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Essential oil composition of *Salvia fruticosa* Mill. populations from Balkan Peninsula

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Abstract

The aim of this study was to investigate the yield and chemical composition of the essential oil (EO) isolated from 19 different populations of *Salvia fruticosa* Mill. (Greek sage, Lamiaceae) from nine different regions of Albania and Greece. The EO yield ranged from 0.25% to 4.00%. Eighteen of the total analyzed populations met the Ph.Eur.8.0 minimal requirements concerning the essential oil yield. Performing GC/FID/MS analyses, a total of 75 components were detected, representing 79.15-97.83% of the oils. Thirteen components (α-pinene, camphene, β-pinene, myrcene, 1,8-cineole, γ-terpinene, *cis*-thujone, *trans*-thujone, camphor, terpinene-4-ol, *trans*-(E)-caryophyllene, aromadendrene and α-humulene) were identified in all samples, with 1,8-cineole as a predominant constituent. Statistical analysis showed that the geographical origin of plants did not have significant influence on the variation in chemical composition of the Greek sage essential oil.

Key words: Greek sage, yield, GC/FID/MS, essential oil composition, Greece, Albania

Introduction

The genus *Salvia* L. from Lamiaceae is one of the largest genera in this family and includes around 1000 species that have almost cosmopolitan distribution (Kintzios, 2000). It is an important aromatic genus which is frequently used as herbal tea and as a source of essential oils and aroma chemicals (Karamanos, 2008). With significant economic importance are the pharmacopoeial herbs: *S. fruticosa* Mill. (Syn. *S. triloba* L. or Greek sage) and *S. officinalis* L. (Dalmatian, common or garden sage) (Kosar et al., 2005).

S. fruticosa is an endemic species of the Eastern Mediterranean basin (Ali-Shtayeh et al., 2000; Carmona et al., 2005; Elmann et al., 2009). Naturalized can be found in parts of the Western Mediterranean regions like Malta, Spain and Portugal. *S. fruticosa* is the most widespread sage species in Greece, forming extended populations in littoral areas of the mainland, as well as the Ionian and Aegean islands (Kintzios, 2000).

The leaves of this herb have been used for treatment of various skin, blood, and infectious ailments as well as ailments of the digestive, circulatory and respiratory systems (Ali-Shtayeh et al., 2000; Carmona et al., 2005). Greek sage posses hypoglycemic effect and can be used against inflammations, hepatitis, and tuberculosis (Pitarokili et al., 2003). On the other hand the essential oil (EO) showed good antimicrobial activity against food borne bacteria (Longaray Delamare et al., 2007) and has antifungal activity (Pitarokili et al., 2003). Numerous investigations have been reported dealing with the essential oil composition and their biological activity, often referring to the *S. officinalis* species (Pierozan et al., 2009; Giweli et al., 2013).

However, to the best of our knowledge, there is limited information on the chemical composition of the essen-

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tial oil isolated from *S. fruticosa* from Balkan Peninsula. Therefore the aim of the present work was to assess and compare the oil yield and composition from Greece and Albania as native area of distribution of this herb.

Experimental

Plant collection

Plant samples were collected from 19 different (18 indigenous and one non-indigenous) populations of *Salvia fruticosa* Mill., Lamiaceae, from nine different locations from Greece and Albania. The leaves were air dried, packed in paper bags and kept in a dark and cold place until analysis. Plant identity was verified and voucher specimens were deposited at the Institute of Pharmacognosy, Faculty of Pharmacy, Skopje, R. Macedonia (Table 1).

Essential oil isolation

The EOs were isolated from dried, cut leaves, by hydrodistillation in all-glass Clevenger apparatus for 2 hours according to pharmacopoeial method (Ph. Eur. 8.0., 2014). The oil yield was measured and presented in Table 1.

