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Determination of The Essential Oil Components of Some Sage (*Salvia* Sp.) Species Naturally Distributed in The Isparta Province

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Abstract

Aim of the study: This study was performed to determine the essential oil components of *Salvia tomentosa* Mill., *Salvia argentea* L. and *Salvia bracteata* Bank et Sol.

Area of study: The study was carried out in two districts (Eğirdir and Şarkikaraağaç) located at Isparta province in Turkey.

Material and methods: The isolation of essential oil components was performed from shoots with leaves and flowers. Qualitative analysis of essential oils was carried out by using a Shimadzu 2010 Plus GC-MS device. The identification of the constituents was carried out by comparing the retention index (RI) and mass spectral data (MS) to those reported in the literature.

Main results: As a result of the GC-MS analysis, the major components of the essential oil were (-)-caryophyllene oxide (49.56%), *β*-vatirenene (7.87%), and α-Muurolol (6.78%) in *S. tomentosa*, sclareol (40.01%), germacrene-D (13.93%) and *β*-pinene (11.93%) in *S. argentea* and eucalyptol (1,8-cineole) (16.6%), *β*-pinene (14.7%) and cembrene (10.88%) in *S. bracteata*. Sclareol, which was determined at a high concentration in *S. argentea* in this study, is an economically valuable component that is widely used as flavoring in food and tobacco industry and as a perfume ingredient in the cosmetic industry.

Highlights: According to this study, the cultivation of *S. argentea* can provide high economic returns.

Keywords: *Salvia*, essential oil, essential oil components, GC-MS, Isparta, Türkiye

Isparta İlinde Doğal Olarak Yayılış Gösteren Bazı Ada çayı (*Salvia* sp.) Türlerinin Uçucu Yağ Bileşenlerinin Belirlenmesi

Öz

Çalışmanın amacı: Bu çalışmada *Salvia tomentosa* Mill., *Salvia argentea* L. ve *Salvia bracteata* Bank et Sol. taksonlarının uçucu yağ bileşenlerinin belirlenmesi amaçlanmıştır.

Çalışma alanı: Çalışma Türkiye'de Isparta ilinde bulunan iki ilçede (Eğirdir ve Şarkikaraağaç) gerçekleştirilmiştir.

Materyal ve yöntem: Uçucu bileşiklerin izolasyonu, yaprak, çiçek ve sürgünden oluşan kısımlardan yapılmıştır. Uçucu yağların kalitatif analizi, Shimadzu 2010 Plus GC-MS (Gaz Kromatografisi/Kütle Spektrometresi) cihazı kullanılarak yapılmıştır. Bileşenlerin tanımlanması, alıkonma indeksi (RI) ve kütle spektral verilerinin (MS) yayınlanan literatürde rapor edilenlerle karşılaştırılmasıyla gerçekleştirilmiştir.

Temel sonuçlar: GC-MS analizi sonucunda uçucu yağın ana bileşikleri (-)-karyofillen oksit (%49.56), β-vatirenen (%7.87), S. *tomentosa*'da α-Muurolol (%6.78), sclareol (40.01), germacrene-D (%13.93) ve β-pinene (%11.93), *S. argentea*'da ve okaliptol (1,8-sineole) (%16.60), β-pinene (%14.70) ve cembrene (%10.88) *S. bracteata* olmuştur. Bu çalışmada S. *argentea*'da yüksek konsantrasyonda tespit edilen sclareol, gıda ve tütün endüstrisinde aroma verici ve kozmetik endüstrisinde parfüm bileşenin olarak kullanılan ekonomik değeri olan bir bileşiktir.

Araştırma vurguları: Bu çalışmaya göre *S. argentea* yetiştiriciliği yüksek ekonomik getiri sağlayabilir.

