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Research Article

Chemical composition of *Salvia yangii* B.T. Drew essential oil

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Abstract

Several aromatic species within the genus *Salvia* (Lamiaceae) possess essential oils. People use these kinds of oils a lot in perfumes, traditional medicine, and flavoring. *Salvia yangii* B.T. Drew (syn. *Perovskia atriplicifolia* Benth.), often known as Russian sage, is a perennial shrub native to Central and Southwestern Asia. Given its ornamental and aromatic significance, there is a paucity of phytochemical data concerning the volatile chemicals of this species, particularly those cultivated in Türkiye.

The present study analyzed the essential oil extracted from the aerial parts of *S. yangii* to determine its chemical composition through gas chromatography with flame ionization detection and mass spectrometry (GC–FID/MS). Forty compounds have been determined, accounting for 95.23% of the total composition. The essential oil was primarily composed of oxygenated monoterpenes and sesquiterpenes, with camphor (17.39 ± 0.01%), 1,8-cineole (13.10 ± 0.00%), and β-caryophyllene (11.48 ± 0.01%) as its major compounds.

This study is, to our knowledge, the first comprehensive report on the volatile composition of S. yangii grown in Türkiye. The results provide important reference data for future chemotaxonomic and phytochemical studies of the *Salvia* genus. These findings provide possibilities for further investigation into the distinctive characteristics of *S. yangii* and its potential applications in medicine, agriculture, and other domains. They also show how important regional studies are for learning about the variety and usefulness of plant species.

Keywords: 1,8-cineole, camphor, essential oil, *Perovskia atriplicifolia*, *Salvia yangii*

1. INTRODUCTION

The genus *Salvia* (Lamiaceae) is one of the biggest in the family, with more than 1000 species around the world [1, 2]. These plants of this genus have become recognized for their strong scent and high concentration of essential oil, resulting in extensive use in traditional medicine, the culinary sector, perfumes, and cosmetics [3, 4]. The essential oils of *Salvia* species are mostly composed of mono- and sesquiterpenes, which impart their unique fragrance and various pharmacological properties [5].

Salvia yangii B.T. Drew (also known *Perovskia atriplicifolia* Benth.) perennial subshrub that grows in the mountains of Central and Southwestern Asia. It is also known as Russian sage. It has silver-gray leaves and violet-blue flowers, which make it a popular ornamental plant around the world [6, 7]. Recent phylogenetic research has reclassified *Perovskia*

species into the genus *Salvia*, creating *Salvia* subg. *Perovskia*, due to its close morphological and genetic affinities [2].

Previous studies on *Salvia* species have shown that the essential oils are influenced by ecological conditions, plant parts, and geographic origin [3]. Significant compounds determined in *Perovskia* species encompass 1,8-cineole, α-pinene, β-pinene, β-caryophyllene, camphor, borneol, and viridiflorol, which enhance their unique fragrant characteristics [8]. To our knowledge, there has been no comprehensive investigation analyzing the essential oil content of *S. yangii* grown in Türkiye.

The present work aimed to determine the chemical composition of the essential oil derived from the aerial part of *S. yangii* by gas chromatography coupled with flame ionization detection and mass spectrometry (GC–FID/MS). This study is the inaugural extensive analysis of the essential oil composition of *S. yangii* from Türkiye, providing significant foundational data for future chemotaxonomic and phytochemical research.

2. MATERIALS AND METHODS

2.1. Plant Material

S. yangii plant was gathered from the village of Günalan in Ankara. Subsequent to collection, the plant material was air-dried in a shaded environment at ambient temperature. The plant has been defined by Dr. Koray Yaylacı from Anadolu University, Faculty of Pharmacy, Department of Pharmaceutical Botany. Voucher specimens of *S. yangii* were made, and the herbarium specimen (ESSE 16364) was registered in the Herbarium of the Faculty of Pharmacy at Anadolu University.

2.2. Hydrodistillation and Preparation of Essential Oil

The essential oil was extracted using hydrodistillation of the air-dried aerial parts of the plant for three hours using a Clevenger-type apparatus, in accordance with the European Pharmacopoeia [9]. The yield of the essential oil was determined on a moisture-free basis. After dehydration with anhydrous sodium sulfate, the essential oil was stored in an amber vial at 4°C. For gas chromatography analysis, the essential oil was diluted with *n*-hexane to a final concentration of 10% (v/v). During gas chromatography analysis, the essential oil was diluted with *n*-hexane to a final concentration of 10% (v/v).

