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# Chemical variation in the essential oil of *Satureja sahendica* from Iran

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**Abstract**

Hydro-distilled volatile oils from the aerial parts of eight populations of *Satureja sahendica* Bornm. were investigated, mainly by a combination of GC and GC/MS. *S. sahendica* is one of the endemic species of *Satureja* in Iran. Thirty-nine components were identified in the oils. The main constituents of the essential oils were thymol (19.6–41.7%), *p*-cymene (32.5–54.9%) and γ-terpinene (1.0–12.8%). Although the main components of all the oils are common, their percentages are different.


*Keywords:* *Satureja sahendica*; Labiatae; Essential oil composition; Thymol; *p*-cymene; γ-terpinene; Iran

## 1. Introduction

*Satureja sahendica* Bornm. is an endemic species of Iran, distributed in northwestern and western Iran. It is a late flowering species (late summer and fall), growing on rock walls, and rocky slopes (Rechinger, 1982).

There are two important famous species of *Satureja* used as culinary herbs. *Satureja hortensis* L., known as summer savory, comprises the principle savory of commerce. It is an herbaceous annual, native to southern Europe and naturalized to sections of North America. *Satureja montana* L., or winter savory, is a hardy, woody perennial, native to Europe and North Africa, and used only limitedly. Flowers of both savory species are pink to blue–white and are known to attract bees.

The main constituents of the essential oil in summer savory are the phenols carvacrol and thymol, as well as *p*-cymene, β-caryophyllene, linalool and other terpenoids. Essential oil from winter savory includes the phenols carvacrol and thymol, as well as *p*-cymene, linalool, terpineol, borneol and various organic acids.

The green leaves and herbaceous sections of stems from both species are used fresh and dried as flavouring agents in seasonings, stews, meat dishes, poultry, sausages, and vegetables. Summer savory has a sweeter and more delicate aroma and fragrance than does winter savory, 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, summer savory has been traditionally used as a stimulant, stomachic, carminative, expectorant, antidiarrheic, and aphrodisiac. The essential oil has shown 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 to study of essential oil content and composition of *Satureja* species in Iran. The essential oil composition of three endemic *Satureja* species of Iran, *S. khuzistanica* Jamzad (Sefidkon & Ahmadi, 2000), *S. bachtiarica* Bunge (Sefidkon & Jamzad, 2004) and *S. spicigera* (C. Koch) Boiss (Sefidkon & Jamzad, xxxx) were previously reported. 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%). Apparently, the oil of *S. sahendica* has not been the subject of previous study.

Literature review showed variation between chemical compositions of different *Satureja* species oils. The main components of *S. boissieri* (Kurcuoglu, Tumen, & Baser,

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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 was piperitone oxide and those of *S. boliviana* (Rojas & Usubillaga, 2000) oil were 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.

In this study, the essential oil compositions of *S. sahandica* from different localities were examined and their differences were compared.

## 2. Materials and methods

### 2.1. Plant material

The aerial parts of *S. sahendica* were collected from three different provinces in northwestern (Azarbayejan and Zanjan) and western (Kurdistan) Iran. Inter-population studies were also undertaken in Zanjan province in different localities. The voucher specimens have been deposited in the national herbarium of Iran (TARI), Table 1.

### 2.2. Isolation procedure

Air-dried aerial parts of the plants (50–70 g) were subjected to hydro-distillation for 4h using a Clevenger-type apparatus to produce oils in yields presented in Table 1. The oils were dried over anhydrous calcium chloride and stored in sealed vials at low temperature (2 °C) before analysis.

### 2.3. Gas chromatography

GC analysis was 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.

### 2.4. Gas chromatography–mass spectrometry

GC–MS analyses were carried out on a Varian 3400 GC–MS system equipped with a DB-5 fused silica column (30 m × 0.25 mm i.d.). Oven temperature was 40–240 °C at a rate of 4 °C, 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, mass range 40–300 amu.

### 2.5. Identification of components

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; Shibamoto, 1987).

