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Chemical composition of the essential oil of three Iranian *Satureja* species (*S. mutica*, *S. macrantha* and *S. intermedia*)

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Abstract

Essential oils from aerial parts of *Satureja mutica* Fisch. & C. A. Mey., *Satureja macrantha* C. A. Mey. and *Satureja intermedia* C. A. Mey. were obtained by hydro-distillation. The oils were analyzed by capillary gas chromatography, using flame ionization and mass spectrometric detection. Forty five components were identified in the oil of *S. mutica* with carvacrol (30.9%), thymol (26.5%), γ-terpinene (14.9%) and *p*-cymene (10.3%) as main constituents. Sixty five compounds were identified in the oil of *S. macrantha*, with *p*-cymene (25.8%), limonene (16.3%) and thymol (8.1%) as main components. Thirty eight compounds were characterized in the oil of *S. intermedia* with thymol (32.3%), γ-terpinene (29.3%) and *p*-cymene (14.7%) as main constituents. The results showed different compositions of the essential oils of these *Satureja* species. There are some minor components in each oil that are not present in the others.

Keywords: *Satureja mutica*; *Satureja macrantha*; *Satureja intermedia*; Labiatae; Essential oil composition; Thymol; Carvacrol; *p*-cymene; γ-terpinene; Limonene; Iran

1. Introduction

Satureja (Labiatae) species are present in mountainous areas in Iran, mainly in western and northern parts. *S. intermedia* C. A. Mey is a rare species endemic of Iran and Talish. It is a small delicate perennial growing on rock-outcrops. *S. mutica* Fisch & C. A. Mey is a highly aromatic species growing on calcareous rocks in north-eastern Iran. *S. macrantha* C. A. Mey. is a small shrub distributed in northwestern and western parts of Iran (Rechinger, 1982). In a comprehensive study of *Satureja* species of Iran, these three species were examined to identify their essential oil components.

There are two important famous species of *Satureja* used as culinary herbs: *Satureja hortensis* L. and *Satureja montana* L.

The main constituents of the essential oil of *S. hortensis* are the phenols, carvacrol and thymol, as well as *p*-cymene, β-caryophyllene, linalool and other terpenoids. Essential oil of *S. montana* includes the phenols, carvacrol and thymol, as well as *p*-cymene, linolool, terpineol, borneol and various organic acids.

The green leaves and herbaceous parts of stems from both species are used fresh and dried as flavouring agents in seasonings, stews, meat dishes, poultry, sausages, and vegetables. *S. hortensis* has a sweeter and more delicate aroma and fragrance than does of *S. montana*, and is therefore the more popular of the two species. Both the essential oils, obtained by steam distillation, and the oleoresin are used in the food industry. In addition, the essential oils of both species have been used in the perfume industry, either alone or blended with other essential oils.

As a medicinal plant, *S. hortensis* has been traditionally used as a stimulant, stomachic, carminative, expectorant, antidiarrheic, and aphrodisiac. The essential oil has demonstrated antimicrobial and antidiarrheic activity because of the phenols in the oil.

Due to these various usages of *Satureja* species or their oils, we were interested in studying essential oil

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contents and compositions of *Satureja* species in Iran. The essential oil compositions of four *satureja* species of Iran, *S. khuzistanica* Jamzad (Sefidkon & Ahmadi, 2000), *S. bachtiarica* Bunge (Sefidkon & Jamzad, 2000), *S. spicigera* (C. Koch) Boiss. (Sefidkon & Jamzad, 2004) and *S. sahendica* Bornm. (Sefidkon, Jamzad, & Mirza, 2004) were reported previously. The major components of *S. khuzistanica* were *p*-cymene (39.6%) and carvacrol (29.6%), while those of *S. bachtiarica* were thymol (44.5%) and γ-terpinene (23.9%). The main constituents of the essential oil of *S. spicigera* were thymol (35.1%), *p*-cymene (22.1%) and γ-terpinene (13.7%). The main constituents of the essential oils of eight populations of *S. sahandica* were thymol (19.6%–41.7%), *p*-cymene (32.5%–54.9%) and γ-terpinene (1.0%–12.8%). Literature searches indicated that the oils of *S. mutica*, *S. macrantha* and *S. intermedia* have not been the subject of previous studies.