Analysis of essential oils' chemical composition

EO samples in hexane (1:1000) were analyzed on Agilent 7890A Gas Chromatography system equipped with FID detector and Agilent 5975C mass spectrometer. For that purpose, HP-5ms capillary column (30 m x 0.25 mm, film thickness 0.25 μm) was used. Analytical conditions were as follows: oven temperature at 60 °C (0 min), 3 °C/min to 240 °C (1 min) and at the end increased to 280 °C at a rate of 10 °C/min (1 min); helium as carrier gas at a flow rate of 1 ml/min; injector temperature 220 °C and that of the FID detector 270 °C. One μl of each sample was injected at a split ratio of 1:1. The mass spectrometry conditions were: ionization voltage 70 eV, ion source temperature 230 °C, transfer line temperature 280 °C and mass range from 50 - 550 Da. The MS was operated in scan mode.

Identification of the components

The compounds were identified on the basis of literature (Adams, 2007) and estimated Kovat's (retention) indices that were determined using a mixture of homologous series of normal alkanes (C9-C25) analyzed under Automated Mass Spectral Deconvolution and Identification System (AMDIS)' conditions. Confirmation was made by

Table 1. Sampling localities and essential oil (EO) yields of 19 *Salvia fruticosa* Mill. populations from Balkan Peninsula

Population	Country (Code)	Locality	Latitude (N)	Longitude (E)	Vouchers specimens	EO Yield [%][1)]
ALB 1	Albania (ALB)	Porto Palermo-Qeparo 1	42°03'09"	19°49'45"	ALBStPQ1/11	2.80
ALB 2	Albania (ALB)	Porto Palermo-Qeparo 2	42°03'09"	19°49'45"	ALBStPQ2/11	2.60
ALB 3	Albania (ALB)	Porto Palermo-Qeparo 3	42°03'09"	19°49'45"	ALBStPQ3/11	2.75
ALB 4	Albania (ALB)	Porto Palermo-Qeparo 4	42°03'09"	19°49'45"	ALBStPQ4/11	3.40
ALB 5	Albania (ALB)	Llogora	40°11'55"	19°34'21"	ALBStL1/11	0.25
ALB 6	Albania (ALB)	Palase	40°09'54"	19°37'29"	ALBStP2/11	2.45
ALB 7	Albania (ALB)	Dhermi	40°09'00"	19°38'00"	ALBStD3/11	2.10
ALB 8	Albania (ALB)	Borsh	40°03'45"	19°51'24"	ALBStB4/11	1.70
ALB 9	Albania (ALB)	Ilias-Vuno	40°08'23"	19°41'37"	ALBStIv5/11	2.05
ALB 10	Albania (ALB)	/	/	/	ALBStK11/13	1.80
ALB 11	Albania (ALB)	Dhermi	40°09'00"	19°38'00"	ALBStD1ju/13	2.50
ALB 12	Albania (ALB)	Dhermi	40°09'00"	19°38'00"	ALBStD1m/14	1.60
ALB 13	Albania (ALB)	Dhermi	40°09'00"	19°38'00"	ALBStD2ju/14	4.00
GR 14	Greece (GR)	Kavoussi 1	35°07'00"	25°51'00"	GRStK1/11	1.60
GR 15	Greece (GR)	Kavoussi 3	35°07'00"	25°51'00"	GRStK3/11	1.60
GR 16	Greece (GR)	Rhizoscaro 1	/	/	GRStR1/11	3.60
GR 17	Greece (GR)	Rhizoscaro 2	/	/	GRStR2/11	3.85
GR 18	Greece (GR)	Vrysses 2	35°21'45"	24°15'11"	GRStV2/11	1.20
GR 19	Greece (GR)	Vrysses 3	35°21'45"	24°15'11"	GRStV3/11	2.40

comparing the mass spectra of the components present in the EOs with the reference spectra obtained from Nist, Wiley and Adams mass spectra libraries. Quantification of the EOs components was performed using the normalization method of the GC/FID peak areas without any correction factors.

Statistical analysis

The significance of differences between oil samples was tested by analysis of variance (ANOVA) using the package Excel for Windows 7 and represented by critical value of an F-test (F) and statistical significance (p). ANOVA was performed on the geographical origin of plants as grouping factor.

