

ESSENTIAL OIL COMPOSITION AND EVALUATION CULTIVATION POTENTIAL OF SOME NATURALLY GROWING SALVIA L. TAXA VICINITY OF YAYLAKONAK TOWN (ADIYAMAN-TÜRKİYE)

Ömer KILIÇ^{1*}, Talip ŞAHİN², Şinasi YILDIRIMLI³

^{1*} Adıyaman University, Faculty of Pharmacy, Department of Botany, Adıyaman / Türkiye ORCID: 0000-0003-3409-1572

² Adıyaman University, Science Institute, Department of Biology, Adıyaman / Türkiye ORCID: 0000-0002-3860-4649

³ Hacettepe University, Faculty of Sciences, Department of Biology-Botany, Ankara /Türkiye ORCID: 0000-0001-9648-7471

*Corresponding author: okilic@adiyaman.edu.tr

Geliş (Received): 26.12.2025

Kabul (Accepted): 03.06.2026

ABSTRACT

Aromatic plants like *Salvia* L. (sage) taxa have been utilized for centuries in traditional medicine and culinary applications, due to their rich bioactive compounds and essential oils. Essential oils play an important role in protecting, pollination and ecological adaptation of plants. The essential oils of most *Salvia* taxa are economically important products; so they are used in perfumery, cosmetics, food, beekeeping, dyes, flavorings, teas, and spices industry. *Salvia* species have been used in ethnobotany and has undergone extensive pharmacognostic research aimed to identify biologically active compounds. Essential oil of *Salvia* taxa has antimicrobial, antioxidant, anticholinesterase, improving cognitive performance and mood, reducing stress, antimutagenic, anticancer, anti-inflammatory, and choleric properties.

Many *Salvia* taxa demonstrate significant agricultural potential due to their adaptability to diverse climatic conditions, relatively low water requirements, and high economic value in pharmaceutical, cosmetic, and food industries. The cultivation of *Salvia* taxa offers promising opportunities for sustainable agriculture, particularly in semi-arid regions, as these plants are drought-resistant and require minimal agricultural inputs. Some plants, such as the *Salvia* taxa found in their habitat, have cultivable value; therefore, sage varieties suitable for the region's ecological conditions can be grown as alternative crops in Adıyaman agriculture.

In this study, essential oils aerial parts of *Salvia virgata* Jacq., *Salvia sclarea* L., *Salvia verticillata* L. subsp. *amasiaca*, *Salvia viridis* L., *Salvia multicaulis* Vahl. were obtained with distillation method and analyzed GC-MS to determine essential oil components. In addition, potential cultivation properties of studied *Salvia* taxa were emphasized. Understanding the essential oil composition of studied sage plants and its cultivation value is important for expanding the potential uses of these plants.

Keywords: *Essential oil; Salvia; Cultivation; Adıyaman; Türkiye.*

YAYLAKONAK KASABASI (ADIYAMAN-TÜRKİYE) YAKINLARINDA DOĞAL YETİŞEN BAZI SALVIA L. TAKSONLARININ ESANSİYEL YAĞ BİLEŞİMİ VE YETİŞTİRME POTANSİYELLERİNİN DEĞERLENDİRİLMESİ

ÖZET

Salvia L. (adaçayı) taksonları gibi aromatik bitkiler, zengin biyoaktif bileşikler ve uçucu yağları nedeniyle yüzyıllardır geleneksel tıp ve mutfaklarda kullanılmaktadır. Uçucu yağlar, bitkilerin korunmasında, tozlaşmasında ve ekolojik adaptasyonunda önemli bir rol oynarlar. Çoğu *Salvia* taksonunun uçucu yağları ekonomik açıdan önemli ürünlerdir; bu nedenle parfümeri, kozmetik, gıda, arıcılık, boya, aroma verici, çay ve baharat endüstrisinde kullanılırlar. *Salvia* türleri etnobotanikte kullanılmakta ve biyolojik olarak aktif bileşikler tanımlamayı amaçlayan kapsamlı farmakognostik araştırmalara konu olmaktadır. *Salvia* taksonlarının uçucu yağı antimikrobiyal, antioksidan, antikolinesteraz, bilişsel performansı ve ruh halini iyileştirici, stresi azaltıcı, antimutajenik, antikanser, antiinflamatuvar ve koleretik özelliklere sahiptir.

Birçok *Salvia* taksonu, çeşitli iklim koşullarına uyum sağlamaları, nispeten düşük su ihtiyaçları; ilaç, kozmetik ve

gıda endüstrilerinde yüksek ekonomik değerleri nedeniyle önemli tarımsal potansiyel göstermektedir. Adaçayı (*Salvia*) taksonlarının yetiştirilmesi, özellikle yarı kurak bölgelerde sürdürülebilir tarım için umut vadeden fırsatlar sunmaktadır; zira bu bitkiler kuraklığa dayanıklıdır ve tarımsal girdileri minimum düzeydedir. Habitatında bulunan *Salvia* taksonları gibi bazı bitkilerin kültüre alınma değerleri vardır; bu nedenle adaçaylarından bölge ekolojik koşullarına uygun olanları Adıyaman tarımında alternatif ürün olarak yetiştirilebilir.

