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Research Article
Volatile Oil Yield and Constituents of *Salvia officinalis*, *S. tomentosa* Mill. and *S. glutinosa* Growing in Ankara, Turkey

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Abstract

Background and Objective: The genus *Salvia* L. is represented in Turkey by 88 species and 45 endemics some of which bear great economic value. Current study aimed at identifying promising *Salvia* species, especially less-common ones, regarding their essential oil yields and constituents in Ankara ecological conditions. **Materials and Methods:** Aerial parts of three *Salvia* spp. growing in Ankara University Experimental Field were set to GC/MS analysis after being dried in shade. **Results:** The essential oil contents of *Salvia officinalis*, *S. tomentosa* and *S. glutinosa* were 1.67% (v/w), 1.56% (v/w) and 0.12% (v/w), respectively. The main chemical groups for *S. officinalis, S. tomentosa* and *S. glutinosa* were oxygenated monoterpenes (49.59%), sesquiterpene hydrocarbons (59.28%) and monoterpene hydrocarbons (69.23%), respectively. **Conclusion:** The *S. glutinosa* was characterized by considerable amount of diterpene (5.87%) β-thujone (31.90%), β-pinene (53.36%) and β-caryophyllene (19.34%) were determined as the most abundant components for *Salvia officinalis*, *S. tomentosa* and *S. glutinosa*, respectively. The results of the analyses of the oils from *Salvia* species revealed that oil with low yield was rich with some components including β-caryophyllene.

Key words: *Salvia* spp., Ankara, essential oil constituents, diterpene, β-thujone, β-pinene, β-caryophyllene, monoterpene hydrocarbons

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Salvia, the large and polymorphous genus of the family Lamiaceae, comprises about 900 species with almost cosmopolitan dissemination[1]. Turkey flora includes a major diversity center for *Salvia* in Asia[2], among them are *Salvia officinalis*, *S. tomentosa* and *S. glutinosa*.

Parallel to their everyday growing medicinal use, natural essential oils have great commercial value. Oil chemical composition of *S. officinalis*, one of the most appreciate herbs for its rich essential oil and its plethora of biologically active compounds extensively used in folk medicine[3], has been the subject of many publications[4-6]. *Salvia tomentosa* with wound healing effect similar to that of iodine tincture[7] contains considerable amounts of secondary metabolites such as phenolics and terpenoids[7,8]. *Salvia glutinosa* L. growing in the woods from Central Russia to Southern Italy[9], hasn't previously been examined for its chemical compositions under Ankara ecological circumstances.

Volatile profiles of some *Salvia* species have been studied in Ankara ecological conditions. For instance, Ipek *et al.*[10,11] comparatively studied the essential oil composition of wild and cultivated *S. forskaohlei* and *S. cryptantha* Montbert & Aucher ex. However, there has been no study on *S. glutinosa* essential oil constituents in Ankara ecological conditions. The aim of the present study was to investigate the chemical profile of *S. glutinosa* as well as to compare the constituents with the two other species; *S. officinalis* and *S. tomentosa*.

MATERIALS AND METHODS

Plant material: Whole plant specimens from localities of Ankara were grown in trial fields of Ankara University the year before analyses.

Essential oil extraction: Dried aerial parts of samples were subjected to hydro-distillation for 3 h, using a clevenger-type apparatus and then kept at 4°C until they were analyzed.

Gas chromatography: The essential oil was broken down by GC/MS. The analysis was done using a Hewlett Packard 6890 N GC, equipped with HP-5 MS capillary column (30 m×0.25 μm) and HP 5973 mass selective detector. For GC-MS detection an electron ionization system with ionization energy of 70 eV was used. Helium was carrier gas, at a flow rate of 1 mL min^{-1}. Injector and MS transfer line temperatures were set at 220 and 290°C, respectively. Column temperature was initially kept at 50°C for 30 min, then imperceptibly increased to 150°C at a 3°C min^{-1} rate, held for 10 min and finally raised to 250°C min^{-1}. Diluted samples (1/100 in acetone, v/v) of 1.0 μL were injected automatically and in the splitless mode. The identities of the components of the oil were established from their GC retention indices, relative to C7-C25 n-alkanes, by comparison of their MS spectra with those reported in the literature data and by computer matching with the Wiley 5 mass spectra library, whenever possible, co-injection with a standard available in the laboratories.