Results and discussion

Essential oil yield

The EO yield of 18 indigenous and one non-indigenous (commercial) population of Greek sage from nine different locations from Greece and Albania ranged from 2.50 ml/kg to 40.00 ml/kg (0.25-4.00 %) (Table 1). The highest yield was recorded in two *S. fruticosa* populations, one from Dhermi, Albania (ALB 13) and the other population from Vrysses, Greece (GR 17), while the lowest was found in the Albanian population (ALB 5) from Llogora. Eighteen of the analyzed 19 populations met the Ph.Eur.8.0 minimal requirements concerning the essential oil yield.

EO composition

Data analysis of the EO chemical composition revealed six different classes of components: monoterpene hydrocarbons (MH), oxygen-containing monoterpenes (OMT), sesquiterpene hydrocarbons (SH), oxygen-containing sesquiterpenes (OST), diterpenes (D) and non-terpene components (NT). Generally, OMT was dominant fractions, present with more than 45% in all tested samples, followed by smaller amounts of MT or ST (Table 2). On the other hand, the diterpene chemical class was absent from two Greek populations (GR 14 and GR 17).

GC/FID/MS analyses of the isolated EOs revealed a total of 75 compounds representing 79.15-97.83% of the oils (Table 2). Thirteen components were detected in all analyzed EOs (Figure 1) with 1,8-cineole as predominant constituent. Eight components: α-pinene (0.36-6.03%), camphene (tr.-6.04%), β-pinene (tr.-6.14%), 1,8-cineole (23.71-58.95%), *cis*-thujone (1.17-10.37%), *trans*-thujone (0.95-4.07%), camphor (tr.-19.19%) and *trans*-(*E*)-caryophyllene (0.57-15.96%) that were found in amounts higher than 3.00% were considered as principal components of Greek sage essential oils.

Our results are in full agreement with Giweli et al. (2013) who reported high amounts of 1,8-cineole, followed by camphor, β-pinene, myrcene and α-pinene in their samples of *S. triloba* provided from Libya. Additionally, Kosar et al. (2005), confirmed 1,8-cineole and camphor as predominant constituents in their Turkish sage samples and the same applies for *S. fruticosa* from Greece (Pitarokili et al., 2003; Pavlidou et al., 2004). On the other hand, Longa-

