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RESEARCH ARTICLE

Agronomical evaluation of Sicilian biotypes of *Lavandula stoechas* L. spp. *stoechas* and analysis of the essential oils

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The aim of this study was to characterize wild lavender, which was collected in three different areas of Sicily (Italy), according to agronomic and chemical evaluation. The collection sites were located in Pantelleria island, Partinico (a warm sub-area of Lauretum) and Castelbuono (a middle sub-area of Lauretum). All the populations were identified as *Lavandula stoechas* L. ssp. *stoechas.* Essential oils were extracted by hydrodistillation and analyzed by gas chromatography–flame ionization detector (GC–FID) and GC–mass spectrometry (GC–MS). GC–FID and GC–MS analyses permitted the identification of 101 components from the essential oils. We analyzed only the flowers and leaves of *L. stoechas* and the samples were analyzed using the PCA (principal component analysis) methodology regarding the chemical composition of the essential oils. Comparisons were carried out between the chemical compositions of essential oils from Sicilian populations and other Mediterranean populations. The essential oils of Sicilian *L. stoechas* biotypes were fenchone chemotype with percentages ranging from 45.29% to 60.27%. The qualitative chemical composition of the essential oils varied according to the different areas of origin of the plant material. Sicilian biotypes of *L. stoechas* showed high differences in chemical composition compared with the populations coming from other Mediterranean areas.

Keywords: wild *Lavandula stoechas* L. ssp. *stoechas*; essential oils; fenchone chemotype; principal component analysis

1. Introduction

The genus *Lavandula* includes thirty-nine species, several hybrids and 400 varieties (1). The geographic distribution of lavender ranges from the Canary Islands to Capo Verde Island including the Mediterranean area, North Africa, the Arab peninsula, the center and the south east of India (2). The two most cultivated and wild species in the Mediterranean area are *Lavandula angustifolia* and *Lavandula stoechas*, including their subspecies and hybrid forms. *Lavandula stoechas* L. ssp. *stoechas* is commonly used in perfumery and cosmetics thanks to the intense and pleasant aroma of the aerial part. Several medicinal properties of the species are reported in the literature and pharmacopeias. *Lavandula stoechas* is traditionally used for its carminatives, antispasmodic, expectorating, anticonvulsant, sedative, diuretic, analgesic and antiseptic properties (3–5). Many of them are linked to the volatile fraction contained in the essential oils (EOs) of the plant. Recent studies showed that EOs of *L. stoechas* have also antimicrobotic and insecticide properties (6–8). Although it is little used for food, it can be used to flavor white wine and vinegar. It is an anheliophila, termophila and xerophila species that grows up until 600 m a.s.l. in the phytoclimatic area of *Lauretum* (9).

Several studies concerning the chemical composition of the EO of *L. stoechas* from some Mediterranean regions (e.g. Morocco, Corsica, Greece and Turkey) highlight that the most common chemotype of the species is camphor–fenchone. Some authors also report a fenchone–1,8-cineol chemotype and a pulegone chemotype (7, 10–15).

The composition of EOs is an important parameter for the qualitative evaluation of aromatic species. EOs are significantly influenced by abiotic (climatic, soil, topographic, agronomic and post-harvest techniques) and biotic factors (plant age, stage of development, genetic characteristics) (3). Aromatic species show a high adaptive capacity to various environments, as in the arid and semi-arid areas of the Mediterranean region. The different climatic and soil characteristics of the Mediterranean region influence the chemical

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Table 1. Geographical localization of *Lavandula stoechas* populations in Sicily.

			Geographical location	
Biotype	Country	Region	Latitude (N)	Longitude (E)
LAP	Italy	Sicily	38°03'21"	13°05'15"
LAPZ	Italy	Sicily	36°46'08"	11°59'30"
LACB	Italy	Sicily	37°54'32"	14°03'39"

Note: LAP, Partinico; LAPZ, Pantelleria island; LACB, Castelbuono.

composition of the EOs and many authors have found different compositions of EOs for the same species (7, 14, 16–22).