Bu çalışmada, Adıyaman-Yaylakonak (Türkiye) bölgesinde habitatlarından toplanan *Salvia virgata* Jacq., *Salvia sclarea* L., *Salvia verticillata* L. subsp. *amasiaca*, *Salvia viridis* L. ve *Salvia multicaulis* Vahl. türlerinin toprak üstü kısımlarının uçucu yağları distilasyon yöntemi ile elde edilerek, uçucu yağın bileşenlerini belirlemek için GC-MS ile analiz edildi. Ek olarak, çalışılan adaçayı türlerinin potansiyel yetiştirme özellikleri vurgulandı. Çalışılan Adaçayı bitkilerinin uçucu yağ kompozisyonunun anlaşılması ve kültüre alma değerlerinin bilinmesi, bu bitkilerin potansiyel kullanım alanlarının genişletilmesi açısından önemlidir.

Anahtar Kelimeler: Uçucu yağ; Adaçayı; Yetiştirme; Adıyaman; Türkiye.

1. INTRODUCTION

Medicinal and aromatic plants are increasingly used in diverse sectors, and accordingly, their global market share is expanding with each passing day. *Salvia* L. members are also have medicinal and aromatic properties. *Salvia* genus is in the Lamiaceae family. The Labiatae family, comprising 236 genera and more than 7130 species, is widely distributed throughout the world (Harley et al., 2004). Lamiaceae taxa are generally distributed in high-altitude plains in tropical and temperate regions where the climate conditions of the Mediterranean region predominant. Türkiye, contains 45 genera and more than 740 taxa in Lamiaceae family; so our country is one of the important gene centers of Labiatae members. Endemism rate of Lamiaceae is approximately 42% in Türkiye. Many plants belonging to Labiatae family are rich in secondary metabolites like essential oils; making them very important in many fields and sectors (Kahraman et al., 2009).

The genus *Salvia* is commonly known as sage, comprises over 900 species distributed worldwide, particularly in temperate and subtropical regions. Many *Salvia* species have been ethnobotanical importance and traditionally used in herbal medicine, culinary practices, and as aromatic plants due to their rich content of bioactive compounds (Kılıç, 2016). In general, *Salvia* species, used in folk medicine as sedative, diuretic, stomachic, antiperspirant, and externally as wound healing and antiseptic. In addition, these plants with a wide variety of biological effects such as antibacterial, antifungal, antiviral, antiseptic, analgesic, antioxidant, astringent, antispasmodic, central nervous system depressant, antidiabetic, anticancer, tuberculostatic, cardiovascular and insecticidal activities (Baytop, 1999). Essential oils of *Salvia* taxa are characterized by complex mixtures of volatile secondary metabolites, predominantly terpenoids, which contribute to their distinctive fragrance and biological activities. Latin name "*Salvia*" derives from the word "to cure," reflecting the historical medicinal importance of these plants. Some members of the genus *Salvia* have great economic importance especially because of their high yield and quality essential oils; such as *S. officinalis* L., *S. fruticosa* Mill., *S. lavandulifolia* Vahl., *S. verbenaca* L., *S. sclarea* L., and *S. tomentosa* Mill. It is estimated that production of essential oil of *S. sclarea*, *S. officinalis*, and *S. lavandulifolia* ranged between 50 and 90 tonnes per year (Lubbe and Verpoorte, 2011). Essential oils are secondary metabolites whose production and composition are influenced by multiple factors including genetic variation (chemotypes), geographical location, environmental conditions, developmental stage, harvest timing, and extraction methods. The remarkable chemical diversity observed within and among *Salvia* species has led to extensive research into their composition, chemotaxonomy, and biological activities. Major constituents typically include monoterpenes and sesquiterpenes, such as 1,8-cineole, camphor, α -thujone, germacrene D, β -caryophyllene, and borneol, which contribute to both biological activity and aromatic profile. Many *Salvia* taxa have been used worldwide in traditional medicine and in

ethnobotany since ancient times to treat various diseases like digestive disorders, infections of the mouth and throat, respiratory ailments, skin disorders, tuberculosis, infections, etc. *Salvia* essential oils have attracted increasing interest for their potential beneficial effects on human health, demonstrating to date various pharmacological activities, including strong antimicrobial and anti-inflammatory potentials (Lu and Yeap, 2002; Fu et al., 2013). Increasing consumer preference for natural products, coupled with concerns regarding synthetic additives and antimicrobial resistance, has intensified research efforts toward valorizing *Salvia* essential oils as sustainable alternatives in various industrial sectors (Bakoğlu et al., 2016; Tohma et al., 2016; Bursal et al., 2019).

Aromatic and medicinal plants have gained much popularity in Türkiye and global markets in the last decades (Kılıç et al., 2017). Many *Salvia* taxa holds considerable significance in agricultural systems due to its multifaceted economic, ecological, and agronomic value. As a commercially cultivated aromatic and medicinal plant, sage contributes substantially to the agricultural economy through the production of essential oils, dried leaves for culinary applications, and pharmaceutical raw materials, with global demand consistently increasing in both developed and emerging markets. *Salvia officinalis* (medicinal sage) does not grow naturally in Türkiye, but there have been advancements in its cultivation in recent years (Ceylan, 1990). From an agronomic perspective, many *Salvia* taxa exhibits remarkable adaptability to diverse climatic conditions and marginal soils, requiring relatively low water inputs compared to conventional crops, thereby representing a sustainable alternative for arid and semi-arid agricultural regions facing water scarcity around the world. *S. officinalis*, *S. sclarea*, *S. lavandulifolia*, *S. fruticosa*, *S. pomifera* are the most cultivated species. *Salvia* cultivation enhances agroecosystem biodiversity by serving as an important melliferous plant that supports pollinator populations, particularly honeybees and native bee species, which are essential for broader agricultural productivity (Kılıç et al., 2021).