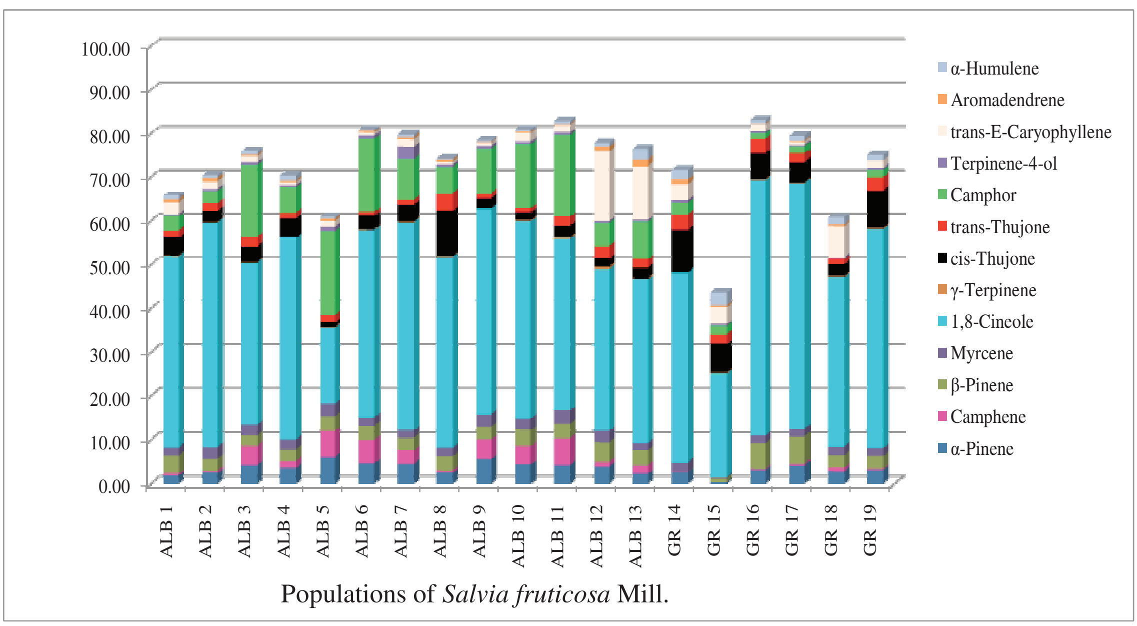

Fig. 1. Thirteen predominant EO constituents identified in all 19 populations of *S. fruticosa* Mill.

Table 2. Chemical composition (%) of the essential oils from 19 *Salvia fruticosa* Mill. populations