The aim of this study was to characterize wild *L. stoechas* L. spp. *stoechas*, which was collected in three different areas of Sicily (Italy), according to agronomic and chemical evaluation Relationships between the composition of EOs of Sicilian populations and other populations in Mediterranean areas were also analyzed. EOs were analyzed using the PCA (principal component analysis) methodology (23).

2. Experimental

2.1. Plant material

Leaves and flowers of wild *L. stoechas* L. spp. *stoechas* were collected from three different locations in Sicily during the full-flowering stage. The three Sicilian collection sites were Castelbuono (LACB), Partinico (LAP) and Pantelleria island (LAPZ). Plant material was found in areas with altitude ranging from 150 to 600 m a.s.l. In each collection site, a descriptive list of the height of the plants, the harvesting date and the ecological characteristics of the site was completed. For each site, a minimum of six plants was collected. Plant materials were characterized taxonomically using analytical keys and by comparing them with *exsiccata* that were prepared and deposited at the Department of Agricultural and Forest Sciences of University of Palermo (Italy). The

Figure 1. Collection sites of *Lavandula stoechas* populations.

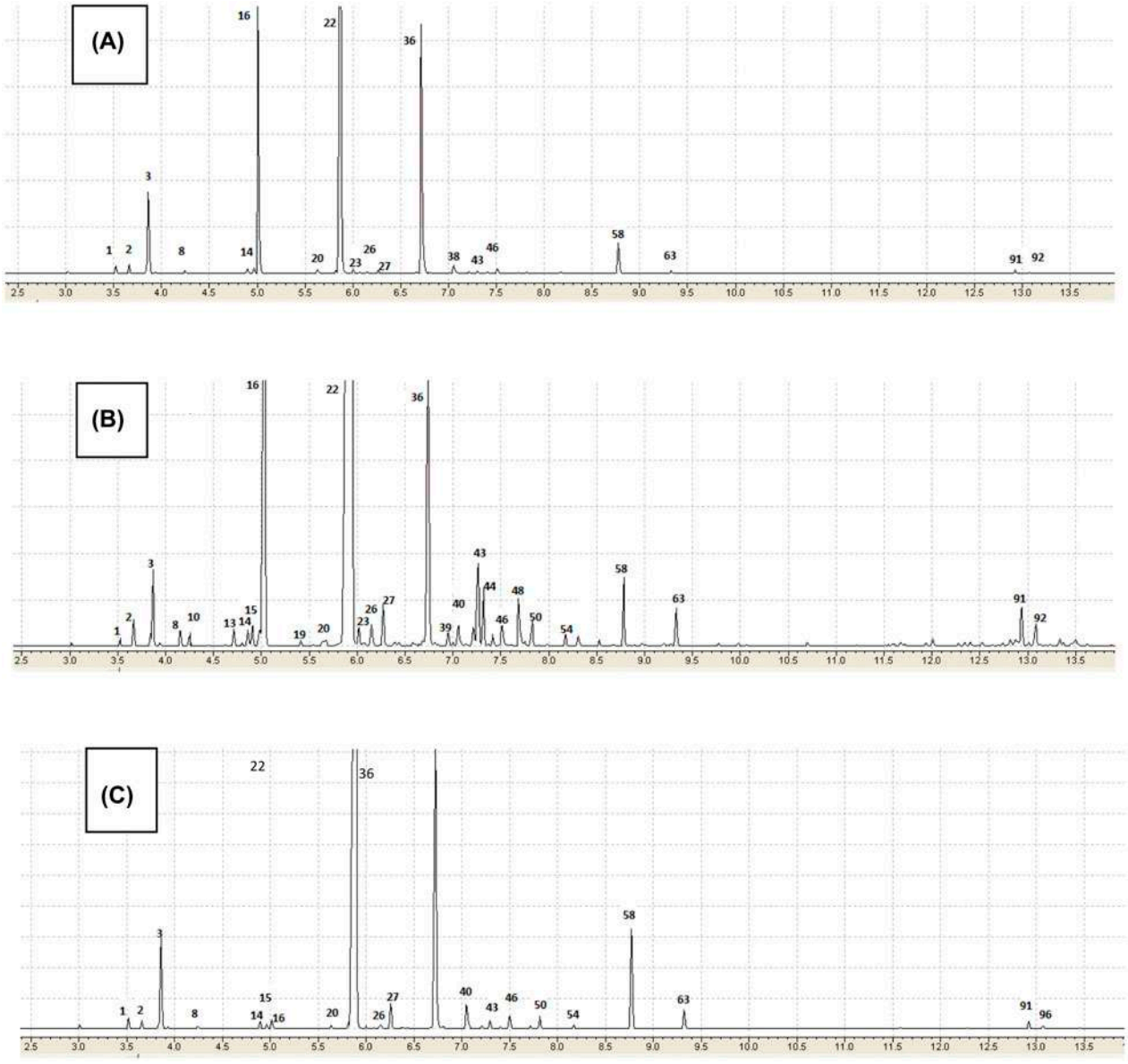

Figure 2. Gas chromatography–mass spectrometry (GC–MS) profiles of the essential oils of the three populations of *Lavandula stoechas* [A = LAP (Partinico); B = LAPZ (Pantelleria island), C = LACB (Castelbuono)].

main biometric and productive parameters of the plants (length and number of the stems, inflorescence diameter, fresh and dry weight, inflorescence dry weight and leaves dry weight) were determined. The phenological stages of the species were also monitored. The harvest was carried out towards the end of June, when the 70% of flowers were completely open. This is commonly the best balsamic period for the *L. stoechas.*

