CHEMIJA. 2009. Vol. 20. No. 3. P. 186–189

γ-Terpinene and carvacrol rich volatile oil of *Satureja sahendica* Bornm. from Maragheh district in Northwest Iran

Mohammad Bagher Hassanpouraghdam[1]*,

Mohammad Safi Shalamzari[2],

Mohammad Ali Aazami[1],

Atefeh Mohajjel Shoja[3]

[1] *Department of Horticultural Sciences, Faculty of Agriculture, University of Maragheh, Maragheh 55181-83111, Iran*

[2] *Research Service Laboratory, Faculty of Chemistry, University of Tabriz, Tabriz 51666, Iran*

[3] *Department of Biology, Rabe-Rashidi Institute, Tabriz, Iran*

The composition of the volatile oil obtained by hydrodistillation of air-dried aerial parts of *Satureja sahendica* Bornm, Lamiaceae from Maragheh district in Northwest Iran has been studied by GC / MS. Thirty-seven compounds representing 96.9% of the total oil were identified. Monoterpenoids (including monoterpene hydrocarbons and oxygenated monoterpenes) were the main (94.2%) class of identified components, followed by a minor proportion of sesquiterpenoids (All C_{15} compounds) (2.5%). Monoterpene hydrocarbons (60.6%) and oxygenated monoterpenes (33.6%) were the dominant subclass of identified constituents occurring in higher proportions. The main monoterpene hydrocarbons of the oil were γ-terpinene (42.2%), p-cymene (6.5%), α-terpinene (5.1%), myrcene (2.3%), limonene (1.1%) and α-thujene (1%). Carvacrol (31.9%) was the predominant representative of oxygenated monoterpene components. Sesquiterpenoids were the minor class of volatile oil components with β-bisabolene (1.4%) as the main one. In total, the studied *Satureja sahendica* Bornm. oil was found to be rich in monoterpenoids with significant amounts of γ-terpinene and carvacrol.

Key words: *Satureja sahendica* Bornm., Lamiaceae, volatile oil components, GC / MS, γ-terpinene, carvacrol, p-cymene, α-terpinene

INTRODUCTION

The genus *Satureja* L. is one of the major taxa of Lamiaceae family [1, 2]. The Mediterranean region can be mentioned as the origin of the genus [1]. This genus is represented in the flora of Iran by 12 species, eight of them (*S. edmondii*, *S. intermedia*, *S. isophylla*, *S. kallarica*, *S. bakhtiarica*, *S. khusstanica* and *S. sahendica*) being endemic and exclusive of Iran [1]. The Persian name of the genus and *S. sahendica* are "Marze" and "Marze-Sahandi," respectively [1]. *Satureja sahendica* Bornm. is registered at the Berlinense Herbarium as a digital specimen image under the barcode of B 10 0086740 [3]. *Satureja sahendica* Bornm. is a perennial, branched and bushy aromatic herb 10 to 30 cm high [4]. This plant spontaneously grows in the western and northwestern parts, specially in the Sahand Mountains of Maragheh District in the northwest of Iran [4, 5]. This plant has long, elliptical complete leaves covered with fine hairs [4]. In wild habitats, this plant is in blossom from June to September with small white-coloured flowers [2]. *Satureja sahendica* Bornm. flowers are nectar-rich, frequently met by honey bees [4]. The genus *Satureja* has a wide diversity of secondary metabolites such as tannins, fatty acids, sugars and volatile oils, from which volatile oil extracted from aerial parts is the most important phytochemical commonly used in culinary and pharmaceutical industries [6].