No.	Components	KIL[1)]	KIE[2)]	ALB 1	ALB 2	ALB 3	ALB 4	ALB 5	ALB 6	ALB 7	ALB 8	ALB 9	ALB 10	ALB 11	ALB 12	ALB 13	GR 14	GR 15	GR 16	GR 17	GR 18	GR 19
1	Tricyclene	921	924	-	-	-	-	-	0.22	-	-	0.55	0.20	tr.	-	-	-	-	-	-	-	-
2	α-Thujene	924	929	-	-	-	-	-	-	-	-	-	0.13	-	-	0.28	-	-	tr.	0.11	-	-
3	Cymen	926	931	-	-	-	-	-	-	-	-	-	-	-	0.43	-	-	1.92	-	-	1.13	-
4	α-Pinene	932	935	1.75	2.45	4.32	3.67	6.03	4.69	4.56	2.53	5.57	4.44	4.33	3.96	2.26	2.79	0.36	3.26	4.22	2.97	3.24
5	Camphene	946	950	0.51	0.56	4.42	1.45	6.04	5.24	3.14	0.61	4.50	4.28	6.03	1.02	1.93	tr.	tr.	0.22	0.35	0.75	0.25
6	Sabinene	969	977	-	-	-	-	-	-	-	-	-	-	-	-	0.15	-	-	0.12	-	tr.	tr.
7	β-Pinene	974	979	4.04	2.58	2.22	2.87	3.20	3.41	2.76	3.04	3.03	3.53	3.38	4.46	3.52	tr.	0.82	5.78	6.14	2.69	2.73
8	Myrcene	988	993	2.07	2.85	2.60	2.10	3.03	1.74	1.78	2.17	2.71	2.62	2.96	2.69	1.57	2.08	0.21	1.70	1.90	2.22	2.05
9	α-Phelandrene	1002	1007	-	tr.	0.10	0.12	-	-	0.10	-	tr.	tr.	tr.	tr.	tr.	tr.	tr.	tr.	0.10	0.11	0.11
10	α-Terpinene	1014	1019	0.15	0.11	0.13	0.10	-	0.10	0.17	0.11	0.11	0.19	0.27	tr.	0.20	tr.	tr.	0.23	0.18	0.24	0.21
11	(o) p-Cymene	1020	1027	0.77	0.77	0.87	0.86	1.22	0.57	0.34	0.91	0.85	0.40	0.18	-	tr.	tr.	0.14	0.51	0.51	0.79	0.73
12	Limonene	1024	1031	43.64	-	36.85	-	0.20	0.60	0.50	0.65	0.60	-	-	0.67	tr.	tr.	-	-	-	-	-
13	1,8-Cineole	1026	1034		51.16		46.10	17.21	42.93	47.43	43.54	47.13	45.02	39.24	36.89	37.36	43.38	23.71	58.27	55.95	38.63	49.89
14	(E)-β-Ocimene	1050	1045	-	-	-	-	-	-	-	0.14	-	-	-	-	-	-	-	-	-	-	-
15	γ-Terpinene	1054	1061	0.17	0.10	0.11	tr.	0.19	0.13	0.15	0.14	tr.	0.28	0.46	0.60	0.43	tr.	0.21	0.22	0.15	0.27	0.28
16	*cis*-Sabinene hydrat	1065	1070	0.14	tr.	tr.	tr.	-	tr.	0.12	tr.	tr.	0.12	0.10	-	0.49	-	-	0.44	0.34	0.16	0.23
17	Terpinolene	1086	1091	0.11	-	-	-	-	0.14	0.13	0.18	0.11	0.18	0.38	tr.	0.15	-	-	0.10	-	0.15	-
18	Linalool	1095	1098	0.39	0.56	0.45	0.29	0.41	0.76	0.83	2.02	0.38	0.62	0.42	-	0.37	1.36	0.40	-	2.63	0.96	0.11
19	*cis*-Thujone	1101	1111	4.03	2.67	3.68	4.34	1.17	3.09	3.87	10.37	2.23	1.89	2.54	1.83	2.29	9.76	6.55	6.05	4.74	2.58	8.61
20	*trans*-Thujone	1112	1120	1.72	1.65	2.30	1.41	1.68	0.95	1.10	4.07	1.28	0.96	2.05	2.82	1.89	3.54	2.28	3.30	1.99	1.19	2.87
21	α-Campholenal	1122	1130	-	-	-	tr.	-	-	-	-	tr.	-	-	-	-	-	-	-	-	6.10	-
22	*iso*-3-Thujanol	1134	1139	-	-	-	-	-	-	-	tr.	-	-	-	-	-	-	-	-	-	-	-
23	Camphor	1141	1149	3.13	2.87	16.33	5.80	19.19	16.60	9.37	5.97	10.10	14.58	18.62	5.24	8.52	2.49	1.77	1.14	1.65	tr.	1.85
24	Isoborneol	1155	1160	-	-	-	-	3.82	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25	*trans*-Pinocam-phone	1158	1164	-	-	-	-	-	0.22	tr.	-	0.39	-	0.20	-	-	-	0.15	0.45	-	tr.	0.35
26	Borneol	1165	1169	-		2.78	-	-	2.53	-	-	-	2.30	-	0.86	0.47	1.50	1.66	-	-	1.54	1.52
27	Terpinene-4-ol	1174	1180	0.56	0.48	0.64	0.43	0.97	0.74	2.88	0.55	0.68	0.62	0.60	0.46	0.43	0.66	0.44	0.43	0.30	0.50	0.45
28	p-Cymen-8-ol	1179	1189	-	-	-	-	-	tr.	-	-	-	-	-	-	-	-	-	-	-	-	-
29	α-Terpineol	1186	1194	2.19	2.34	2.23	2.50	5.69	2.26	-	2.29	2.71	2.74	2.06	2.65	3.26	3.61	3.18	5.80	6.39	5.26	3.58