2.2. Isolation, GC–FID and GC–MS analyses of the essential oils

The leaves and flowers were air dried (for thirty days) at room temperature in a shady place, protected from direct light. EOs have been obtained by hydrodistillation of air-dried plant material (50–100 g) for 3 hours. EOs have been dried on anhydrous sodium sulfate and stored under N_2 until required. Gas chromatographic (GC) analyses were run on a Shimadzu gas chromatograph, Model 17-A, equipped with a flame ionization detector (FID). Analytical conditions: SPB-5 capillary column (15 m × 0.10 mm × 0.15 μμm), with helium as the carrier gas (1 mL/minute.); injection in split mode (1:200), injected volume 1 μL (4% EO/CH_2C_{l2} v/v), injector and detector temperature 250° and 280°C, respectively. The oven temperature was held at 60°C for 1 minute, then programmed from 60° to 280°C at 10°C/minute, then 280°C for 1

Table 2. Main biometric parameters that were determined in the study.

Biotype	Plant height (cm)		Stems length (cm)		Stems/plant (no.)	Inflorescence diameter (mm)		Fresh weight/plant (g)		Dry weight/plant (g)		Dry weight of leaves and flowers/plant (g)		EO leaves and flowers/ plant (%)	
LAP	90.38	AB	74.00	AB	34.78	8.53	A	1972.80	A	1043.80	A	480.77	A	0.73	B
LACB	103.03	A	77.15	A	37.78	6.81	B	886.30	B	470.60	B	174.29	B	1.00	A
LAPZ	68.78	B	51.96	B	35.00	6.75	B	1199.90	AB	539.30	B	282.93	B	1.08	A

Notes: **Highly significant at $p<0.01$; *significant at $p<0.05$; ns, not significant according to the Tukey test. LAP, Partinico; LAPZ, Pantelleria island; LACB, Castelbuono.