Anahtar Kelimeler: Ada çayı, Uçucu Yağ, Uçucu Yağ Bileşenleri, GC-MS, Isparta, Türkiye

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Introduction

Turkey is in one of the geographies of the world with a rich diversity of plant species. It has 11707 plant taxa, including 3649 endemic ones, due to its highly diverse ecosystems with different geological, geomorphological and climatic features and due to the existence of different plant species from three different phytogeographical regions (Güner et al., 2012). It is also accepted as an important gene center for *Lamiaceae* flora. The *Lamiaceae* family, which contains a wide variety of species, is represented by 45 genera, 565 species and 735 taxa in the flora of our country (Başer, 1993). *Lamiaceae* is a rich family of plants that naturally grow especially in Mediterranean countries and are cultivated in many countries located in the temperate zone (Saleem, 2000). Moreover, it is among the most well-known and studied plant families for essential oils in the world (Ceylan, 1996). In the *Lamiaceae* family, which is an important family due to its high content of the essential oils used in the medicine and perfumery industries, the essential oils are produced by glandular trichomes (hairs) on the epidermis. The secretory tissues of this family are characterized by an eight-cell head (Baytop, 1977).

Essential oils are secondary metabolites that accumulate in very small droplets in some specialized metabolic tissues and organs of plants, such as secretory tissues, secretory pockets, secretory canals and secretory cells (Erbaş et al., 2017). Most essential oils are of terpenoid origin and are mixed with the derivatives of benzene aromatic compounds and terpenes to a small extent (Dönmez, 2005). Essential oils represent the plant volatile fraction isolated by hydrodistillation or steam distillation. Volatile compounds (essential oils, ethereal oils) and their aromatic extracts are widely used by the flavor and fragrance industries in the preparation of perfumes, cleaning products, food additives, medicines and cosmetics, as the synthesis starting material or as a source of aroma-chemicals of useful semi-synthetic and nature-identical flavor chemicals (Weiss, 1997; Yorulmaz & Erbaş, 2014). Since volatile compounds are complex compounds with different components, they differ in terms of their biological effects. While their effects vary based on their active contents, most essential oils have antimicrobial, carminative, choleretic (increasing the volume of secretion), sedative, diuretic and antispasmodic effects (Maksimović et al., 2005).

The *Salvia* genus is very rich in the aromatic plants, contains nearly 1000 species spreading naturally in the temperate regions of the Northern and Southern hemispheres in the world (Seçmen et al., 2000; Güner et al., 2000). The genus *Salvia* L. has a total of 109 taxa in Turkey. Fifty-one of these species are endemic, and their endemism percentage is very high (52.50%) (Güner et al., 2012; Şenkal et al., 2012). As *Salvia* species are medically significant, they have economic importance and are grown as ornamental plants in the urban parks and landscapes, due to their beautiful flowers, as well (Demirci et al., 2002). *Salvia* species, some of the oldest medicinal plants used by people are used in folk medicine as anti-flatulent, sedative, carminative, diuretic, stomachache and shortness of breath reliever, anti-sudorific and anti-sore throat, external wound healing and antiseptic agents (Muntean et al., 2007; Akbulut et al., 2019; Akbulut, 2021). The therapeutic efficacy of medicinal and aromatic plants depends on the plants' phytochemical contents and compounds (Sarrou et al., 2016). In the studies performed by different researchers in various regions, it has been determined that the secondary metabolites isolated from *Salvia* L. species have a wide variety of biological effects such as antifungal, antibacterial, antioxidant, antiviral, antispasmodic, analgesic, astringent, antiseptic, central nervous system depressant, anticancer, antidiabetic, anti-sudorific, insecticide and antimicrobial activities (Lu & Foo, 2002; Perry et al., 2003; Russo et al., 2003; Topçu, 2006; Baydar et al., 2013; Asili et al., 2021). *Salvia* species are rich in essential oils which play an important role in their biological properties (Carović-Stanko et al., 2016).

Salvia species have a great value in the cosmetics, pharmaceutical and food industries (Baydar et al., 2009; Carović-Stanko et al., 2016). The Mediterranean region, Southeast Africa, and Central and South America are the primary cultivating regions for the genus Salvia L. It is grown for culinary, therapeutic, and decorative uses (Lopresti, 2017). *Salvia officinalis* (Dalmatian sage) and *S. fruticosa* (Anatolian sage) species are grown in our country and production of 1300 tons is made on an area of 6.6 ha (Anonymous, 2022).

Studies conducted by different researchers in various regions have revealed that *Salvia* species have a wide diversity in terms of their yields and compositions of essential oils. In this study, the essential oil contents and compounds were identified from the species of *S. tomentosa* Mill, *S. argentea* L. and *S. bracteata* Bank et Sol. The information presented in this study may be used to identify the right direction for researchers and producers depending on market needs and different varius uses such as the breeding or farming of the plant.