Table 1
Materials used in this study and oil yields obtained from *Satureja sahendica*

| Sample code | Locality | Morphological characters | Oil yield (%) |
|---|---|---|---|
| $S_1$ | Iran, Zanjan, road towards Dandi, Ghezlu, 2315 m, Jamzad et al., 83143 (TARI). | Dense verticillasters, long corolla tube | 2.86 |
| $S_2$ | Iran, Zanjan, road towards Dandi, Ghezlu, 2315 m, Jamzad et al., 83142 (TARI). | 2–3 Flowered verticillasters, long corolla tube | 2.61 |
| $S_3$ | Iran, Zanjan, road towards Dandi, Ghezlu, 2315 m, Jamzad et al., 83141 (TARI). | Dense verticillasters, short corolla tube | 1.53 |
| $S_4$ | Iran, Zanjan, S. of Soltanieh, shalvar village, 2047 m, Jamzad et al., 83144 (TARI). | Dense verticillasters, long corolla tube | 2.41 |
| $S_5$ | Iran, Zanjan, Gheidar, Zarrin abad, Gholamveis village, 2105 m, Jamzad et al. 83146 (TARI) | Dense verticillasters, short corolla tube | 2.88 |
| $S_6$ | Iran, Zanjan, Gheidar, Zarrin abad, Gholamveis village, 2105 m, Jamzad et al. 83145 (TARI). | 2–3 Flowered verticillasters, long corolla tube | 2.53 |
| $S_7$ | Iran, Azarbayejan, Miandoab, 2400–2600 m, Ghahramani, s.n. | Mixed specimens with dense and lax, verticillasters and long corolla tube | 2.56 |
| $S_8$ | Iran, Kurdestan, 25 Km from Bijar to Takab, Salavat-abad village, 1950 m, Maroofi and Naser, 5552. | Mixed specimens with dense and lax, verticillasters and long corolla tube | 1.50 |

## 3. Results and discussion

The oils isolated by hydro-distillation from the aerial parts of eight population of *S. sahendica* were found to be yellow liquids and were obtained in yields of 1.50–2.88% (w/w) based on dry weights. The highest oil yield obtained was from $S_5$ (Zanjan Province) and the lowest from $S_8$ (Kurdestan Province).

The chemical composition of the *S. sahendica* oils can be seen in Table 2. The components are listed in order of their elution on the DB-5 column. Thirty-nine compounds were identified in the essential oils of *S. sahendica*. The major components of all the oils were found to be thymol (19.6–41.7%), *p*-cymene (32.5–54.9%) and γ-terpinene (1.0–12.8%).

Comparing the oil composition of these populations showed (although all of the samples belonged to one chemotype), some differences. Comparison between the percentages of some main components in the oils is shown in Fig. 1.

The first major compound of $S_1$, $S_2$, $S_6$ and $S_7$ was thymol. While the first major compound of $S_3$, $S_4$, $S_5$ and $S_8$ was *p*-cymene. The lowest percentage of γ-terpinene was found in $S_5$ (1.0%) oil. The amount of γ-terpinene increased to 3.2 in $S_8$ oil and other samples contained 8.9–12.8% of this compound. Some minor or trace components, such as sabinene, δ-3-carene, (E)-β-ocimene, estragole, cuminyl aldehyde, and α-humulene were not found in any of the oils. β-bisabolene, that was found in $S_2$ and $S_5$ oil at percentages of 3.3% and 4.5%, was not observed in the oil of $S_4$.

Comparing these results with that of other *Satureja* species, showed the oil composition of *S. sahendica* is like that of *S. bachtiarica* and *S. spicigera*.