No.	Components	KIL[1)]	KIE[2)]	ALB 1	ALB 2	ALB 3	ALB 4	ALB 5	ALB 6	ALB 7	ALB 8	ALB 9	ALB 10	ALB 11	ALB 12	ALB 13	GR 14	GR 15	GR 16	GR 17	GR 18	GR 19
30	Myrtenol	1194	1200	0.13	-	0.19	0.21	0.38	0.34	0.12	-	0.43	0.10	0.20	-	-	-	0.26	0.22	-	-	0.21
31	Linalyl formate	1214	1220	-	-	-	0.12	-	0.99	-	-	0.16	-	-	-	-	-	-	-	-	-	-
32	Linalyl acetate	1254	1260	-	-	-	-	-	-	1.14	-	-	-	0.32	-	-	0.70	0.65	-	0.11	-	-
33	Bornyl acetate	1284	1289	tr.	-	0.56	0.28	0.33	0.33	0.20	0.16	0.16	tr.	0.63	-	0.35	-	tr.	-	tr.	-	tr.
34	Thymol	1289	1293	-	-	tr.	tr.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
35	Carvacrole	1298	1301	-	-	-	0.16	-	-	-	-	tr.	0.49	0.55	-	-	-	-	-	-	-	-
36	δ-Terpenyl acetate	1316	1321	-	0.14	tr.	tr.	-	-	0.12	-	0.11	-	-	-	-	-	-	-	-	-	-
37	Linalyl proprionate	1334	1339	-	-	-	-	-	-	-	4.03	-	-	-	-	-	-	-	-	-	-	-
38	δ-Elemene	1335	1340	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.11	-
39	α-Terpenyl acetate	1346	/	2.91	3.29	1.24	2.21	3.05	2.78	2.68	4.21	2.08	-	1.38	-	1.39	5.25	3.98	-	0.16	-	3.14
40	Eugenol	1356	1361	-	-	-	-	-	-	-	-	-	-	-	4.53	-	-	-	-	-	-	-
41	Neryl acetate	1359	1365	-	-	-	-	-	-	tr.	-	-	-	-	-	-	-	-	-	-	-	-
42	Isoledene	1374	/	tr.	tr.	-	tr.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
43	α-Yaglene	1373	/	-	-	-	-	-	-	-	0.17	-	-	-	-	-	-	-	-	-	-	-
44	α-Copaene	1374	1379	-	tr.	tr.	tr.	-	-	tr.	tr.	tr.	-	-	-	-	-	0.13	-	-	0.12	tr.
45	n.i. 1	/	1382	-	-	-	tr.	-	tr.	-	0.26	-	-	-	-	-	-	-	-	-	0.14	-
46	7-*epi*-sesquithujene	1390	1396	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.16	-	-	-	0.16
47	sesquithujene	1405	1412	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.14	-	-	-	0.27
48	*trans*-E-Caryophyllene	1417	1423	2.59	1.63	1.31	0.69	1.25	0.67	1.62	0.57	0.69	1.92	1.83	15.96	12.39	3.65	3.85	1.81	0.76	7.00	1.63
49	β-Copaene	1430	1432	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.11	-
50	n.i. 2	/	1455	-	-	-	-	-	-	-	-	-	-	tr.	-	0.16	-	-	-	-	-	-
51	Aromadendrene	1439	/	0.71	0.74	0.33	0.38	0.49	0.35	0.50	0.48	0.19	0.24	0.19	1.12	1.41	1.05	0.46	0.12	0.20	0.36	tr.
52	α-Humulene	1452	1458	0.92	0.59	0.83	1.05	0.42	0.41	0.56	0.21	0.29	0.65	0.66	0.80	2.55	2.31	3.00	0.77	1.03	1.62	1.16
53	*allo*-Aromadendrene	1458	1454	tr.	tr.	tr.	tr.	-	tr.	tr.	-	tr.	-	-	-	0.35	-	0.18	-	tr.	-	tr.
54	9-*epi*-(E)-Caryophyllene	1464	1465	-	-	-	-	-	-	-	-	-	-	-	2.88	-	-	-	tr.	-	0.15	-
55	γ-Murrolene	1478	1480	0.19	0.14	-	-	-	0.10	0.16	-	tr.	tr.	tr.	-	0.14	0.59	0.54	tr.	tr.	0.36	-
56	ar-Kurkumen	1479	1481	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.80	-	-	-	1.36
57	β-Selinene	1489	1493	-	-	-	-	-	-	-	-	-	-	tr.	-	-	-	-	-	-	-	-
58	Valencene	1496	1498	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.12
59	Viridiflorene	1496	1499	0.24	0.20	0.16	0.23	0.19	0.13	0.19	0.16	0.13	0.11	0.17	-	0.55	0.60	-	-	0.12	0.45	-