Materials and Methods

Materials

The materials of this study were composed of specimens collected from the Grid Square C3 in the Flora of Turkey and the East Aegean Islands between 2019 and 2020, including *S. tomentosa* (Isparta Yukarı Gokdere, 1400 m), *S. argentea* (Kasnak Oak Forest Nature Reserve, 1600 m), and *S. bracteata* (Isparta Sarkikaragac, 1100 m). These species were identified by Prof. Dr. Hüseyin Fakir. A field study was conducted during the flowering period (May-June) of the *Salvia* taxa in the study area, and the specimens (shoots with stem, leaves and flowers) were collected (~1 kg). The collected and recorded plant specimens were dried according to the standard herbarium techniques and placed in the Forest Botany Laboratory of the Faculty of Forestry at the Isparta University of Applied Sciences for conservation. The identification of the plants was performed according to the "Flora of Turkey" (Davis et al., 1988). The voucher specimens (No. ISPO 1001, 1002, 1003) were kept at the Herbarium Laboratory of the Faculty of Forestry at the Isparta University of Applied Sciences.

Distillation Process

100 g of dried all plant parts (stem, leaf and flower) was subjected to the distillation for 3 h by a Clevenger-type hydrodistillation apparatus. In the process, the shoot with leaves and flowers was put into a container including 5 L distilled water (1/3) according to the standard method recommended in the European Pharmacopoeia (1975). The hydrodistillation process was conducted under ambient atmospheric pressure. After distilling for 3 hours, the essential oil content was measured as an average percentage (%, v/w). Afterward, the essential oils were dried with anhydrous sodium sulfate for a while and stored at +4ºC until the analysis of fragrance components.

Identification of Essential Oil Components

The components of essential oils were determined by the GC-MS device. 2.5 mL of n-hexane was used to dissolve 25 L of essential oil before injecting it into the split mode (1/100). GC-MS (Gas Chromatography/Mass Spectrometry) analysis of essential oil was carried out on Shimadzu 2010 Plus (a Quadrapole (QP-5050) detector). The analysis was carried out under the given conditions: capillary column, Restek Rxi®-5Sil MS (50 m × 0.32 mm, film thickness 0.25 µm); injector and detector temperature, 240°C; oven heat program, 60°C/ (10 min. hold) to 90°C rising at 4°C/min., and increasing to 240°C (11.5 min. hold) rising at 15°C/min.; ionization type, EI; carrier gas, helium (20 mL/min.); flow speed, 1 psi; sample injected 1 µL; detector: 70 eV. The identification of the compositions was conducted with the help of the data given in the Nist, Wiley and Tutor library, the composition of the mass spectra and the retention index (RI) of the standard substances (Erbaş & Baydar, 2016).

Results and Discussion

The essential oil contents of *S. tomentosa* were found as 0.17% ± 0.005. This means that 1 kg of essential oil is produced from 588 ± 23.4 kg in *S. tomentosa*. A total of 24 scent compositions were determined in the *S. tomentosa* essential oil by the GC-MS analysis. The essential oil of the *S. tomentosa* consisted of 66.54% oxygenated sesquiterpene represented particularly by (-)-caryophyllene oxide (49.56%), α-muurolol (6.78%) and β-copaen-4-α-ol (6.29%), a 25.52% sesquiterpene hydrocarbons compounds which were all *β*-vatirenene (7.87%), alloaromadendrene (5.51%), germacrene-D (4.23%), *trans* β-caryophyllene (4.01%) and α-humulene (2.60%) (Table 1).