Table 3. Chemical components of the essential oils of the three Sicilian populations of *Lavandula stoechas.*

Peak no.[a]	RI[b]	RI[c]	Compound	LAPZ	LAP	LACB
1	921	927	Tricyclene	0.14	0.36	0.36
2	933	939	α-Pinene	0.87	0.42	0.24
3	949	953	α-Fenchene	1.65	3.85	3.28
4	954	960	Thuja-2,4(10)-diene	0.10	0.11	0.07
5	961	960	Benzaldehyde	0.02	0.00	0.01
6	969	968	Verbenene	0.46	0.05	0.00
7	976	979	β-Pinene	0.16	0.16	0.13
8	979	979	1-Octen-3-ol	0.02	0.00	0.00
9	984	991	3-Octanol	0.06	0.00	0.02
10	989	991	dehydro-1,8-Cineole	0.05	0.04	0.01
11	996	1004	*p*-Mentha-1(7),8-diene	0.46	0.02	0.00
12	1000	1017	α-Terpinene	0.03	0.00	0.02
13	1013	1025	*p*-Cymene	0.07	0.07	0.04
14	1020	1026	*o*-Cymene	0.44	0.18	0.33
15	1022	1029	Limonene	0.17	0.06	0.15
16	1031	1031	1,8-Cineole	11.47	16.31	0.13
17	1040	1042	Benzene acetaldehyde	0.00	0.02	0.01
18	1052	1060	γ-Terpinene	0.16	0.08	0.04
19	1063	1070	*trans*-Sabinene hydrate	0.09	0.05	0.00
20	1066	1073	*cis*-Linalool oxide	0.05	0.12	0.08
21	1076	1082	Camphenilone	0.02	0.00	0.02
22	1081	1087	Fenchone	56.10	45.29	60.27
23	1087	1097	Linalool	0.30	0.12	0.08
24	1089	1098	*cis*-Sabinene hydrate	0.00	0.21	0.04
25	1095	1106	α-Fenchocamphorone	0.04	0.24	0.16
26	1096	1102	2*Z*-Heptenyl acetate	0.28	0.02	0.00
27	1098	1117	endo-Fenchol	1.05	0.27	0.02
28	1106	1122	exo-Fenchol	0.07	0.09	1.18
29	1115	1123	*trans*-Pinene hydrate	0.01	0.12	0.04
30	1117	1126	α-Campholenal	0.09	0.00	0.01
31	1121	1123	3-Octanol acetate	0.02	0.00	0.07
32	1124	1139	*trans*-Pinocarveol	0.10	0.04	0.03
33	1127	1138	*p-cis*-Mentha-2,8-dien-1-ol	0.00	0.00	0.01
34	1136	1140	Nopinone	0.00	0.00	0.03
35	1138	1142	*trans*-Sabinol	0.10	0.00	0.00
36	1147	1146	Camphor	7.94	18.42	20.15
37	1148	1150	Camphene hydrate	0.04	0.02	0.01
38	1159	1159	Sabina ketone	0.36	0.03	0.00
39	1163	1165	Pinocarvone	0.05	0.10	0.03
40	1170	1169	Borneol	0.76	1.23	1.36
41	1178	1177	*trans*-Linalool oxide	0.05	0.02	0.01
42	1181	1177	Terpinen-4-ol	0.48	0.34	0.24
43	1190	1183	*p*-Cymen-8-ol	1.86	0.31	0.43
44	1193	1189	*p-trans*-Mentha-1(7),8-dien-2-ol	0.01	0.00	0.01
45	1197	1189	α-Terpineol	0.66	0.16	0.09
46	1204	1196	Myrtenol	0.49	0.00	0.87
47	1211	1196	Myrtenal	0.19	0.00	0.00
48	1216	1205	Verbenone	1.48	0.84	0.23
49	1222	1198	Shisofuran	0.01	0.00	0.00
50	1227	1220	Fenchyl acetate	0.78	0.37	0.70
51	1236	1239	Isobornyl acetate	0.05	0.00	0.00
52	1239	1229	*cis*-Carveol	0.06	0.05	0.05
53	1248	1242	Cumin aldehyde	0.01	0.00	0.01
54	1251	1243	Carvone	0.34	0.22	0.24
55	1263	1252	Thymoquinone	0.02	0.00	0.00
56	1282	1290	Lavandulyl acetate	0.22	0.00	0.01
57	1287	1290	Thymol	0.05	0.03	0.04
58	1295	1289	Bornyl acetate	0.95	3.44	4.54
59	1296	1291	*p*-Cymen-7-ol	0.03	0.03	0.01
60	1300	1290	Thymol	0.05	0.00	0.00

(*Continued*)

Table 3. (*Continued*).