RESULTS AND DISCUSSION

The essential oil content in dry leaves was 1.67% (v/w) for *S. officinalis*, 1.56% (v/w) for *S. tomentosa* and 0.12% (v/w) for *S. glutinosa.* The composition of the essential oils of the studied *Salvia* species is presented in Table 1 in order of their retention indices.

Seventeen components were identified for S. *officinalis*, representing 93.57% of the total oil. The oil was dominated by monoterpenes of which monoterpenes hydrocarbons such as β-pinene (13.08%) as well as oxygenated monoterpenes like β-thujone (31.90%) and α-humulene (10.17%) were detected in high quantities. Besides, oxygenated sesquiterpene viridiflorol was found in a considerable amount (10.74%).

Reports on the chemical compositions of the oils isolated from *S. officinalis* are abundant. In the chemical compositions of these oils elucidated by GC/MS analysis from Iran, 1,8-cineole, α and β-pinene, α and β-thujone and camphor are abundant[6]. The constituents' patterns of the reports are in agreement with data given in this study. However, there are some significant differences either in components or proportions of the oils: Members of oxygenated monoterpenes fraction namely 1,8-cineole (39.5-50.3%) and camphor (8.8-25.0%) were screened in specimens from Jordan[12]. Again, essential oils of polish samples exhibited remarkable amounts of oxygenated monoterpenes (α-thujone, 1,8-cineole, camphor, β-thujone) together with monoterpene hydrocarbons (α-pinene and β-pinene)[13]. But there are few references reporting α-humulene and viridiflorol with substantial peaks only occurred in the last decade[5,14]. In this regard, occurrence of these components, especially oxygenated sesquiterpene of viridiflorol, in Turkey is unique.

Eighteen components were characterized in the oil of *S. tomentosa*, constituting 85.10% of the total oil. The oil was characterized by a high content of β-pinene (53.36%), followed by α-pinene (9.12%), β-caryophyllene (4.37%),

Table 1: Essential oil components of *Salvia officinalis*, *S. tomentosa* and *S. glutinosa*

Components	Retention indices	*S. officinalis*	*S. tomentosa*	*S. glutinosa*
α-pinene	9.43	3.02	9.12	-
Camphene	10.24	0.60	1.27	-
Sabinene	11.33	0.41	-	-
β-pinene	11.55	13.08	53.36	-
Myrcene	12.14	1.02	1.01	-
α-terpinene	13.24	0.27	0.38	-
β-phellandrene	13.81	0.90	2.13	-
Eucalyptol	13.91	9.39	1.75	-
α-terpinene	15.21	0.69	1.65	-
Terpinolene	16.59	-	0.31	-
Linalool	17.23	0.28	-	3.58
β-thujone	17.47	31.90	-	-
α-thujone	17.93	4.68	-	-
Camphor	19.20	-	1.37	-
Isoborneol	20.22	3.14	0.81	-
terpinen-4-ol	20.77	0.20	0.77	-
β-elemene	30.36	-	-	2.64
β-caryophyllene	31.51	3.08	4.37	19.34
β-cubebene	31.88	-	0.47	-
α-humulene	32.90	10.17	2.41	9.81
α-amorphene	33.85	-	1.13	3.29
Germacrene-D	34.02	-	1.38	17.06
α-bergamotene	34.61	-	-	4.85
δ-cadinene	35.73	-	1.41	2.29
Nerolidol	37.33	-	-	4.02
Caryophyllene oxide	38.07	-	-	8.09
Viridiflorol	38.39	10.74	-	
α-cadinol	39.79	-	-	2.75
T-cadinol	40.12	-	-	4.65
Phytol	46.62	-	-	5.87
Monoterpene hydrocarbons		19.99	69.23	-
Oxygenated monoterpenes		49.59	4.70	3.58
Sesquiterpene hydrocarbons		13.25	11.17	59.28
Oxygenated sesquiterpenes		10.74	-	19.51
Diterpenes		-	-	5.87
Total (%)		93.57	85.10	88.24
Essential oil content (%)		1.67	1.56	0.12