2.3. Gas Chromatography-Mass Spectrometry (GC–MS) and Gas Chromatography-Flame Ionization Detection (GC–FID) Analysis

The volatile compounds were analyzed by GC-MS/FID. Established protocols for GC-MS and GC-FID analysis were adhered to [10]. The experiment used an Agilent Innowax FSC column (60 m × 0.25 mm, 0.25 µm film thickness) with 0.8 mL/min helium flow. The GC oven temperature was initially 60 °C for 10 minutes, then increased to 220 °C at 4 °C/min, kept at 220°C for 10 minutes, and lastly raised to 240 °C at 1 °C/min. When appropriate, commercial standards or pure substances were co-injected to quantify essential oil components and fatty acid methyl esters. Mass spectra were compared to the Adams Library, MassFinder software 4.0 (Dr. Hochmuth Scientific Consulting, Hamburg, Germany), and Wiley-NIST GC/MS Library (Wiley, NY, USA) and for identification of compounds [11, 12]. The Library of Essential Oil Constituents was created for validation from chromatographic examinations of pure components under standard analytical circumstances. Relative retention indices (RRIs) of identified compounds were determined using a standard mixture of *n*-alkanes (C_8–C_{40}; Fluka, Buchs, Switzerland). FID peak areas were used to determine chemical percentages without normalization.

3. RESULTS AND DISCUSSION

Within the scope of this investigation, the hydrodistillation of the aerial parts of *Salvia yangii* yielded 0.78 g of nearly colorless essential oil, corresponding to 1.96% (w/w, calculated on a dry weight basis). The essential oil possessed a characteristic aromatic odor typical of *Salvia* species.

3.1. Chemical Composition of Essential Oil

The compounds of the essential oil derived from the aerial parts of *S. yangii* were examined using GC–FID/MS methodologies. Table 1 shows the compounds arranged by their elution sequence on the HP-Innowax FSC column, accompanied by their relative percentages, retention indices, and identification methodologies. The GC–FID/MS chromatogram of the essential oil hydrodistilled from the aerial parts of *S. yangii* is presented in Figure 1.

Table 1. Essential oil analysis results of *S.yangii* aerial parts

No	$RRI_{exp.}$	$RRI_{lit.}$	Compound*	%	References
1	1032	1032	α-Pinene	4.28±0.01	[13]
2	1076	1076	Camphene	1.70±0.00	[14]
3	1118	1118	β-Pinene	1.60±0.01	[15]
4	1159	1154	δ-3-Carene	5.28±0.00	[16]
5	1174	1174	Myrcene	0.58±0.01	[17]
6	1176	1176	α-Phellandrene	0.10±0.00	[18]
7	1188	1188	α-Terpinene	0.22±0.01	[15]
8	1203	1198	Limonene	7.90±0.00	[19]
9	1213	1212	1,8-Cineole	13.10±0.00	[20]
10	1246	1246	*(Z)*-β-Ocimene	0.30±0.00	[21]
11	1255	1253	γ-Terpinene	0.40±0.00	[22]
12	1280	1280	*p*-Cymene	0.21±0.00	[23]
13	1286	1286	Isoterpinolene	0.12±0.00	[24]
14	1290	1282	Terpinolene	0.50±0.00	[19]
15	1466	1466	α-Cubebene	0.10±0.00	[24]
16	1474	1474	*trans*-Sabinene hydrate	0.20±0.00	[25]
17	1497	1509	α-Copaene	0.20±0.00	[26]
18	1532	1515	Camphor	17.39±0.01	[19]
19	1544	1538	α-Gurjunene	0.30±0.00	[22]
20	1553	1543	Linalool	0.20±0.00	[19]
21	1565	1565	Linalyl acetate	0.30±0.00	[27]
22	1590	1590	Bornyl acetate	1.90±0.02	[28]
23	1612	1617	β-Caryophyllene	11.48±0.02	[29]
24	1638	1638	Cadina-3,5-diene	0.19±0.00	[30]
25	1682	1687	δ-Terpineol	0.50±0.11	[31]
26	1687	1693	α-Humulene	10.17±0.17	[32]
27	1696	1696	γ-Terpinyl acetate	2.38±0.03	[19]
28	1709	1709	α-Terpinyl acetate	2.00±0.00	[33]
29	1719	1732	Borneol	0.78±0.01	[26]
30	1776	1785	γ-Cadinene	1.42±0.02	[34]
31	2008	2008	Caryophyllene oxide	1.11±0.00	[35]
32	2071	2071	Humulene epoxide II	0.77±0.00	[36]
33	2080	2080	Cubenol	0.81±0.01	[37]
34	2187	2187	τ-Cadinol	5.49±0.00	[38]
35	2209	2209	τ-Muurolol	0.10±0.00	[39]
36	2239	2239	Carvacrol	0.10±0.00	[40]
37	2250	2266	α-Eudesmol	0.39±0.00	[41]
38	2255	2255	α-Cadinol	0.27±0.00	[39]
39	2257	2258	β-Eudesmol	0.19±0.01	[15]
40	2316	2316	Caryophylladienol-I	0.20±0.00	[42]
Total				95.23	