The allelopathic properties of some *Salvia* species have also attracted attention for their potential applications in integrated pest management and biological weed control, offering environmentally friendly alternatives to synthetic agrochemicals. Additionally, sage can be strategically integrated into crop rotation systems and agroforestry practices to improve soil health, prevent erosion, and diversify farm income streams. The cultivation of sage aligns with the growing global emphasis on sustainable agriculture, organic farming, and the production of high-value specialty crops, positioning it as an increasingly important component of modern agricultural diversification strategies and rural development initiatives. The yields of *Salvia* taxa obtainable in are of high quantity and best quality. Thus, the introduction of sage in crop rotation systems should be seriously considered for the near future. Extensive cultivation of sage might be proved to be highly beneficial for the environment, for drought-tolerant landscape, with respect to biodiversity conservation and minimizing soil erosion, land degradation and desertification processes in many degraded lands of the arid or semi-arid zone, where sage cultivation might be proved to be ideal (Kintzios, 2000).

Salvia, *Mentha*, *Rosmarinus*, *Thymbra*, *Thymus*, *Sideritis*, *Nepeta*, *Lavandula*, *Ocimum*, *Melissa* are among the most commonly used and best-known genera in Lamiaceae family. Many species of Lamiaceae (mint) are important plants in terms of forage quality (Başbağ et al., 2018). Worldwide, the medicinal leaves and essential oil of sage are widely used in alternative herbal medicine and food additives (Elmas and Elmas, 2021). In Türkiye, large part of sage exports consists of *Salvia fruticosa* and *Salvia tomentosa* species collected from nature (Karakuş et al., 2017). The *Salvia* taxa examined in this study, naturally occurring in arid and semi-arid habitats, which dominat climatic properties of Adıyaman ecological conditions.

These taxa exhibit inherent adaptation to water-limited conditions in their habitats. In our floristic study around the Çelikhan district of Adıyaman, we identified seven different *Salvia* species in the area (Kılıç & Yıldırım, 2022). The prevalence of *Salvia* species in Adıyaman's ecological conditions indicates that sage species can be easily cultivated in Adıyaman conditions as alternative crops. Many *Salvia* species offer distinct advantages including drought tolerance, minimal irrigation requirements, and high-value essential oil production potential. The introduction of such drought-adapted aromatic plants could enhance agricultural sustainability while providing economic opportunities for local farming communities facing increasing water scarcity challenges. Sustainable cultivation of suitable *Salvia* species could reduce pressure on wild populations while simultaneously creating new agricultural opportunities and preserving valuable genetic resources for future medicinal and aromatic plant development. The agricultural cultivation of native *Salvia* taxa not only supports biodiversity conservation but also provides farmers with high-value alternative crops suitable for organic and sustainable farming systems. Therefore, to promote sustainable use and sustainable development of region, it is essential to increase the cultivation of high-quality, high-yield plants like sage that meets the quantity and standards demanded by global markets.

Investigating the essential oil profiles of *Salvia* taxa indigenous to the natural ecological conditions of Adıyaman is of critical importance for identifying chemical constituents, providing comparative assessments with specimens from diverse geographical regions, expanding the commercial and agricultural potential of this economically significant genus. In response to the growing demand for natural products in pharmaceutical and industrial applications, comprehensive characterization of essential oil constituents in *Salvia* taxa has gained considerable importance. The present study evaluate to elucidate the essential oil composition and potential cultivation properties of *Salvia* taxa indigenous to Adıyaman (Türkiye), to assess their prospective utility related sectors and to contribute to studies on the subject.

2. MATERIALS AND METHODS

2.1. Plant Materials

Plant samples were collected from their natural habitats; within the scope of Yaylakonak (Adıyaman) floristic project (ADYU, ECZMAP/2024-0001) field works. Studied plant samples (*Salvia virgata*, *Salvia sclarea*, *Salvia verticillata* subsp. *amasiaca*, *Salvia viridis*, *Salvia multicaulis*) were collected from vicinity of Yaylakonak town (Adıyaman), steppe slopes, water limited stony areas, arid or semi-arid habitats, on may and june 2025, by authors, collection numbers are ÖK 3612-3616 respectively. All plant samples were identified by Kiliç with Flora of Turkey and East Aegean Islands of 7 (Davis, 1982). The voucher specimens have been deposited in Adıyaman University, Pharmacy Faculty, Pharmaceutical Botany Department and in Herbarium of Ş. Yıldırım (Ankara-Sincan). Images of studied the plant taxa in their habitats are shown below.



Salvia sclarea (Foto: Ö.Kılıç)



Salvia virgata (Foto: Ö.Kılıç)



Salvia verticillata subsp. *amasiaca* (Foto: Ö.Kılıç)



Salvia multicaulis (Foto: Ö.Kılıç)



Salvia viridis (Foto: Ö.Kılıç)

2.2. Isolation of essential oils

Aerial parts of plant materials were air-dried at room temperature for 10 days and then comminuted. About 120 g crushed sample from each plant was used to get essential oil, and the essential oils were obtained by hydro-distillation with cleverger apparatus devices for 3 hours

(Figure 2).

Obtained essential oil was poured in colorful small tubes and was kept in temperature $-5\text{ }^{\circ}\text{C}$ in the freezer until testing and analysis.