In our country, the research on the essential oil content and composition of *S. tomentosa* were carried out in different locations. The essential oil rate of *S. tomentosa* plant collected from İzmir, Elazığ, Balıkesir, Osmaniye and Isparta was 0.8% (Haznedaroğlu et al., 2001), 0.3% (Bağcı & Koçak, 2008), 1.0% (Aşkun et al., 2010), 0.31-0.51% (Tepe et al., 2005; Ulukanlı et al., 2013) and 2.36% (Avcı, 2013) respectively. The differences observed in our study can be explained primarily by the use of different parts of the plant, as well as by being influenced by ecological, orographic, edaphic or biotic factors. These factors caused changes in *S. tomentosa* essential oil profiles. Başer (2002) reported that there are α-pinene (6.0-29.0%) and β-pinene (5.0-33.0%) groups in *S. tomentosa* essential oil. On the other hand, Ulukani et al. (2013) and Tepe et al. (2005) reported higher β-pinene (37.28% and 39.70%, respectively), and Bağcı & Koçak (2008) reported higher α-pinene (33.7%). Apart from these components, Aşkun et al. (2010) reported 14.9% camphor and 13.20% borneol; Avcı (2013) 29.32% borneol, Haznedaroğlu et al. (2001) 17.0% 1,8-cineole, 11.0% β-caryophyllene, 10.0% cyclofencene, 6.0% δ-cadinene and 4.1% borneol; and Bağcı & Koçak (2008) reported 7.5% germacrene D, 6.8% β-pinene, 6.0% α-humulene, 3.8% veridiflorol, 3.1% limonene and 0.6% borneol. A high rate of (-)-caryophyllene oxide was determined in our *S. tomentosa* essential oil composition and it was emphasized that there is no safety concern in its use as a flavoring agent at current levels of intake according to FAME (Flavor and Extract Manufacturers Association) standards (Burdock, 2010).

Our research is the first report conducted on the essential oil of *S. argentea* in our region. The essential oil content of *S. argentea* is 0.10% ± 0.002%, and 1 kg of essential oil was obtained from approximately 1 ton of plants. As a result of the GC-MS analysis of the obtained essential oil, a total of 14 components were identified. *S. argentea* consisted of 24.26% of monoterpene hydrocarbon (11.93% of this group is β-pinene, 6.59% is α-pinene and 3.35% is sabinene), 18.40% of sesquiterpene hydrocarbone (13.90% is germacrene-D, 3.24% is *trans* β-caryophyllene and 1.24% is bicyclogermacrene) and 49.66% of oxygenated diterpenes (40.01% is sclareol and 9.65% is sclareol oxide (cis-A/B)) (Table 1).

Low essential oil content and different essential oil composition have been reported in the *S. argentea* plant collected in different areas (Holeman et al., 1984; Couladis et al., 2001; Farhat et al., 2013; Velickovic et al., 2014). According to reports, the main composition of essential oils in Macedonia was caryophyllene oxide (37.50%), which was followed by α-copaene (8.50%), humulene epoxide II (6.30%), and β-caryophyllene (6.10%). (Velickovic et al., 2014). Moreover, it is reported that the main components of *S. agrentea* essential oil in Serbia are 32.40% viridiflorol, 14.60% manool, 10.7% α-humulene and 7.30% β-thujone (Couladis et al., 2001). Although the composition of *S. argentea* collected from two different areas in Tunisia is richer in terms of monoterpene hydrocarbons (14.50% and 13.50%), the main compositions are viridiflorol 18.70-26.90%, manool 6.10-13.60%, α-thujone 7.30-8.10% and α-humulene 4.10-5.30% (Farhat et al., 2013). On the other hand, essential oils obtained from *S. argentea* in Morocco were reported to be rich in camphor (45.10%), camphene (19.40%), α-pinene (9.30%) and borneol (9.00%) (Holeman et al., 1984). In Tunisia, Taarit et al. (2013) also reported that the highest essential oil content in *S. argentea* was during the full bloom period (0.15%), and they characterized the highest viridiflorol (15.90%), camphor (9.00%), methyl eugenol (6.90%) and 1,8-cineole (5.80%) in the essential oil during this period. In our study, it was determined that the highest component was sclareol, sclareol oxide, β-pinene and germacrene-D, and it has been observed that there was a different essential oil composition from the studies. Ecological, orographic, edaphic, or biotic factors may cause differences in the plant, as well as ontogenetic, morphogenetic and diurnal variability, drying conditions and distillation methods may affect the volatile oil content and compounds.