Table 2
Percentage composition of the oils of 8 populations of *Satureja sahendica*

| No | Compound | RI | $S_1$ | $S_2$ | $S_3$ | $S_4$ | $S_5$ | $S_6$ | $S_7$ | $S_8$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | α-Thujene | 930 | 0.9 | 0.6 | 0.5 | 0.8 | t | 0.9 | 0.8 | 3.3 |
| 2 | α-Pinene | 938 | 0.6 | 0.7 | 0.5 | 0.6 | 0.4 | 0.6 | 0.6 | 0.6 |
| 3 | Camphene | 952 | 0.1 | t | t | t | – | t | 0.1 | 0.9 |
| 4 | Sabinene | 975 | t | t | – | t | – | t | t | – |
| 5 | β-Pinene | 980 | 0.1 | 1.0 | 0.3 | t | 0.7 | 0.2 | 0.2 | 0.3 |
| 6 | Myrcene | 990 | 1.5 | 1.1 | 1.3 | 1.4 | t | 1.5 | 1.4 | 1.0 |
| 7 | α-Phellandrene | 1004 | 0.1 | 0.3 | 0.2 | t | 0.2 | 0.2 | 0.2 | – |
| 8 | 3-Carene | 1010 | t | t | – | t | – | t | t | – |
| 9 | α-Terpinene | 1017 | 1.4 | 1.1 | 1.0 | 1.3 | t | 1.4 | 1.2 | 0.6 |
| 10 | *p*-Cymene | 1025 | 32.5 | 33.0 | 47.1 | 41.7 | 33.4 | 33.2 | 37.4 | 54.9 |
| 11 | Limonene | 1030 | 0.5 | 2.0 | 1.1 | 0.5 | 2.1 | 0.8 | 0.5 | 1.4 |
| 12 | 1,8-Cineole | 1033 | t | 0.2 | t | t | t | t | t | – |
| 13 | (E)-β-ocimene | 1050 | t | t | - | t | – | t | t | – |
| 14 | γ-Terpinene | 1061 | 10.9 | 9.1 | 8.9 | 11.0 | 1.0 | 12.8 | 9.9 | 3.2 |
| 15 | Terpinolene | 1088 | 0.2 | 0.1 | – | 0.3 | – | – | t | 0.3 |
| 16 | *Trans* sabinene hydrate | 1096 | 0.2 | 0.2 | 0.2 | 0.3 | t | 0.2 | 0.2 | 0.2 |
| 17 | Linalool | 1098 | 1.0 | 0.9 | 1.7 | 1.2 | 0.4 | 1.0 | 0.8 | 1.4 |
| 18 | *Trans p*-menth-2-en-1-ol | 1140 | t | t | t | t | t | t | t | – |
| 19 | Camphor | 1143 | t | 0.2 | t | t | t | t | t | – |
| 20 | Borneol | 1165 | t | t | t | 0.3 | t | – | 0.1 | 0.6 |
| 21 | Terpinen-4-ol | 1177 | 0.6 | 0.4 | t | 0.6 | t | 0.6 | 0.5 | 0.7 |
| 22 | *p*-Cymen-8-ol | 1183 | 0.3 | t | t | 0.4 | t | t | 0.3 | 0.7 |
| 23 | α-Terpineol | 1189 | t | t | t | t | – | t | t | – |
| 24 | Estragole | 1195 | – | – | 0.7 | – | 0.5 | t | – | – |
| 25 | Dihydrocarvone | 1200 | – | 2.2 | 0.9 | – | 2.8 | 0.4 | t | – |
| 26 | Cuminyl aldehyde | 1214 | t | – | – | t | – | – | t | – |
| 27 | Pulegone | 1237 | – | 1.1 | 0.4 | – | 1.2 | t | – | 0.3 |
| 28 | α-Terpinen-7-al | 1282 | 1.0 | 0.7 | 0.9 | 1.4 | 1.6 | 1.0 | 0.7 | – |
| 29 | Thymol | 1290 | 41.7 | 33.4 | 27.5 | 30.2 | 32.7 | 37.6 | 41.2 | 19.6 |
| 30 | Carvacrol | 1297 | 1.1 | 0.8 | 0.7 | 1.3 | 0.9 | 1.0 | 0.8 | 1.2 |
| 31 | Thymyl acetate | 1355 | t | 0.3 | t | 0.4 | 8.2 | 1.2 | t | – |
| 32 | β-Caryophyllene | 1418 | 2.0 | 1.7 | 0.7 | 2.0 | 0.6 | 1.6 | 0.5 | 0.9 |
| 33 | 2-Phenyl ethyl butanoate | 1439 | 0.8 | – | – | 0.8 | – | t | 1.3 | – |
| 34 | α-Humulene | 1454 | t | – | – | t | – | – | t | – |
| 35 | Valencene | 1491 | t | - | – |  | – | – | t | – |
| 36 | Virdiflorene | 1493 | – | – | – | t | – | – | – | – |
| 37 | β-Bisabolene | 1509 | t | 3.3 | 1.4 | – | 4.5 | 0.9 | t | 0.8 |
| 38 | Spathulenol | 1576 | 0.8 | 0.7 | 0.3 | 1.1 | 1.3 | 0.6 | 0.7 | 0.9 |
| 39 | Caryophyllene oxide | 1581 | 1.5 | 1.6 | 0.7 | 2.5 | 1.6 | 1.2 | 0.4 | 2.5 |