Peak no.[a]	RI[b]	RI[c]	Compound	LAPZ	LAP	LACB
61	1306	1299	Carvacrol	0.09	0.12	0.09
62	1326	1319	*Z*-Patchenol	0.05	0.00	0.04
63	1331	1327	Myrtenyl acetate	1.03	0.48	0.99
64	1335	1343	Piperitone	0.01	0.00	0.00
65	1357	1351	α-Cubebene	0.01	0.01	0.01
66	1363	1359	Eugenol	0.12	0.08	0.09
67	1375	1371	Cyclosativene	0.07	0.08	0.05
68	1385	1377	α-Copaene	0.03	0.01	0.01
69	1390	1381	Geranyl acetate	0.02	0.02	0.01
70	1398	1385	β-*E*-Damascenone	0.02	0.01	0.01
71	1398	1391	7-*epi*-Sesquithujene	0.02	0.00	0.00
72	1412	1392	Sativene	0.02	0.01	0.00
73	1429	1419	Caryophyllene	0.10	0.03	0.02
74	1441	1435	α-*trans*-Bergamotene	0.02	0.03	0.00
75	1464	1455	α-Humulene	0.03	0.00	0.02
76	1469	1455	*trans*-Muurola-3,5-diene	0.06	0.05	0.01
77	1480	1477	*trans*-Cadina-1(6),4-diene	0.01	0.00	0.00
78	1490	1485	Germacrene D	0.03	0.05	0.04
79	1495	1490	β-Selinene	0.08	0.00	0.11
80	1498	1492	10,11-epoxy-Calamenene	0.05	0.10	0.00
81	1503	1494	*epi*-Cubebol	0.10	0.14	0.08
82	1513	1500	Biciclogermacrene	0.04	0.05	0.02
83	1525	1512	δ-Amorphene	0.09	0.07	0.02
84	1531	1523	δ-Cadinene	0.19	0.16	0.06
85	1541	1535	*trans*-Cadina-1(2),4-diene	0.03	0.01	0.01
86	1552	1546	α-Calacorene	0.11	0.10	0.11
87	1579	1569	Ledol	0.03	0.03	0.02
88	1588	1578	Spathulenol	0.08	0.11	0.01
89	1594	1583	Caryophyllene oxide	0.21	0.16	0.09
90	1598	1585	Globulol	0.12	0.02	0.02
91	1605	1593	Viridifluorol	1.11	0.99	0.53
92	1617	1595	Caratol	0.66	0.57	0.31
93	1639	1629	1-*epi*-Cubenol	0.14	0.14	0.07
94	1643	1637	*cis*-Cadina-4-en-7-ol	0.10	0.06	0.05
95	1648	1641	epoxy-allo-Alloaromadendrene	0.09	0.02	0.01
96	1652	1640	α-*epi*-Cadinol	0.17	0.17	0.10
97	1657	1646	α-Muurolol	0.02	0.02	0.04
98	1663	1651	β-Eudesmol	0.08	0.06	0.04
99	1685	1677	Cadalene	0.04	0.05	0.04
100	1690	1678	Occidenol	0.08	0.07	0.07
101	1711	1688	Eudesma-4(15),7-dien-1-β-ol	0.05	0.02	0.01
Monoterpene hydrocarbons				4.71	5.36	4.66
Oxygenated monoterpenes				87.68	89.15	92.34
Sesquiterpenes				4.09	3.40	1.95
Others				0.52	0.12	0.12
Total				97.00	98.03	99.07

Notes: [a]The numbering refers to elution order, and values (relative peak area percent) represent averages of three determinations; [b]retention index (RI) relative to standard mixture of *n*-alkanes on SPB-5 column; [c]retention index (RI) from literature (25). LAP, Partinico; LAPZ, Pantelleria island; LACB, Castelbuono.