Literature review showed variation between chemical composition of different *Satureja* species oils. The main components of *S. boissieri* (Kurcuoglu, Tumen, & Baser, 2001) oil from Turkey were reported to be carvacrol (40.8%) and γ-terpinene (26.4%). The main constituents of *S. brownei* (Rojas & Usubillaga, 2000) oil from Venezuela were found to be pulegone (64.3%) and menthone (20.2%). The main compound of *S. parvifolia* (Viturro et al., 2000) oil from Argentina is piperitone oxide and those of *S. Boliviana* (Rojas & Usubillaga, 2000) oil are γ-terpinene, β-caryophyllene and germacrene D.

Germacrene D has also been detected as the main compound of *S. coerulea* (Tumen, Baser, Demirci, & Ermin, 1998) oil from Turkey. The main components of *S. hortensis* (Baher, Mirza, Ghorbanli, & Rezaii, 2002) cultivated in Iran were carvacrol and γ-terpinene.

2. Materials and methods

2.1. Plant material

The aerial parts of *S. mutica*, *S. macrantha* and *S. intermedia* were collected at the full flowering stage, from Khorassan, Azarbayejan and Ardebil provinces, respectively, in Iran. Voucher specimens have been deposited in the national herbarium of Iran (TARI).

2.2. Isolation procedure

Air-dried aerial parts of the plants (50–70 g, three times for each species) were subjected to hydro-distillation for 3 h using a Clevenger-type apparatus. The oils were obtained in yields of 2.31%, 1.48% and 1.45% from *S. mutica*, *S. macrantha* and *S. intermedia*, respectively. The oils were dried over anhydrous calcium chloride and stored in sealed vials at low temperature before analysis.

2.3. GC and GC/MS analysis

GC analyses were performed using a Shimadzu GC-9A gas chromatograph equipped with a DB-5 fused silica column (30 m × 0.25 mm i.d., film thickness 0.25 μm). Oven temperature was held at 50 °C for 5 min and then programmed to 250 °C at a rate of 3 °C/min. Injector and detector (FID) temperature were 290 °C; helium was used as carrier gas with a linear velocity of 32 cm/s.

GC-MS analyses were carried out in a Varian 3400 GC-MS system equipped with a DB-5 fused silica column (30 m × 0.25 mm i.d.). Oven temperature was 40 °C–240 °C at a rate of 4 °C/min, transfer line temperature 260 °C, carrier gas helium with a linear velocity of 31.5 cm/s, split ratio 1/60, ionization energy 70 eV; scan time 1 s and mass range of 40–300 amu. The percentages of compounds were calculated by the area normalization method, without considering response factors. The components of the oil were identified by comparison of their mass spectra with those of a computer library or with authentic compounds and confirmed by comparison of their retention indices, either with those of authentic compounds, or with data published in the literature (Adams, 1995).

3. Results and discussion

3.1. General

The oils isolated by hydro-distillation from the aerial parts of *S. mutica*, *S. macrantha* and *S. intermedia* were found to be yellow liquids and obtained in yields of 2.31%, 1.48% and 1.45% (w/w), based on dry weights, respectively.

Forty five components were identified in the essential oil of *S. mutica*. The major components were carvacrol (30.9%), thymol (26.5%), γ-terpinene (14.9%) and *p*-cymene (10.3%). Sixty five compounds were identified in the oil of *S. macrantha*. The main components of this oil were *p*-cymene (25.8%), limonene (16.3%) and thymol (8.1%). Thirty eight compounds were characterized in the oil of *S. intermedia*, with thymol (32.3%), γ-terpinene (29.3%) and *p*-cymene (14.7%) as main constituents. The results showed different compositions of the essential oils of these *Satureja* species.