Figure 2. Isolation of essential oils with clavenger apparatus device

2.3. Essential oil analysis

Common physical method for separation of essential oil components is Gas Chromatography (GC) which is based on the sample release of two phases between residents (solid) and mobile phase (gas). Diagnosing obtained components occurs from the inhibition time. Then for detection and isolation of components in the oil, two devices, gas chromatography and mass spectrometry as coupled, were used that the GC and GC-MS devices in central laboratory of Adiyaman University. For GC analysis thermoquest gas chromatograph equipped with DB-1 column, type the length of 60 meters and diameter 0.25 mm and thickness layer $0.25\text{ }\mu\text{m}$ were used. Oven temperature of $60\text{ }^{\circ}\text{C}$ to $250\text{ }^{\circ}\text{C}$ with $4\text{ }^{\circ}\text{C}$ per minutes speed increased. Part injection temperature $250\text{ }^{\circ}\text{C}$ and making clear $280\text{ }^{\circ}\text{C}$ and nitrogen azotes' carrier gas with a speed 1 ml min was used. For GC-MS analysis, equipped with a DB-1 column 60 m in length and diameter of 0.25 mm thickness layer and $0.25\text{ }\mu\text{m}$ were used. Helium gas with speed 1 ml per minute and ionizing energy 70 eV in the coupled mass spectrometer with gas chromatograph was used. Compared inhibition index (Retention index) of each essential oil components were reported. Comparison of mass spectra of each essential oil components with mass spectra available in libraries (Wiley and Nist).

3. RESULTS AND DISCUSSION

In this study, caryophyllene oxide (23.6%), β -caryophyllene (15.4%), germacrene D (12.8%), spathulenol (9.2%) in *S. virgata*; caryophyllene oxide (22.3%), spathulenol (17.5%), linalool (9.4%), β -caryophyllene (8.3%) in *S. sclarea*; germacrene D (18.3%), β -caryophyllene (11.4%), spathulenol (10.7%), limonene (10.9%), 1,8-cineole (9.3%) in *S. verticillata* subsp. *amasiaca*; germacrene D (18.7%), β -pinene (17.8%), γ -muurolene (14.8%), 1,8-cineole (12.5%), borneol (9.2%) in *S. viridis*; β -caryophyllene (22.5%), caryophyllene oxide (13.2%), β -pinene (17.8%) in *S. multicaulis* were identified as main compounds (Table 1).

Table 1. Essential oil compounds of *Salvia taxa*

Compounds	RI (Retention Index)	<i>S. virgata</i> %	<i>S. sclarea</i> %	<i>S. verticillata</i> subsp. <i>Amasiaca</i> %	<i>S. viridis</i> %	<i>S. multicaulis</i> %
α -Pinene	932	0.6	2.3	14.2	0.7	1.3
Camphene	940	1.1	1.2	-	1.2	9.5
α -Phellandrene	955	-	0.9	2.3	-	1.8
Sabinene	965	2.3	-	-	1.3	0.8
α -Thujene	972	-	2.6	0.5	1.1	0.6
β -Pinene	978	4.2	3.4	3.8	17.8	3.3
Myrcene	992	1.1	2.5	-	-	-
p-Cymene	1015	-	1.4	1.8	1.7	0.7
Limonene	1020	0.2	-	10.9	-	14.1
1,8-Cineole	1025	3.7	2.4	9.3	12.5	1.2
β -Ocimene	1033	-	1.2	-	0.6	-
γ -Terpinene	1045	2.1	1.2	0.9	-	0.9
α -Terpinolene	1071	-	-	3.9	0.7	-
Linalool	1084	0.4	9.4	-	1.4	2.8
Camphor	1126	1.8	5.5	2.8	2.2	11.3
Verbenol	1135	-	-	1.2	-	-
Borneol	1143	0.5	0.5	-	9.2	1.3
4-Terpineol	1156	-	0.4	0.3	-	0.5
Myrtenol	1178	0.2	-	0.4	1.5	-
Bornylacetate	1260	1.3	-	0.3	-	1.1
Estregole	1270	4.6	0.5	-	0.6	0.6
Carvacrol	1274	-	2.2	6.8	-	-
Bicycloelemene	1320	1.2	-	0.3	0.5	0.2
α -Copaene	1355	3.1	1.3	1.0	0.9	0.9
β -Bourbenene	1385	-	0.5	-	1.1	0.9
α -Cubebene	1390	0.9	-	0.4	-	-
β -Caryophyllene	1420	15.4	8.3	7.4	3.4	22.5
γ -Muurolene	1455	1.5	-	-	14.8	0.5
β -Elemene	1463	-	0.4	2.8	-	0.5
Germacrene D	1480	12.8	4.6	8.3	18.7	4.3
β -bisabolene	1490	2.0	-	-	0.5	-
δ -Cadinene	1495	2.2	-	0.5	-	0.3
Bicyclogermacrene	1545	-	0.8	-	2.4	3.1
Spathulenol	1570	9.2	17.5	10.7	0.9	5.6
Caryophyllene oxide	1580	23.6	22.3	3.5	0.6	5.2
Aromadendrene	1605	0.3	-	2.5	-	-
Ledol	1615	0.7	1.4	-	0.1	0.4
Cadinol	1620	-	2.4	0.7	-	1.1
β -Eudesmol	1635	0.7	0.5	-	0.2	0.2
		97.7	98.4	97.5	98.7	96.5

The chromatogram shape, based on the essential oil results of the plants are shown in below Figures 3-7.