minute. Percentages of compounds were determined from their peak areas. GC–mass spectrometry (GC–MS) was carried out in the fast mode on a Shimadzu GC–MS model GCMS-QP5050A, with the same analytical conditions used for GC–FID; ionization voltage 70 eV, electron multiplier 900 V, ion source temperature 180°C. Mass spectra data were acquired in the scan mode in range 40–400 *m*/*z*. The same oil solutions (1 μL) were injected in split mode (1:96). All analyses were carried out in triplicate.

2.3. *Identification of components*

The identity of components was based on their GC retention index (relative to C_9–C_{22} *n*-alkanes on the SPB-5 column), computer matching of spectral MS data with those from NIST MS libraries (24), the comparison

Table 4. Chemical compounds higher than 1% identified for the three Sicilian geographic areas.

RI sperimental	RI literature	Compound	LAPZ	LAP	LACB	*F*	Sig.
949	953	a-Fenchene	1.65	3.85	3.28	23.73	**
1031	1031	1.8-Cineole	11.47	16.31	0.13	72.85	**
1081	1087	Fenchone	56.10	45.29	60.27	43.39	**
1098	1117	endo-Fenchol	1.05	0.27	0.02	19.27	**
1106	1122	exo-Fenchol	0.07	0.09	1.18	2209.55	**
1147	1146	Camphor	7.94	18.42	20.15	30.24	**
1170	1169	Borneol	0.76	1.23	1.36	50.61	**
1190	1183	*p*-Cymen-8-ol	1.86	0.31	0.43	13.53	**
1216	1205	Verbenone	1.48	0.84	0.23	52.37	**
1295	1289	Bornyl acetate	0.95	3.44	4.54	99.78	**
1331	1327	Myrtenyl acetate	1.03	0.48	0.99	11.17	**
1605	1593	Viridifluorol	1.11	0.99	0.53	28.02	**
			85.46	91.52	93.11		

Notes: *F*, test of the variance analysis: **highly significant at $p<0.01$; significant at $p<0.05$; ns, not significant. LAP, Partinico; LAPZ, Pantelleria island; LACB, Castelbuono.

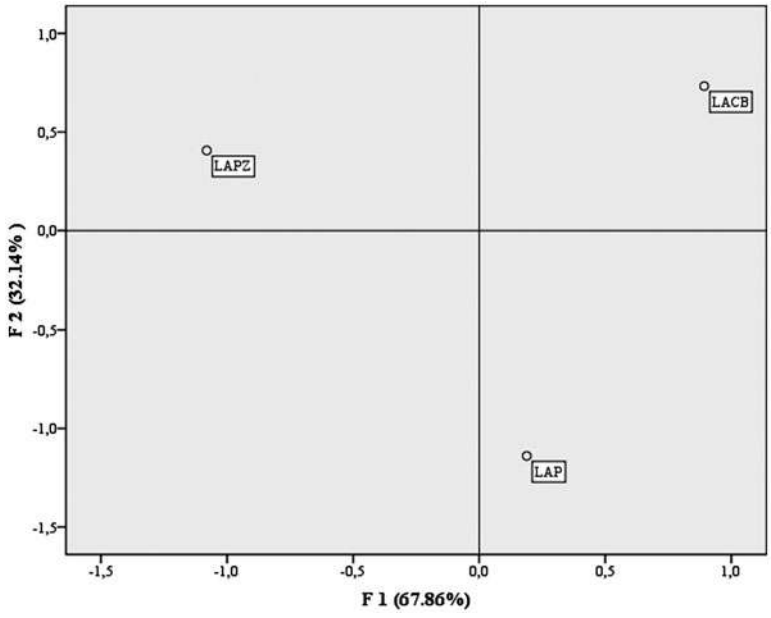

Figure 3. Distribution of the three Sicilian populations as a function of the two main components (F).

of the fragmentation patterns with those reported in literature (25) and, whenever possible, co-injection with authentic samples. Pure standards were purchased from Aldrich Chemical Co. (Extrasynthese, France), and FlukaChemie AG (Switzerland). EO composition of the three Sicilian populations of *L. stoechas* was compared with results obtained from other authors on spontaneous plants of the same species found in other Mediterranean areas and using the same extraction methods and plant parts.