The cosmetics sector, which accounts for around 45.8% of worldwide sclareol consumption, is the primary driver of the sclareol market globally (Ample Market Research, 2019). The sclareol derivative ambroxide is used in the formulation of high quality perfumes. Today, sclareol is obtained by extraction from farming of clary sage (Caniard et al., 2012). However, the Interprofessional Technical Institute of Fragrance, Medicinal, Aromatic and Industrial Plants (ITEIPMAI) in France is researching on the development of clary sage cultivars with increased sclareol yield or the identification of sage species with sclareol content. For this reason, *S. argentea* species collected in our region can be used as a source of sclareol. However, the maximum concentration of 5.2% in *S. sclarea* sage species used as a source of sclareol has increased the importance of *S. argentea* species as a source of sclareol (Souleles & Argyriadou, 1997). However, although the low essential oil content in *S. argentea* compared to *S. sclarea* is a disadvantage, the essential oil content in *S. argentea* can be increased with prospective breeding studies or agricultural practices.

S. bracteata essential oil content was 0.17% ± 0.005. This means that 1 kg of essential oil is produced from 588 ± 23.4 kg of *S. bracteata* plants. According to GC-MS analysis of essential oil of this species; a total of 67 scent compounds were determined. The essential oil of *S. bracteata* consists of maximum monoterpene hydrocarbons, oxygenated monoterpenes, sesquiterpene hydrocarbons and monocyclic diterpene groups. The total concentration of scent molecules in this group was determined as 84.86%. The highest fragrance components in the essential oil are 1,8-cineole (16.06%), β-pinene (14.07%), *trans* β-caryophyllene (12.34%) and cembrene (10.88%), and these compounds were followed by 3-Methyl-3-buten-1-ol (7.75%), α-pinene (5.75%) and β-ocimene (4.99%), *trans*-sabinene hydrate (3.83%) and camphor (3.51%) (Table 1).

The essential oil content of *S. bracteata* has been reported between 0.20% and 2% (Amiri, 2007; Cardile et al., 2009; Demirci et al., 2003; Doğan et al., 2014). On the essential oil concentration and composition of S. bracteata, similar investigations have been reported. Sefidkon et al. (2007) identified 46 compounds in the essential oil of *S. bracteata* including β-caryophyllene 10.7-41.6%, γ-muurolene 27.1-36.3%, bicyclogermacrene 1.8-9.9%, caryophyllenoxide 1.5-9.6% and α-humulene 1.1-9.4% in Iran. Amiri (2007) identified fifty compositions in *S. bracteata* in the flowering period, the main components being α-pinene (28.90%), β-pinene (7.90%), limonene (7.17%) and myrcene (7.65%). Yılar et al. (2020) have reported that the essential oil in *S. bracteata* was contained ledol (24.12%), camphor (15.54%) and valencene (5.64%). When compared with these studies, we can say that the essential oil content is low, but it has similar scent components, although the contents are different.

Table 1**.** The essential oil components of *S. bracteata*, *S. argentea* and *S. tomentosa* (%)