RI = retention index; t = trace = less than 0.05%.

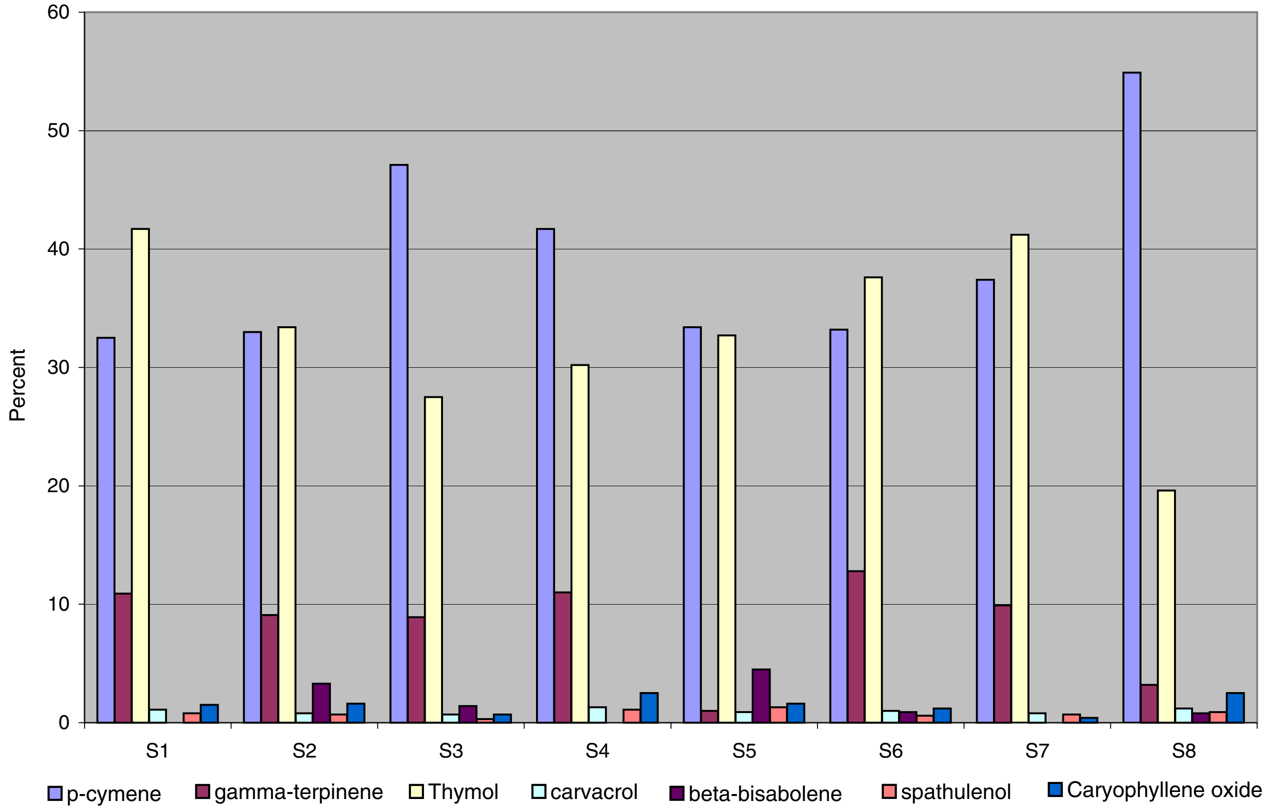


Fig. 1. Graph 1 – comparison between some main components of the oils.

Furthermore, we observed an inter-population morphological variation in Zanjan province: specimens with dense verticillasters (more than three flowered); specimens with 2–3 flowered verticillasters and specimens with long corolla tube (excluded flowers) and short corolla tube (more or less included flowers within the dense verticillasters) type (Table 1). There are differences in major compounds in specimens collected within populations, which are somehow correlated with the morphological characters ($S_1$, $S_2$ and $S_3$). However, comparing the essential oil profile among different populations, did not show any correlation between morphological characters, and major components of oil, e.g., samples $S_3$ and $S_5$ (Table 1).

Due to the high amount of thymol and *p*-cymene and other terpenoids in the oil of *S. sahendica* and similarity of the oil composition to *S. hortensis* and *S. montana*, it can be concluded that the herb and essential oil of *S. sahendica* can be used as flavouring agents in food and also in the medicinal and perfume industries.

## References

Adams, R. P. (1995). *Identification of essential oil components by gas chromatography/mass spectroscopy*. Carol Stream, USA: Allured Publishing Corp.

Baher, Z. F., Mirza, M., Ghorbanli, M., & Rezaii, M. (2002). The influence of water stress on plant height, herbal and essential oil yield and composition in *Satureja hortensis* L.. *Flavour and Fragrance Journal, 17*(4), 275–277.