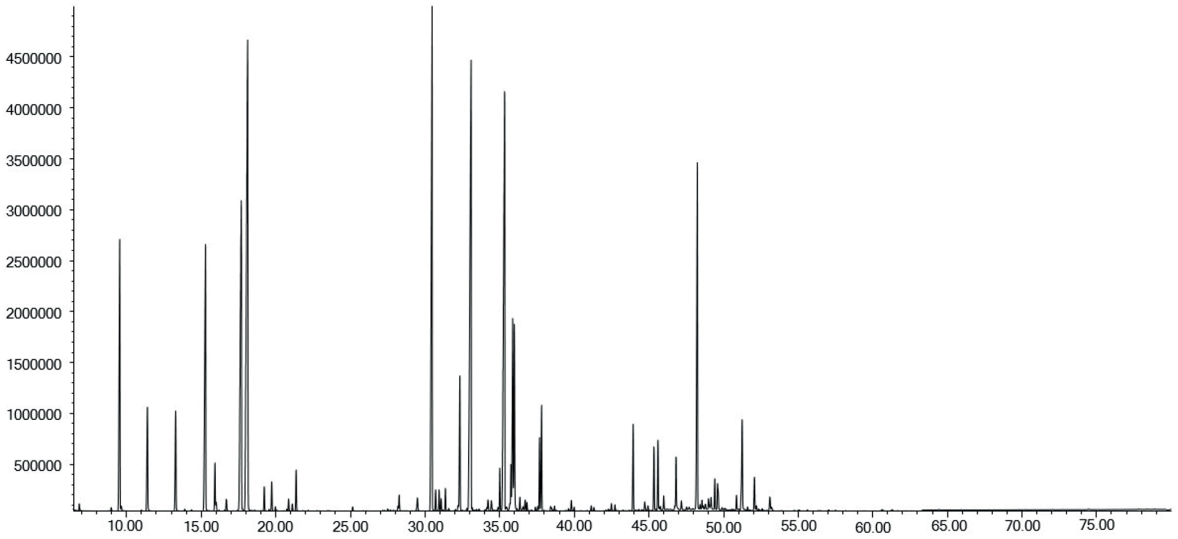


Figure 1. GC–FID/MS chromatogram of the essential oil obtained from the aerial parts of *S. yangii*

The gas chromatographic study of the essential oil from the aerial parts of *S. yangii* identified 40 compounds, accounting for 95.23% of the essential oil. The principal compounds of the essential oil were camphor (17.39±0.01%), 1,8-cineole (13.10±0.00%), β-caryophyllene (11.48±0.01%), and α-humulene (10.17±0.17%).