2.4. Statistical analyses

Statistical analysis was performed with the package MINITAB Release 14 for Windows and SPSS version 17.0. and included one-way analysis of variance (ANOVA). The difference between means was carried out using the Tukey test.

PCA was used for highlight the relationships among Sicilian populations based on their chemical compounds.

3. Results and discussion

Plant material was collected in the phyto-climatic area of *Lauretum*. The collection sites of Pantelleria island and Partinico were located in the warm sub-area of *Lauretum* while the collection site of Castelbuono was in the middle sub-area of *Lauretum*. All the populations were identified as *L. stoechas* L. ssp. *stoechas*. Table 1

Table 5. Comparison of the contents of the main Sicilian chemical compounds with those from the other Mediterranean areas.

Compound	LAPZ	LAP	LACB	S	G	LS1	LS2	LS3	LS4	LS5	LS6	LS7	LS8	LS9	LS10	LS11
α-Fenchene	1.65	3.85	3.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00
1.8-Cineole	11.47	16.31	0.13	0.13	16.30	0.16	8.71	8.49	4.28	4.19	2.21	1.30	7.51	2.63	5.69	7.85
Fenchone	56.10	45.29	60.27	66.23	45.19	11.27	37.48	24.11	24.14	36.76	16.35	14.56	34.48	26.52	29.92	32.42
endo-Fenchol	1.05	0.27	0.02	0.44	0.00	0.42	1.37	0.61	0.75	1.01	0.58	0.93	1.00	1.30	0.79	0.80
exo-Fenchol	0.07	0.09	1.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Camphor	7.94	18.42	20.15	12.31	9.90	9.77	5.81	1.94	17.12	15.50	21.80	11.56	8.69	8.99	13.19	14.52
Borneol	0.76	1.23	1.36	1.14	0.90	1.13	0.20	0.21	0.71	0.73	0.52	0.95	0.32	0.63	0.87	0.29
p-Cymen-8-ol	1.86	0.31	0.43	0.29	0.20	2.64	1.32	2.00	1.81	1.60	1.31	1.78	2.77	2.74	1.53	1.83
Verbenone	1.48	0.84	0.23	0.07	0.60	2.67	2.18	1.22	1.78	1.43	0.70	1.36	2.07	1.49	1.22	0.90
Bornyl acetate	0.95	3.44	4.54	3.76	0.00	2.82	0.47	0.46	2.36	3.03	3.73	4.00	1.61	1.52	3.12	0.92
Myrtenyl acetate	1.03	0.48	0.99	4.36	0.00	1.27	0.61	2.17	1.69	1.62	2.54	1.72	1.01	2.51	1.68	2.14
Viridifluorol	1.11	0.99	0.53	0.01	0.00	7.38	4.88	6.81	4.34	3.58	7.14	6.44	3.01	3.80	5.07	2.89
Total	85.46	91.52	93.11	88.72	73.09	39.53	63.03	48.02	58.98	69.45	56.88	44.60	62.50	52.13	63.08	64.56

Notes: LAP, Partinico; LAPZ, Pantelleria island; LACB, Castelbuono; S, Sardinia; G, Greece; LS1–LS11, Algeria.

and Figure 1 show the geographical localization of *L. stoechas* populations.

The main biometric parameters were reported in Table 2. All the parameters showed high significant differences with the exception of the number of plant stems. Plant height ranged from 103.03 (LACB) to 68.78 cm (LAPZ). The lavender population collected in Partinico showed the highest fresh (1972.80 g) and dry weight (1043.80 g) plants but the lowest EO percentage (0.73%). The highest EO percentage (1.08%) was found in the lavender population collected in Pantelleria, which also showed the lowest height (68.78 cm) and stems length (51.96 cm).