Kurcuoglu, M., Tumen, G., & Baser, K. H. C. (2001). Essential oil constituents of *Satureja Biossieri* from Turkey. *Khimiya Prirodnykh Soedinenii, 37*(4), 280–281.

Rechinger, K. H. (1982). Satureja in *Fl. Iranica*. *Akademische Druck-u. Verlagsanstalt, Graz, 150*, 495–504.

Rojas, L. B., & Usubillaga, A. (2000). Composition of the essential oil of *Satureja brownei* (sw) Briq From Venezuela. *Flavour and Fragrance Journal, 15*(1), 21–22.

Sefidkon, F., & Ahmadi, Sh. (2000). Essential oil of *Satureja Khhuzistanica* Jamzad. *Journal of Essential Oil Research, 12*, 427–428.

Sefidkon, F., & Jamzad, Z. (2004). Essential oil composition of *Satureja spicigera* from Iran. Flavour & Fragrance Journal, 19, in press.

Sefidkon, F., Jamzad, Z. Essential oil composition of *Satureja spicigera* from Iran, *Flavour and Fragrance Journal* (Submitted).

Shibamoto, T. (1987). Retention Indices in Essential Oil Analysis. In P. Sandra & C. Bicchi (Eds.), *Capillary gas chromatography in essential oil analysis* (pp. 259–274). New York: Huethig, Verlag.

Tumen, G., Baser, K. H. C., Demirci, B., & Ermin, N. (1998). The essential oils of *Satureja coerulea* Janka and *Thymus aznavourii* Velen. *Flavour and Fragrance Journal, 13*(1), 65–67.

Viturro, C. I., Molina, A., Guy, I., Charles, B., Guinaudeau, H., & Fournet, A. (2000). Essential oils of *Satureja boliviana* and *S. pavifolia* growing in the region of Jujuy, Argentina. *Flavour and Fragrance Journal, 15*(6), 377–382.