The chemical composition of the oils can be seen in Table 1. The components are listed in order of their elution on the DB-5 column.

Comparison of the oil compositions of these *Satureja* species showed that, although most of the compounds were present in all of the oils, their percentages were different. For example, the amount of thymol varied from 8.1% to 32.3% and carvacrol from 0.4% to 30.9%. The oil of *S. macrantha* contains 16.3% limonene, while

Table 1
Percentage composition of the oils of three *Satureja* species

No.	Compound	Retention index	*Satureja mutica*	*Satureja macrantha*	*Satureja intermedia*	Methods of identification
1	α-Thujene	930	0.8	**0.3**	0.8	RI, MS
2	α-Pinene	938	0.5	1.9	0.6	RI, MS, CoI
3	Camphene	952	0.1	0.2	0.1	RI, MS, CoI
4	Sabinene	975	t	0.2	0.8	RI, MS
5	β-Pinene	980	0.2	1.4	1.3	RI, MS, CoI
6	Myrcene	990	1.1	0.7	1.4	RI, MS, CoI
7	3-Octanol	992	t	t	–	RI, MS
8	α-Phellandrene	1004	0.2	0.1	0.2	RI, MS
9	δ-3-Carene	1010	0.1	t	0.1	RI, MS, CoI
10	α-Terpinene	1017	2.0	0.6	3.3	RI, MS, CoI
11	*p*-Cymene	1025	10.3	25.8	14.7	RI, MS, CoI
12	Limonene	1030	2.6	16.3	3.3	RI, MS, CoI
13	1,8-Cineole	1033	0.9	3.3	0.1	RI, MS, CoI
14	(*Z*)-β-Ocimene	1039	–	2.2	0.2	RI, MS
15	(*E*)-β-Ocimene	1050	0.1	2.2	0.2	RI, MS
16	γ-Terpinene	1061	14.9	6.4	29.3	RI, MS, CoI
17	*cis* Sabinene hydrate	1068	0.7	0.3	0.1	RI, MS
18	*cis* Linalool oxide	1073	–	0.1	–	RI, MS
19	Terpinolene	1087	–	0.1	0.1	RI, MS, CoI
20	*trans* Sabinene hydrate	1096	0.1	0.3	0.1	RI, MS
21	α-Thujone	1101	0.1	0.2	–	RI, MS, CoI
22	β-Thujone	1113	0.1	0.4	–	RI, MS, CoI
23	*cis* Pinene hydrate	1121	0.1	0.2	–	RI, MS
24	*cis* Limonene oxide	1133	0.1	0.8	–	RI, MS
25	*trans* Limonene oxide	1138	0.1	0.6	–	RI, MS
26	Menth-2-en-1-ol (*trans* – *p*)	1140	–	0.1	–	RI, MS
27	Camphor	1143	0.1	0.3	–	RI, MS, CoI
28	Menthone	1154	0.7	2.4	–	RI, MS, CoI
29	Menthofurane	1163	0.1	0.4	–	RI, MS, CoI
30	Borneol	1165	0.3	1.3	0.1	RI, MS, CoI
31	l-Menthol	1172	0.8	2.6	–	RI, MS, CoI
32	Terpinen-4-ol	1177	0.3	0.3	0.2	RI, MS, CoI
33	*p*-Cymen-8-ol	1181	–	0.2	–	RI, MS
34	*cis* Pinocarveol	1183	–	0.1	–	RI, MS
35	α-Terpineol	1189	0.1	0.2	0.1	RI, MS, CoI
36	*n*-Decanal	1203	0.1	0.2	–	RI, MS
37	*trans* Carveol	1216	0.1	0.5	–	RI, MS, CoI
38	*cis* Carveol	1228	–	0.3	–	RI, MS
39	Methyl thymol	1234	–	0.2	–	RI, MS
40	Pulegone	1237	–	0.9	–	RI, MS, CoI
41	Carvone	1241	0.2	0.4	–	RI, MS, CoI
42	Methyl carvacrol	1243	0.5	–	–	RI, MS
43	Thymoquinone	1248	–	–	0.1	RI, MS
44	Piperitone	1251	–	0.1	–	RI, MS
45	Thymol	1290	26.5	8.1	32.3	RI, MS, CoI
46	Carvacrol	1297	30.9	0.4	1.0	RI, MS, CoI
47	α-Terpinenyl acetate	1314	–	t	0.1	RI, MS
48	Thymyl acetate	1354	0.1	–	0.1	RI, MS
49	α-Copaene	1375	–	0.3	–	RI, MS
50	β-Bourbonene	1383	–	0.3	–	RI, MS
51	Cyperene	1397	–	0.1	–	RI, MS
52	Methyl eugenol	1400	–	–	0.2	RI, MS
53	β-Caryophyllene	1418	1.1	1.4	0.7	RI, MS, CoI
54	(*Z*)-*trans*-α-Bergamotene	1435	–	0.1	–	RI, MS
55	Aromadendrene	1438	–	0.1	–	RI, MS
56	(*Z*)-β-Farnesene	1442	–	–	0.2	RI, MS
57	α-Humulene	1453	0.1	0.1	–	RI, MS, CoI
58	allo-Aromadendrene	1460	–	0.3	–	RI, MS
59	Germacrene D	1478	0.2	1.4	0.3	RI, MS, CoI
60	β-Selinene	1483	–	0.1	–	RI, MS
61	Bicyclogermacrene	1493	0.1	1.9	0.3	RI, MS
62	β-Bisabolene	1508	0.9	0.8	0.2	RI, MS, CoI