RI[lit]	Name	Molecular structure	Group	*Salvia bracteata*	*Salvia argentea*	*Salvia tomentosa*
746**	3-Methyl-3-buten-1-ol	$C_5H_{10}O$	AAl	7.75		
936.1*	α-Pinene	$C_{10}H_{16}$	MH	5.75	6.59	2.21
950.3*	Camphene	$C_{10}H_{16}$	MH	0.82	0.88	
973**	Sabinene	$C_{10}H_{16}$	MH		3.35	
977.7*	β-pinene	$C_{10}H_{16}$	MH	14.07	11.93	
989.2*	β-Myrcene	$C_{10}H_{16}$	MH	1.22		0.07
1002.8*	*n*-Octanal	$C_8H_{16}O$	AA	0.02		
1017.1*	α-Terpinene	$C_{10}H_{16}$	MH	0.29		
1024.3*	p-Cymene	$C_{10}H_{14}$	MH	1.06		
1029.5*	Limonene	$C_{10}H_{16}$	MH	0.91	0.75	0.08
1030**	β-Phellandrene	$C_{10}H_{16}$	MH	2.49		
1031.8*	1,8-Cineole	$C_{10}H_{18}O$	OM	16.06		0.33
1037.8*	β-ocimene	$C_{10}H_{16}$	MH	4.99		
1059.7*	γ-terpinene	$C_{10}H_{16}$	MH	0.78	0.76	
1086.9*	Terpinolene	$C_{10}H_{16}$	MH	0.31		
1098.1*	*trans*-Sabinene hydrate	$C_{10}H_{18}O$	BM	3.83		
1100.7*	β-Fenchyl alcohol	$C_{10}H_{18}O$	MAl			0.55
1103.3*	*n*-Nonanal	$C_9H_{18}O$	AA	0.11		
1107**	Thujone	$C_{10}H_{16}O$	OM	0.01		
1109**	6-Camphenol	$C_{10}H_{16}O$	OM	0.24		
1130**	Cosmene	$C_{10}H_{14}$	MH	0.03		
1130**	β-2,6-Dimethyl-1,3,5,7-octatetraene	$C_{10}H_{14}$	H	0.33		
1135**	p-Mentha-1,5,8-triene	$C_{10}H_{14}$	MH	0.28		
1135.5*	β-Pinone	$C_9H_{14}O$	BM	0.07		
1143.4*	Camphor	$C_{10}H_{16}O$	OM	3.51		
1154.7*	(E,Z)-2,6-nonadienal	$C_9H_{14}O$	MA	0.03		
1160.6*	Pinocarvone	$C_{10}H_{14}O$	OM	0.27		
1166.2*	Borneol	$C_{10}H_{18}O$	BM	0.10		
1169**	*trans*-p-Mentha-1(7),8-dien-2-ol	$C_{10}H_{16}O$	AAl		0.12	
1177.1*	4-Terpineol	$C_{10}H_{18}O$	OM	1.45		
1189.7*	α-Terpineol	$C_{10}H_{18}O$	OM	0.21		
1192**	(1R)-(-)-Myrtenal	$C_{10}H_{14}O$	BM	0.27		
1200.4*	β-Pinene oxide	$C_{10}H_{16}O$	OM	0.32		
1205.4*	n-Decanal	$C_{10}H_{20}O$	MA	0.03		
1218.3*	β-Cyclocitral	$C_{10}H_{18}O$	OM	0.02		
1237.9*	p-Cuminaldehyde	$C_{10}H_{12}O$	MA	0.01		
1242.1*	Z-Citral	$C_{10}H_{16}O$	OM	0.04		
1263.4*	Dec-2-enal	$C_{10}H_{18}O$	OM	0.01		
1270.3*	E-Citral	$C_{10}H_{16}O$	OM	0.06		
1283.5*	Bornyl acetate	$C_{12}H_{20}O_2$	OM	0.91		
1317.6*	2,4-Decadienal	$C_{10}H_{16}O$	OM	0.01		
1362.9*	Neryl acetate	$C_{12}H_{20}O_2$	OM	0.08		
1376.2*	α-Copaene	$C_{15}H_{24}$	SH	0.23		
1384.2*	β-Bourbonene	$C_{15}H_{24}$	SH			0.65
1386.6*	β-Cubebene	$C_{15}H_{24}$	SH	0.26		
1390.4*	β-Elemene	$C_{15}H_{24}$	SH	0.08		
1408.6*	α-Gurjunene	$C_{15}H_{24}$	SH	0.23		
1420.1*	trans β-Caryophyllene	$C_{15}H_{24}$	SH	12.34	3.24	4.01
1422.4*	β-Cedrene	$C_{15}H_{24}$	SH	0.06		
1425.6*	Ionone	$C_{13}H_{20}O$	OS	0.02		
1434.5*	*α-trans*-Bergamotene	$C_{15}H_{24}$	SH	0.10		
1451.8*	Geranyl acetone	$C_{13}H_{22}O$	MK	0.05		
1453.1*	α-Humulene	$C_{15}H_{24}$	SH	0.75		2.60
1459.9*	Alloaromadendrene	$C_{15}H_{22}$	SH	0.38		5.51
1480.6*	Germacrene D	$C_{15}H_{24}$	SH		13.90	4.23
1482.4*	α-Amorphene	$C_{15}H_{24}$	SH	0.24		
1492.2*	Viridiflorene	$C_{15}H_{24}$	SH	0.04		
1492.2*	Ledene	$C_{15}H_{24}$	SH	0.10		
1494.1*	Bicyclogermacrene	$C_{15}H_{24}$	SH		1.26	
1498.3*	α-Muurolene	$C_{15}H_{24}$	SH	0.60		