No.	Components	KIL[1)]	KIE[2)]	ALB 1	ALB 2	ALB 3	ALB 4	ALB 5	ALB 6	ALB 7	ALB 8	ALB 9	ALB 10	ALB 11	ALB 12	ALB 13	GR 14	GR 15	GR 16	GR 17	GR 18	GR 19
60	α-Murrolene	1499	1503	tr.	-	-	-	-	-	-	tr.	tr.	-	-	-	-	-	0.13	-	-	0.10	tr.
61	γ-Cadinene	1513	1517	0.10	tr.	tr.	tr.	-	tr.	tr.	-	tr.	-	tr.	-	tr.	-	0.31	tr.	tr.	0.28	0.11
62	*trans*-Calemene	1521	1526	0.33	0.26	0.15	tr.	0.34	-	0.28	-	0.19	-	-	-	-	-	0.82	-	tr.	-	-
63	δ-Cadinene	1530	1527	-	-	-	-	-	0.16	-	0.23	-	tr.	0.15	-	0.21	0.73	-	0.16	-	0.74	0.24
64	α-Calocarene	1544	/	tr.	tr.	tr.	tr.	-	-	-	-	-	-	-	-	-	-	0.11	-	-	0.06	tr.
65	Elemol	1548	/	-	-	-	-	-	-	-	-	-	-	0.70	-	-	-	-	-	-	-	-
66	Sphatulenol	1577	/	0.53	0.58	0.14	0.19	0.38	0.18	0.17	0.15	tr.	0.18	0.10	-	0.19	-	0.22	0.18	0.18	0.29	-
67	Caryophyllene oxide	1582	1587	2.35	1.77	1.26	1.21	2.48	0.84	1.13	0.89	0.94	1.25	-	-	0.32	1.99	2.98	1.16	0.56	2.39	0.72
68	Globulol	1590	1594	4.96	4.81	3.05	6.03	5.42	2.36	2.51	2.25	2.98	2.73	-	-	-	-	9.95	1.74	-	3.38	1.56
69	Viridiflorol	1592	1596	-	-	-	-	-	-	-	-	-	-	1.21	4.42	5.51	5.39	-	-	3.15	-	-
70	Humulene epoxide	1608	1613	1.07	0.89	0.62	1.20	1.22	0.49	0.47	0.41	0.51	0.34	-	-	-	-	-	0.52	0.65	0.63	0.72
71	1-*epi*-Cubenol	1627	/	-	-	-	-	-	-	-	-	-	0.16	-	-	-	-	-	-	-	-	-
72	β-Eudesmol	1649	1653	-	-	-	-	-	-	-	-	-	-	0.13	-	-	-	-	-	-	-	-
73	α-Cadinol	1652	/	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.27	-	-	-	tr.
74	*neo*-Intermedol	1658	1663	-	-	-	-	-	-	-	-	-	-	0.50	-	-	-	-	-	-	-	-
75	Manool	2056	2060	4.46	3.09	3.11	4.42	5.39	0.78	1.92	1.64	1.71	1.37	0.66	3.54	2.75	-	6.41	0.27	-	3.94	2.93

Chemical Classes	ALB 1	ALB 2	ALB 3	ALB 4	ALB 5	ALB 6	ALB 7	ALB 8	ALB 9	ALB 10	ALB 11	ALB 12	ALB 13	GR 14	GR 15	GR 16	GR 17	GR 18	GR 19
Non-terpene (NT)	/	0.14	/	0.12	/	0.22	1.26	4.03	0.82	0.20	0.50	/	/	/	/	/	/	/	/
Monoterpenes (MT)	9.71	9.42	14.77	11.17	19.71	16.02	13.75	9.83	16.88	16.17	18.09	13.83	10.98	4.87	3.66	12.58	14.00	11.48	9.94
Oxygen-containing monoterpenes (OMT)	58.70	65.02	67.25	63.73	53.90	74.52	68.48	73.18	67.57	69.32	68.81	50.75	56.33	72.25	45.03	75.66	73.92	56.76	72.47
Sesquiterpenes (ST)	5.08	3.56	2.78	2.35	2.69	1.82	3.31	2.08	1.49	2.92	3.00	20.76	17.41	8.93	10.45	2.86	2.11	11.54	5.05
Oxygen-containing sesquiterpenes (OST)	8.91	8.05	5.07	8.63	9.50	3.87	4.28	3.70	4.43	4.66	2.14	8.95	6.37	7.38	13.60	3.60	4.54	6.69	3.00
Diterpenes (DT)	4.46	3.09	3.11	4.42	5.39	0.78	1.92	1.64	1.71	1.37	0.66	3.54	2.75	/	6.41	0.27	/	3.94	2.93
Total	86.86	89.28	92.98	90.42	91.19	97.23	93.00	94.46	92.90	94.64	93.20	97.83	93.84	93.43	79.15	94.97	94.57	90.41	93.39