The analysis results of essential oils from other growing regions in the literature are examined; Δ^3-Carene (22.3%), 1,8-cineole (27.4%), and β-caryophyllene (10.8%) were found to be the main ingredients in the essential oil that was made by hydrodistillation from plant material gathered in Pakistan and analyzed using GC/MS [43]. In another study, GC and GC–MS analyzes of the essential oil from the aerial parts of the plant in Pakistan, identifying α-humulene (9.2%), *trans*-caryophyllene (9.3%), α-globulol (10.2%), limonene (16.7%), and camphor (28.9%) as the major components [44]. The main chemicals found in the plant's aerial parts collected in Iran and studied using GC and GC-MS were τ-cadinol (5.4%), β-caryophyllene (15.9%), α-humulene (14.4%), limonene (11.4%), and δ-3-carene (9.8%). The GC and GC/MS techniques were used to analyze the essential oil that was steam-distilled from the aerial parts of *P. atriplicifolia.* Of the 39 discovered compounds, the predominant compounds were 1,8-cineole + limonene (40.13%), and α-pinene (17.87%) [45]. Essential oil from *S. aethiopis* L. makes up 98.2% of the total component. The primary chemical components were α-copaene (14.6%), α-humulene (8.6%), germacrene D (17.3%), and *(E)*-caryophyllene (34.6%) [46]. Analysis of *S. aristata*'s essential oil found 74 compounds. Sesquiterpene hydrocarbons made up 32.79% of the compounds. The rest was made up of β-*trans*-caryophyllene (8.37%), caryophyllene oxide (8.26%), and bicyclogermacrene (5.73%) [47]. GC/FID and GC/MS analyses showed that the main parts of *S. argentea*'s L. essential oil were germacrene D-4-ol (26.3%), epi-α-muurolol (19.2%), and epi-α-cadinol (10.2%) [48]. The current study found that monoterpenes made up 50.39% of the components in *S. mirzayanii* Rech.f. & Esfand essential oil, while sesquiterpenes made up 39.9%. It also contained linalool (9.97%), α-terpineol (8.33%), α-terpinyl acetate (8.15%), 1,8-cineole (5.2%), and thymol (4.36%). In the essential oil of *S. hypoleuca* Benth., sesquiterpenes comprised 68.4%, while monoterpenes constituted 26.83%. Sesquiterpene hydrocarbons constituted 45.76%. The main chemicals that made it up were *trans*-β-caryophyllene (14.12%), caryophyllene oxide (12.17%), α-pinene (9.04%), germacrene D (8.69%), and β-pinene (8.47%) [49].

Our findings emphasize that although some constituents overlap with those previously reported, the essential oil of *S. yangii* analyzed in this study

exhibits a distinct chemical composition, likely due to environmental and methodological differences. It is believed that various factors, including climate, planting dates, fertilizer varieties, and agricultural techniques such as temperature, humidity, radiation, wind, soil properties, geographical location, and harvesting time and methods, influence the yield, concentration, and composition of essential oils. Finally, among post-harvest techniques, factors such as drying methods, extraction methods, distillation duration, and analysis conditions also play a significant role in causing this situation [50, 51].

4. CONCLUSION

This study offers a comparative analysis of the essential oil composition of *S. yangii* from various geographical origins, highlighting the influence of environmental conditions on the volatile profile. Notably, this is the inaugural detailed report on the essential oil composition of *S. yangii* grown in Türkiye. The results improve our knowledge of the chemical diversity within the *Salvia* genus and could serve as a standard for future research on ecological variation, quality control, and potential industrial uses. Additionally, the results revealed that the essential oil has significant potential in the health field, as the main components identified, including camphor, 1,8-cineole, β-caryophyllene, and α-humulene, are notable for their antimicrobial, anti-inflammatory, and antioxidant effects. The presence of these components suggests that the essential oil can offer a wide range of complementary and supportive treatment options, from respiratory illnesses to skin health, and from boosting the immune system to pain management. Specifically, oxygenated monoterpenes and sesquiterpenes can provide natural protection against harmful microorganisms and play a protective role at the cellular level by reducing the effects of free radicals. The volatile oil profile of ‘n grown in Türkiye illustrates the influence of regional environmental factors on chemical diversity, which can facilitate the development of natural and safe components in health products. In conclusion, this study not only expands the potential uses of ‘s in botanical and chemical terms but also in the fields of health and industry and provides a solid foundation for future clinical and pharmacological research.

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Ethical approval

Not applicable, because this article does not contain any studies with human or animal subjects.

Author contribution

Conceptualization, K.Ö. and T.Ö.; Methodology, K.Ö. and T.Ö..; Formal analysis, K.Ö. and T.Ö.; Investigation, K.Ö. and T.Ö.; Resources, K.Ö. and T.Ö.; Data curation, K.Ö. and T.Ö.; Writing—original draft preparation, K.Ö. and T.Ö.; Writing—review and editing, K.Ö. and T.Ö.; Visualization, K.Ö. and T.Ö.; Supervision, T.Ö. All authors have read and agreed to the published version of the manuscript.

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Conflict of interest

The authors declared that there is no conflict of interest.

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