Table 1. *(Continued)*

RI[lit]	Name	Molecular structure	Group	*Salvia bracteata*	*Salvia argentea*	*Salvia tomentosa*
1504.1[*]	(E, E)-Farnesene	$C_{15}H_{24}$	SH	0.20		0.23
1508.4[*]	β-Bisabolene	$C_{15}H_{24}$	SH	0.10		
1513.1[*]	γ-Cadinene	$C_{15}H_{24}$	SH	1.40		
1515[**]	β-Vatirenene	$C_{15}H_{22}$	SH	0.11		7.87
1522.9[*]	*cis*-Calamenene	$C_{15}H_{22}$	SH	0.60		
-	8,9-dehydro-Cycloisolongifolene	$C_{15}H_{22}$	TS			0.19
1523.2[*]	δ-Cadinene	$C_{15}H_{24}$	SH	0.08		0.42
1523.5[*]	β-Sesquiphellandrene	$C_{15}H_{24}$	SH	0.12		
1547.5[*]	α-Elemol	$C_{15}H_{26}O$	OS	0.31		
1548[**]	1,5-epoxysalvial-4(14)-ene	$C_{15}H_{24}O$	OS		2.64	
1550.9[*]	Germacrene B	$C_{15}H_{24}$	SH	0.16		
1562[**]	3,8-triene-Cadala-1(10)	$C_{15}H_{22}$	SE	0.11		
1576.4[*]	Spathulenol	$C_{15}H_{24}O$	OS			0.61
1580.2[*]	β-Copaen-4-α-ol	$C_{15}H_{24}O$	OS			6.29
1580.6[*]	(-)-Caryophyllene oxide	$C_{15}H_{24}O$	OS	0.95	4.84	49.56
1584[**]	salvial-4(14)-en-1-one	$C_{15}H_{24}O$	OS			1.99
1595[**]	Alloaromadendrene oxide	$C_{15}H_{24}O$	OS			0.32
1642.9[*]	α-Muurolol	$C_{15}H_{26}O$	OS			6.78
1672.8[*]	cis-α-Santalol	$C_{15}H_{24}O$	OS			0.96
1694.4[*]	*cis*-Farnesol	$C_{15}H_{26}O$	OS	0.08		
1730[**]	Murolan-3,9(11)-diene-10-peroxy	$C_{15}H_{24}O_2$	OS			0.03
1823[**]	Phytol	$C_{18}H_{36}O$	OD			0.36
1881[**]	Sclareol oxide (Cis-A/B)	$C_{18}H_{30}O$	OD		9.65	
-	Methyl 4,7-octadecadiynoate	$C_{19}H_{30}O$	H			3.95
1939[**]	Cembrene	$C_{20}H_{32}$	MD	10.88		
2227[**]	Sclareol	$C_{20}H_{36}O_2$	OD		40.01	
			TOTAL	**99.33**	**99.92**	**99.80**

AA: Aromatic Aldehyde; AAl: Aromatic Alcohol; BM: Bicyclic Monoterpene; H: Hydrocarbon; MA: Monoterpene Aldehyde; MAl: Monoterpene Alcohol; MD: Monocyclic Diterpene; MH: Monoterpene Hydrocarbon; MK: Monoterpene Ketone; OD: Oxygenated Diterpene; OS: Oxygenated Sesquiterpene; OM: Oxygenated Monoterpene; SE: Sesquiterpene Ester; SH: Sesquiterpene Hydrocarbon; TS: Tricyclic Sesquiterpene ; [*]: Hudaib et al., (2001); [**]: Babushok et al., (2011).

Conclusions

In conclusion, the essential oil content and composition of three sage species were investigated in our study. When the previous research findings in the field and the species in our study were compared, it was determined that there were similarities and differences. As a result of our study, it has been observed that the essential oils of *S. argentea* and *S. tomentosa* species contain very valuable fragrance components. *S. argentea* essential oil is highly rich in sclareol and sclareol oxide, and *S. tomentosa* essential oil is rich in (-)-caryophyllene oxide. The fact that these compounds have special uses may be among the species that can be recommended to increase the diversity of these species in aromatic plant agriculture. Our efforts to bring these two species into agricultural production continue.

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Conflict of Interest

The authors have no conflicts of interest to declare.

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