1) KIL - Kovat's Index Literature [27]; 2) KIE - Kovat's Index Estimated (AMDIS) [28]; tr. = traces (< 0.02%).

ray Delamare et al. (2007) and Pierozan et al. (2009) found α-thujone as a major compound in their analyzed populations which is in contrast with our results and other available data.

Taking into concideration high cineole and camphor content, compounds with well established antibacterial properties, potential antimicrobial activity of the essential oil of *S. fruticosa* from Greece and Albania can be foreseen. Positive results of this activity could be used in the pharmaceutical industry, food production, and in the production of cosmetics or in any other purposes as substituted for *S. officinalis*.

Statistical analysis of variance (ANOVA) of the chemical composition of the essential oils for the complete data set of 19 samples revealed that there wasn't a statistically significant difference in the EO composition of *S. fruticosa* populations, regardless its origin.

Conclusion

The essential oils of 19 different populations of *S. fruticosa* was chemically analyzed and the oil yields were determinate and compared with the pharmacopeial requirements. The EO yield ranged from 0.25% to 4.00% and eighteen of the total analyzed populations met the minimal requirements (≥1.20%). Regarding the chemical analysis, a total of 75 components were detected, and 13 components (α-pinene, camphene, β-pinene, myrcene, 1,8-cineole, γ-terpinene, *cis*-thujone, *trans*-thujone, camphor, terpinene-4-ol, *trans*-(E)-caryophyllene, aromadendrene and α-humulene) were present in all samples. 1,8-Cineole was a predominant constituent in all sage populations, followed by camphor.

The results obtained from the essential oils isolated from Greek sage correlate with the available literature data, and the statistical analysis showed that the oil composition is not influenced by the geographical locations.

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Резиме

Состав на етерично масло од популации на *Salvia fruticosa* Mill. од Балканскиот полуостров

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Клучни зборови: Грчка жалфија, принос, GC/FID/MS, состав на етерични масла, Грција, Албанија.

Целта на оваа студија беше да се испита приносот и хемискиот состав на етеричните масла изолирани од 19 различни популации на *Salvia fruticosa* Mill. (грчка жалфија, Lamiaceae) од девет различни региони од Р. Албанија и Р. Грција. Содржината на маслата се движи од 0,25% до 4,00%. Осумнаесет од анализираните 19 популации одговараат на пропишаните минимални барања во европската фармакопеја за содржината на маслото. Со GC/FID/MS анализа на соодветните етерични масла, беа идентификувани вкупно 75 компоненти, што претставуваат 79,15-97,83% од вкупната содржина. Тринаесет компоненти (α-пинен, камфен, β-пинен, мирцен, 1,8-цинеол, γ-терпинен, *cis*-тујон, *trans*-тујон, камфор, терпинен-4-ол, *trans*-(E)-кариофилен, аромадендрен и α-хумулен), се детектирани во сите примероци, а 1,8-цинеол е определена како најзастапена поединечна компонента. Статистичката анализа на резултатите покажа дека географското потекло на растенијата нема значајно влијание на варијациите во хемискиот состав на етеричното масло од *S. fruticosa*.