One hundred and one chemical compounds of the EOs were identified with GC–MS analyses. These compounds represent 97.00–99.08% of the total composition of the EOs of the three Sicilian biotypes of *L. stoechas* (Table 3; Figure 2). Table 4 describes only the twelve chemical compounds that were higher than 1% of the total composition of the EOs. These compounds represent 85.46–93.11% of the total composition of the EOs.

One-way ANOVA showed high significant differences among the chemical compounds that were higher than 1%. The chemical profiles of the EOs of lavender populations collected in Castelbuono and Partinico were identified as fenchone–camphor chemotype, while the EOs of lavender populations collected in Pantelleria was identified as fenchone–1.8-cineole chemotype.

The total variance showed by the PCA analysis identifies two components according to the rules of Kaiser (eigenvalues>1) that represents 100.0% of the total variance. For our study, a further factorial analysis using the two principal components (F) was performed. The diagram obtained by the two axes of F underlines the existence of two groups (Figure 3), subdivided according to the main components represented by F1 and F2. The compounds that were most represented from F1 (67.86% of the total variance) were bornyl acetate, endo-fenchol, *p*-cymen-8-ol, camphor, borneol, and verbenone, while the F2 (32.14% of the total variance) was most represented from fenchone and myrtenyl acetate.

In Figure 3, we observed a distribution of Sicilian lavender populations in two geographical areas: the major Sicily island (LAP, LACB) and the minor Pantelleria island (LAPZ). The distribution was made based on F1 that represents the most explicative component of the variance. EOs of LAPZ lavender population were characterized by moderate values of camphor (7.94%) and bornyl acetate (0.95%), and higher percentages of endo-fenchol (1.05%), ρ-cymene-8-ol (1.86%) and verbenone (1.48%) than the other populations.

The quantities of each of the twelve main compounds (>1%) were compared with those determined by other authors on oils extracted from the leaves and flowers of *L. stoechas* from other areas of the Mediterranean [South Sardinia (7), North Algeria (21) and North-East Greece (22)]. We chose these studies for comparison because the authors used similar extraction techniques and plant parts (Table 5). EO compositions of Sardinia and Sicily showed a high percentage of fenchone (45.29–66.23%) and a low percentage of α-cadinol (0.00–0.02%). The EO composition of Sicilian biotypes was different with respect to the Sardinian biotypes for the presence of viridifluorol (0.53–1.11%) and for low values of α-pinene (0.24–0.87%), which associate them with Algerian compositions. EOs of LACB and LAP lavender populations showed high percentages of bornyl acetate (respectively 4.54% and 3.44%) and low percentages of α-cadinol, β-pinene, linalool and ρ-cymene. Lavandulyl acetate and camphene were absent. EOs of LAPZ lavender population showed high percentages of linalool (0.30%) and lavandulyl acetate (0.22%), and lower percentages of bornyl acetate (0.95%). The Greek biotype was found to have high 1.8-cineole percentages and intermediate levels of fenchone compared with other Italian and Algerian biotypes.

4. Conclusions

EOs that were obtained by hydrodistillation from leaf and flower of Sicilian biotypes of *L. stoechas* L. spp. *stoechas* were fenchone chemotype. However, the contents of the compounds was different based on the areas of origin of the biotypes (major Sicily island and minor Pantelleria island). Two chemotypes were observed: fenchone–camphor type (LAP, LACB) and fenchone18-cineole type (LAPZ).

The Sicilian biotypes of *L. stoechas* showed high differences in chemical composition compared with the populations coming from other Mediterranean areas. This fact can be the result of a '*Terroir*' effect, intended as the expression of genetic, environmental and ecological characteristics, like climatic conditions, attraction of pollinating insects or the repellency against antagonists. However, little is known about the determinism of the chemical diversity between oils extracted by leaves and flowers, and these need further investigation and study (26–30).

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