α-humulene (2.41%) and β-phellandrene (2.13%). The monoterpene fraction was the main group of the compounds (73.93%), of which monoterpene hydrocarbons were the prevailing group (69.23%) compared to oxygenated monoterpenes (4.70%), while sesquiterpenes constituted 11.17% of the oil.

Outputs presented here do not support the findings of some previous study for example, Arslan[15] reported camphor, α-pinene and β-thujone as the main constituents of *S. tomentosa* oil, in which camphor is abundant (17.68%).

In another report, α-pinene (25.1%), camphor (14.9%) and borneol (13.2%) were identified as the major components of Turkish *S. tomentosa*[7]. However, the main component is of monoterpene hydrocarbons but oxygenated monoterpenes comprises great proportion of the oil, a record that doesn't match the previous output in which the mentioned fraction just constitutes 4.7% of the oil. On the other hand, chemical composition of the oil of this herbal species corresponded on a large scale to previous results refereeing to Turkish samples in which GC and GC/MS analyses revealed that the major constituents of the oil were β-pinene (39.7%), α-pinene (10.9%) and camphor (9.7%)[16]. Chemical composition and bioactivity of essential oil from *S. tomentosa* natively grown in Bulgaria were investigated. GC-MS analysis identified 60 compounds through which the prevalent constituents were monoterpenes with borneol (10.3%) as the dominant compound[17].

Thirteen components, representing 88.24% of the oil, were identified in *S. glutinosa*. The most abundant constituents were β-caryophyllene (19.34%), germacrene-D (17.06%), α-humulene (9.81%) and caryophyllene oxide (8.09%). Monoterpene hydrocarbon compounds were not detected, even in traces, in the oil. The leaf essential oil was dominated mainly by sesquiterpene hydrocarbons

(59.28%), followed by oxygenated sesquiterpenes (19.51%). Phytol diterpene was only detected in the oil of *S. tomentosa* leaves.

Components from other fractions were characterized as prominents in some previous studies: Oxygenated sesquiterpenes (1-octadecanol and caryophyllene oxide) from Turkey[18], oxygenated monoterpenes (Bornyl acetate) from Yugoslavia[19], whereas in some others, sesquiterpene hydrocarbons were predominant: γ-muurolene was found as the major component for the leaves and flowering tops of *S. glutinosa* growing in Italy[20]. The GC-MS analysis of *S. glutinosa* oil from Greece, also, revealed butyl butyryl lactate (26.7%) as major component where sesquiterpene hydrocarbon compounds constituted 32.2%[21]. The presence and percentage of inter and intra-species constituents in the oil depends upon the external factors and localities. Detection of phytol in *S. glutinosa* specimen, for instance, could be a brilliant example for inter-species components. Inter-species comparing revealed that the oil of *S. officinalis* was rich with oxygenated monoterpenes, among which β-thujone was the characteristic components. While it was neither detected in *S. tomentosa* nor in *S. glutinosa*. β-pinene, absent in *S. glutinosa*, was the highest in the leaf oil of *S. tomentosa*, while it was lower in that of *S. officinalis*.

CONCLUSION

It is concluded that current study findings on *S. glutinosa* showed oil-poor species of Lamiaceae which possess oils rich in sesquiterpene hydrocarbons. On the other hand, β-caryophyllene predominance of essential oil seems to be unique of the Turkish *S. glutinosa*, that hasn't been reported elsewhere.

SIGNIFICANCE STATEMENT

This study evaluates essential oil content and constituents of three *Salvia* species namely *Salvia officinalis*, *S. tomentosa* and *S. glutinosa* in Ankara ecological conditions and reveals promising results on the components of species especially *S. glutinosa* including β-caryophyllene.

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