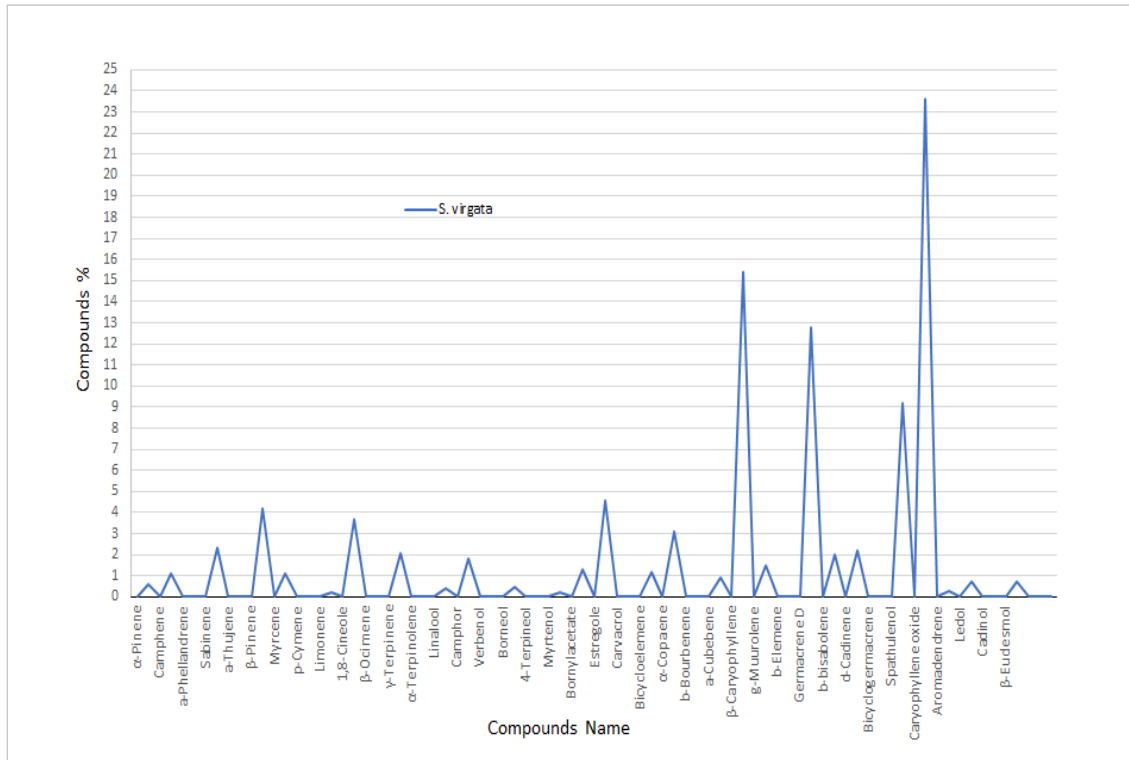


Figure 3. Chromatogram graph of *Salvia virgata*

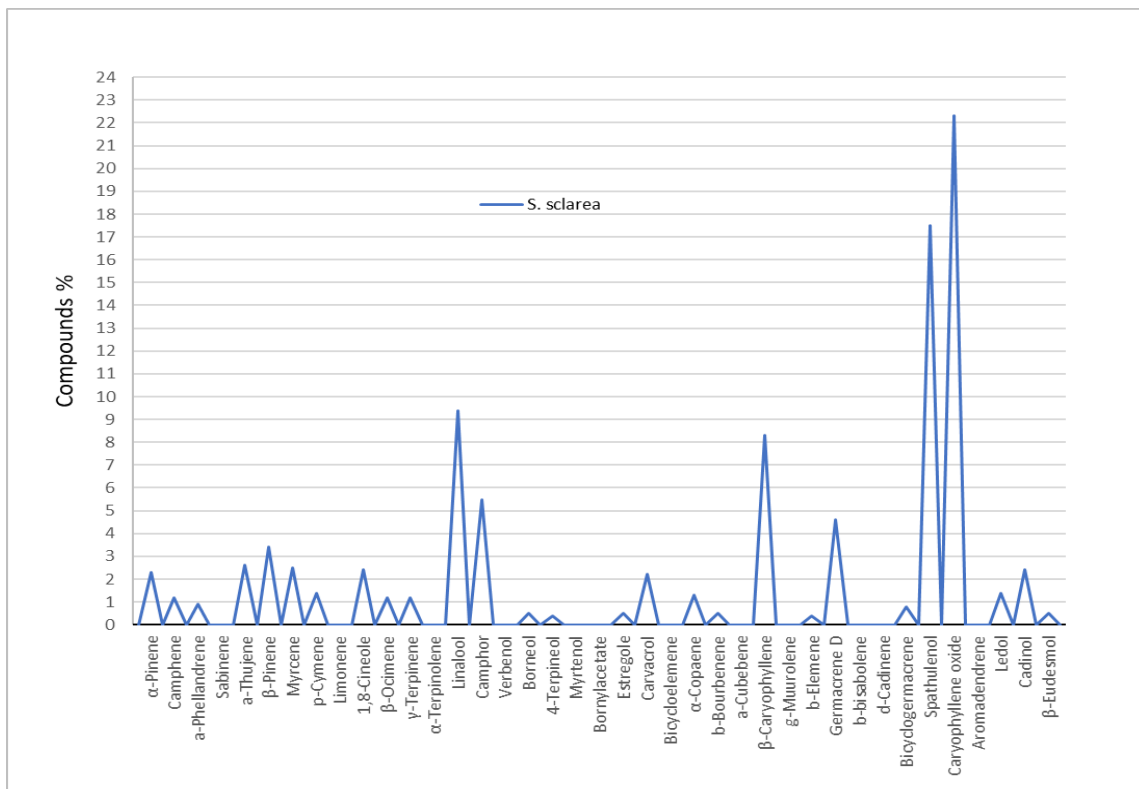


Figure 4. Chromatogram graph of *Salvia sclarea*

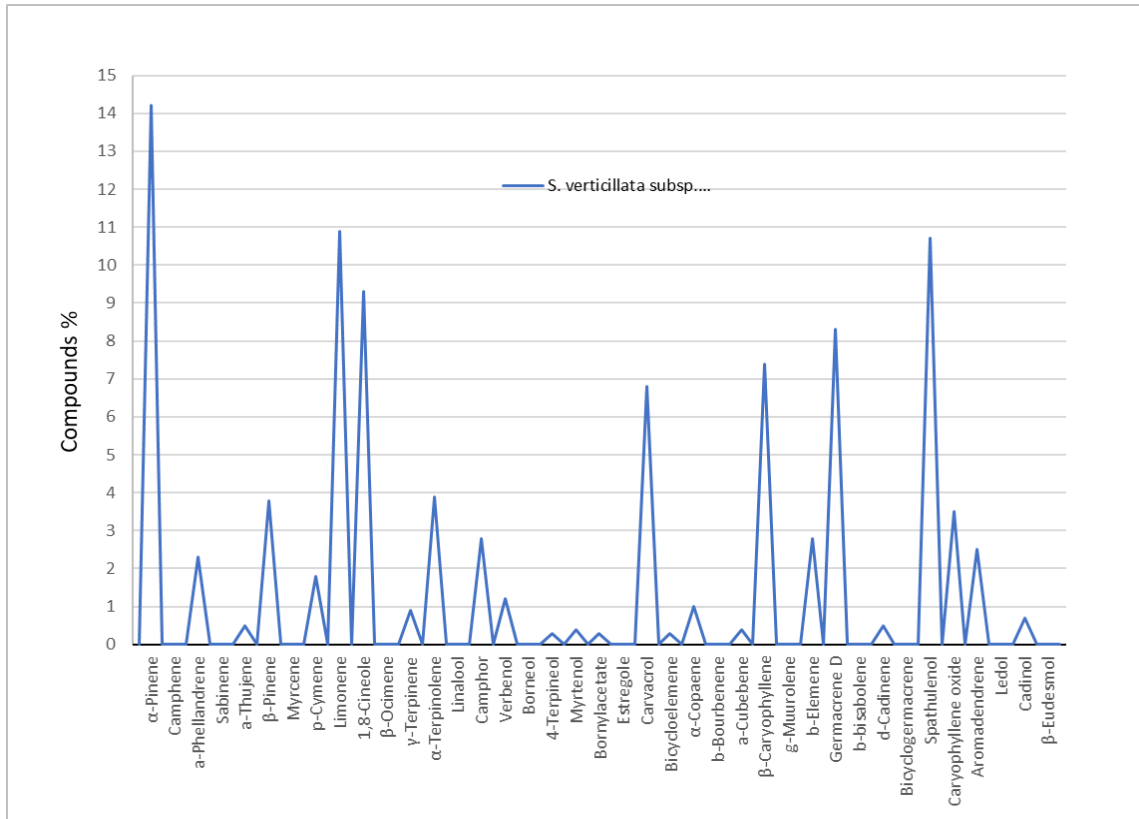


Figure 5. Chromatogram graph of *Salvia verticillata subsp. amasiaca*

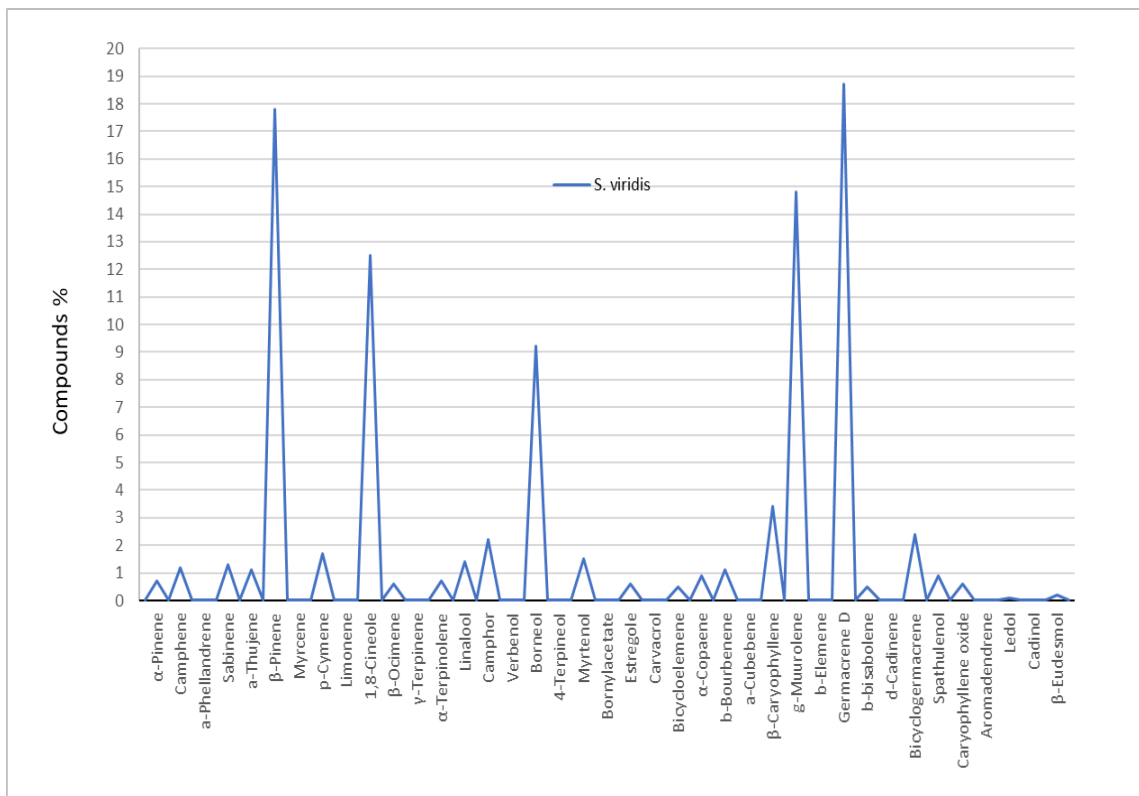


Figure 6. Chromatogram graph of *Salvia viridis*

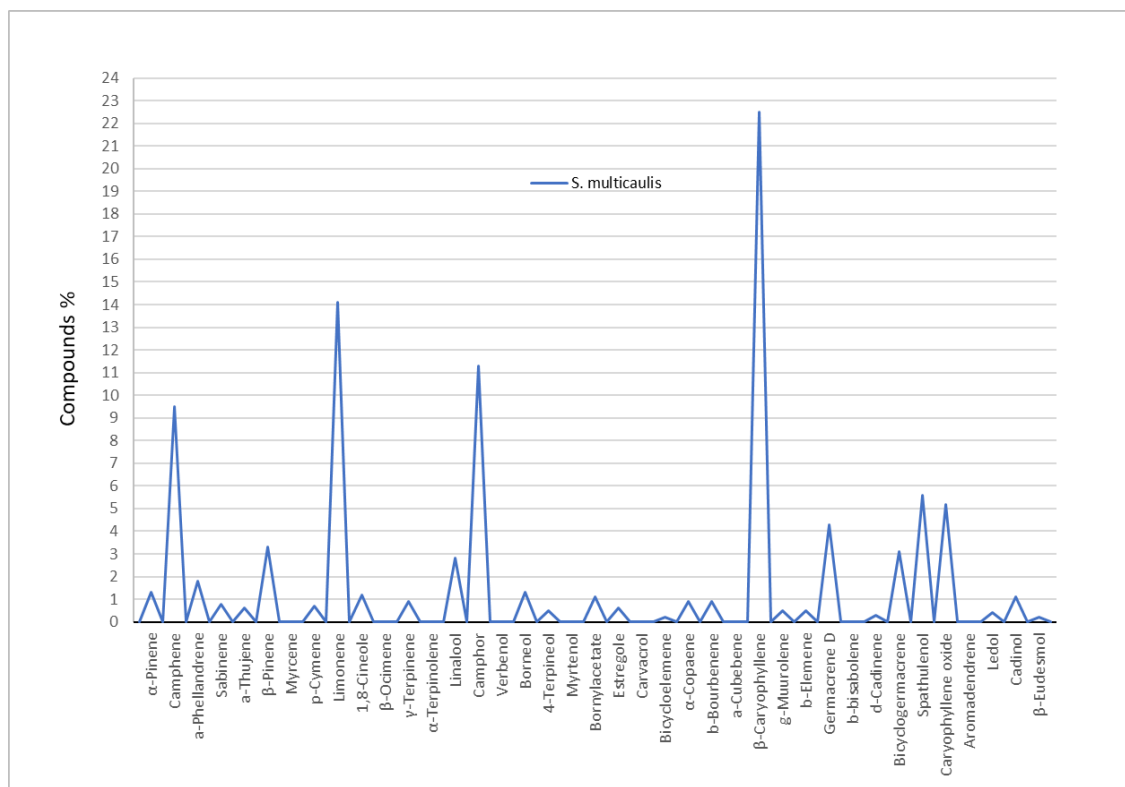


Figure 7. Chromatogram graph of *Salvia multicaulis*

In a previous study essential oil of *S. virgata* from Türkiye was investigated; eventually isocaryophyllene (13.2%) and caryophyllene oxide (6.94%) were detected as the main compounds (Yılar et al., 2017). This study results are similar indicating β -caryophyllene (15.4%) and caryophyllene oxide (23.6%) as the major components, but with some differences in the percentages of the main compounds like spathulenol and germacrene D. It is noteworthy to mention that