(*continued on next page*)

Table 1 (*continued*)

No.	Compound	Retention index	*Satureja mutica*	*Satureja macrantha*	*Satureja intermedia*	Methods of identification
63	δ-Cadinene	1522	0.1	0.3	0.1	RI, MS
64	Elemicine	1552	–	–	4.8	RI, MS
65	Germacrene B	1554	0.1	–	1.4	RI, MS
66	Spathulenol	1575	–	2.2	0.2	RI, MS
67	Caryophyllene oxide	1580	0.1	0.7	0.1	RI, MS
68	Globulol	1582	–	0.1	–	RI, MS
69	Dill apiol	1620	0.2	0.3	0.1	RI, MS
70	β-Eudesmol	1647	–	0.2	–	RI, MS
71	α-Cadinol	1651	–	0.2	–	RI, MS
72	α-Bisabolol	1680	–	0.1	–	RI, MS

RI = retention index; MS = mass spectroscopy; CoI = co-injection; t = trace = less than 0.05%.

the concentration of this compound in other oils is below 3.5%. The highest amount of *p*-cymene and the lowest amount of γ-terpinene were observed in the oil of *S. macrantha*. There are some minor components in the oil of *S. macrantha*, such as *cis* linalool oxide, *p*-cymen-8-ol, *cis* pinocarveol, *cis* carveol, methyl thymol, and pulegone, that are not present in the other two oils. However, the oils of *S. mutica* and *S. macrantha* also have minor components, such as methyl carvacrol, germacrene B and others that are not present in the third oil.

4. Conclusion

The essential oils of three Iranian *Satureja* species have been investigated for the first time and compared with oil contents and compositions of the other species. The percentages of essential oils were acceptable on comparison with other *Satureja* species.

The highest oil yield was obtained from *S. mutica* (2.31%) and the oil yields of both of the other species were about 1.5%.

Due to the high amounts of thymol and/or carvacrol, *p*-cymene and other terpenoids in the oils of *S. mutica* and *S. intermedia* and similarity of the oil composition to *S. hortensis* and *S. montana*, it can be concluded that the herbs and essential oils of *S. mutica* and *S. intermedia* can be used as flavouring agents in food and also in the medicinal and perfume industries. The low amounts of phenols, thymol and carvacrol and high amounts of *p*-cymene and limonene in the oil of *S. macrantha*, suggest that this plant could have specific usage in the medical industry. This should be tested in further research.

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