha* and *S. tomentosa* are characterized by distinctive essential oil constituents, namely phytol and caryophyllene oxide, and possess high levels of macronutrients K and Ca. The fact that heavy metal concentrations remain below the permissible limits supports the safe utilization of these species. The findings indicate that both species may represent valuable biological resources for the pharmaceutical, nutraceutical, and food industries. Future studies are recommended to investigate their biological activities in detail and to evaluate their potential for commercial applications.

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(Manuscript received on 30 September, 2024; revised on 22 August, 2025)