linalool and camphor were found in low amounts (0.4% and 1.8%, respectively), while α -amorphene was not detected in this study (Table 1). This study represents the first report on *S. virgata* essential oil collected from vicinity of Yaylakonak town (Adıyaman-Türkiye) habitat.

Salvia sclarea is a xerophytic plant species that naturally grows in temperate regions, exhibiting high adaptability to dry and semi-arid environmental conditions. The aerial parts of the plant are rich in essential oils characterized by a distinctive fresh, floral, and herbaceous aroma. These kind of essential oils are of considerable industrial importance, commonly utilized in the formulation of flavoring agents in tobacco and alcoholic beverages, as well as in perfumery and cosmetic products. *S. sclarea* (clary sage) has characteristics essential oil profile and the has been cultivated in several countries in the Mediterranean Basin, including France, which was a leading producer of the oil by the late 1950s (Tibaldi et al., 2010). *S. sclarea* has drought tolerant and thus can be grown in marginal areas with little irrigation conditions like Adıyaman (Türkiye) climate. In this research totally 30 components were identified in *S. sclarea* essential oil, constituting 98.4% of the total oil. The most abundant constituents were caryophyllene oxide (22.3%), spathulenol (17.5%), linalool (9.4%), and β -caryophyllene (8.3%); monoterpene hydrocarbons were the major components in the essential oil (Table 1). Hayta et al. (2015) was detected spathulenol (19.0%), caryophyllene oxide (15.5%), linolyl acetate (11.3%) and linalool (8.5%) as the main essential oil compounds of *S. sclarea*. Variations were evidenced in the amount of the essential oil constituents compared to our results. This could probably be attributed to the different geographical and ecological areas sampled, and the period

of the sample collection.

Salvia verticillata has two subspecies (subsp. *verticillata* and subsp. *amasiaca*) in flora of Türkiye. Hayta et al. (2015) analyzed the *S. verticillata* subsp. *verticillata* essential oil from Türkiye; as a result monoterpenes were also the predominant class; germacrene D (13.8%) and spathulenol (10.0%) were among the the main essential oil compounds. Similarly, except for borneol (9.2 %) and β -caryophyllene (11.4%); germacrene D (18.3%) and spathulenol (10.7%) were among the dominating constituent in the sample studied here with *S. verticillata* subsp. *amasiaca* (Table 1).

Overall, 28 compounds were found, representing a range of 98.7% of the essential oils of *S. viridis* collected from vicinity of Yaylakonak (Adıyaman). The qualitative oil compositions did not present much differences; however, quantitative variation was observed. The most abundant constituents were germacrene D (18.7%), β -pinene (17.8%), g-muurolene (14.8%) and 1,8-cineole (12.5%) (Table 1). 1,8-cineole (eucalyptol), is widely distributed in medicinal-aromatic plants and is found in high concentrations in the essential oil of *Eucalyptus polybractea*; this compound broadly used in cosmetics industry, therapeutic applications, muscular pain, for cough treatment, neurosis, rheumatism, asthma, and urinary stones (Wichtel, 2002; Shiekh et al., 2024). A previous study has been carried out in the *S. viridis* essential oil from Türkiye, sesquiterpene hydrocarbons were shown to be the main group of constituents (in flower: 52.8%, in leaf: 50.2%, in stem: 48.7%); the major compounds of the oils of *S. viridis* were β -pinene, trans-muuro-la-diene and germacrene D (Kahriman et al., 2010). It is noteworthy to mention the presence of germacrene D and β -pinene in considerable amounts in *S. viridis* here in examined. Our results were generally in accordance with previous reports on *S. viridis* essential oil from Türkiye (Kahriman et al., 2010).

S. multicaulis, which has medicinal aspects and ethnobotanical properties. Essential oil composition of *S. multicaulis* growing naturally in different habitats of Dikme upland from Bingöl province (Türkiye) was analyzed. Caryophyllene oxide (22.5%), spathulenol (12.7%) and β -pinene (7.5%) were detected as the main constituents of *S. multicaulis* (Kılıç, 2016). However, in this research β -caryophyllene (22.5%), caryophyllene oxide (13.2%), β -pinene (17.8%) were the major compounds of *S. multicaulis* (Table 1). The essential oils bearing complex chemical composition are influenced not only by environmental and factors but also harvested period and methods. Various factors, both endogenous and exogenous, can affect the composition of the essential oil of *Salvia* taxa. Several papers have reported on the variation in the essential oil composition induced by environmental, physiological, and edaphic factors which can induce changes in biosynthesis accumulation or metabolism of given compounds of the essential oil (Abd-Elkhalek and Heikal, 2017; Vaičiulytė et al., 2022). The data presented here showed that the studied *Salvia* taxa possessed many interesting essential oil compositions and is certainly encouraging for a future application in the pharmaceutical, agricultural, chemical and nutraceutical fields.

4. CONCLUSION

The genus *Salvia* represents a rich source of essential oils with variation both among and within species. The existence of multiple chemotypes, influenced by genetic, geographical, developmental, and environmental factors, creates a complex landscape for research and commercial applications. Understanding this chemical diversity is crucial for optimizing the therapeutic efficacy, quality control, and sustainable production of *Salvia* derived products. The continued investigation of essential oil composition, combined with modern analytical

techniques and chemometric approaches, will enhance our ability to harness the full potential of remarkable *Salvia* taxa for medicinal, aromatical, culinary, agricultural and industrial applications.

In this study, new information regarding the quantitative and qualitative variation essential oils wild-growing five different *Salvia* taxa was obtained. Essential oils of some *Salvia* taxa have not been pharmacologically studied so far. However, additional experimental studies should be carried out in order to determine the possible applications of studied *Salvia* essential oils. According to the findings, differences were determined in terms of the basic components and proportions of the essential oil compared to previous studies. These differences may depend on various biotic and abiotic factors. Additionally, relevant literature reveals that sage (*Salvia*) cultivation offers significant potential in terms of both economic value and medicinal importance. The evaluations based on the data obtained in this study, along with the natural distribution of some sage species in the Adıyaman flora, indicate that suitable sage species can be cultivated in Adıyaman's ecological conditions and that high-quality active component content can be achieved. However, further research is needed to determine the optimum cultivation parameters of the selected sage species under different ecological conditions and to develop disease and pest management strategies. Expanding sage cultivation in Adıyaman's ecological conditions will contribute to regional development and enable the sustainable fulfillment of the increasing demand for medicinal and aromatic plants.

In this context, with the increasing use of sage in the pharmaceutical, forage, food, cosmetic and other industries is of great importance. To ensure the sustainable cultivation of *Salvia* species and to maximize their commercial potential, it is necessary to expand the cultivation of varieties that yield high-quality products and are suitable for the ecological conditions of Adıyaman. We hope that this study will help the way for suitable sage cultivation in the ecological conditions of Adıyaman, contribute to related studies, and raise awareness.

ACKNOWLEDGEMENTS

This study was supported under project number ECZMAP / 2024-0001, which was accepted by the Adıyaman University BAP Commission.

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