The volatile oil of *Satureja* and its preparations have been used as tonic, antiseptic, stomachic, flatulent, digestive, diuretic, antidiarrheic, carminative and aphrodisiac drugs [5, 6]. Furthermore, in some cases these plants have been used for curing asthma [6]. Externally, a lotion of *Satureja* plants has shown healing effects on ulcers and wounds [6]. Traditionally, a decoction of the aerial parts of *Satureja* species has been used for relief of rheumatoid and nervous ailments as well as for promoting the physical capabilities in the elderly [6]. The aromatic and medicinal properties of the genus *Satureja* have made it one of the most popular plants throughout the world. It is more likely that a great part of the above-mentioned

* Corresponding author. E-mail: hassanpouraghdam@gmail.com

biological activities is due to the volatile components. Therefore, there is a considerable research interest toward the compositional analysis of *Satureja* volatile oil. Apart from two well-known and cosmopolitan species of *Satureja*, i. e. *S. hortensis* and *S. montana*, studies concerning the composition of *S. sahendica* volatile oil are very limited. In previous investigations, Tabatabaei-Raisi et al. [7, 8] reported thymol (31.5%), γ-terpinene (29.33%) and p-cymene (23.48%) as the main components of inflorescence volatile oil and p-cymene (44.88%), thymol (28.22%) and γ-terpinene (10.07%) as the principal components of leaf and stem volatile oil of *S. sahendica* from East Azerbaijan province in Northwest Iran. Thymol (19.6–41.6%), p-cymene (32.5–54.9%) and γ-terpinene (1–12.8%) were the main components of *S. sahendica* volatile oil from eight localities in Iran [5] as well. Despite these reports, information about the compositional analysis of *Satureja sahendica* Bornm. volatile oil from its main habitat is lacking.

The aim of the present work was to determine the volatile oil composition of *Satureja sahendica* Bornm. from the Sahand Mountains of Maragheh District in Northwest of Iran for the first time.

EXPERIMENTAL

Plant material. The flowering aerial parts of wild *Satureja sahendica* Bornm. plants growing in rocky slopes of the Sahand Mountains in Maragheh District of Northwest Iran were collected in late summer 2008. The plants were verified by a plant taxonomist. A voucher specimen was deposited in the Herbarium of the Faculty of Agriculture, University of Maragheh. The harvested plant material from about ten individual plants was air-dried in a shaded place with a constant temperature of 25 ºC for 4–5 days. The air-dried plant material was mixed and ground to obtain a homogeneous fine-grade powder.

Volatile oil extraction. 50 grams of air-dried and powdered plant material was hydrodistilled by an all-glass Clevenger type distiller for 4 h. The extracted pale-yellow volatile oil was trapped with 1 ml of hexane as a collecting solvent. The oil was dried over anhydrous Na_2SO_4 and refrigerated in sealed glass vials until required.

GC / MS analysis. The analysis of the oil was carried out using a GC (Agilent Technologies 6890N) interfaced with a mass-selective detector (MSD, Agilent 5973B) equipped with an apolar Agilent HP-5ms (5%-phenyl methyl poly siloxane) capillary column (30 m × 0.25 mm i. d. and 0.25 μm film thickness). The carrier gas was helium with the linear velocity of 1 ml/min. The oven temperature was set at 50 ºC for 2 min, then programmed until 100 ºC at a rate of 10 ºC/min with a hold-time of 3 min, once more heated to 150 ºC at a 5 ºC/min rate with a 2 min hold-time, then to 200 ºC at the 10 ºC/min rate and finally increased at the rate 20 ºC/min to 280 ºC, isothermal at the temperature for 2 min. The injector and detector temperatures were 300 ºC and 200 ºC, respectively. Injection mode, split; split ratio 1 : 100, volume injected 4 μl of the oil. The MS operating parameters were as follows: ionization potential 70 eV, interface temperature 200 ºC, and acquisition mass range 50–800.

Identification and quantification of constituents. The relative percentage of the volatile oil components was evaluated from the total peak area (TIC) by apparatus software. The identification of volatile oil components was based on a comparison of their mass spectra and retention time with those of the authentic compounds and by computer matching with NIST and WILEY library as well as by comparison of the fragmentation pattern of the mass spectral data with those reported in the literature [5, 7–9].

RESULTS AND DISCUSSION

Hydrodistillation of the *Satureja sahendica* Bornm. aerial parts afforded a pale-yellow liquid with a yield of 1.3 ± 0.2% (V/W) based on dry weight. The general chemical profile of the analysed oil, percentage content of the individual components and their retention indices are summarized in Table. The main chemical classes of components and major subclasses of volatile oil constituents are also reported in Figs. 1 and 2, respectively. In total, 37 components were identified, which represented about 97% of the whole detected constituents (Table). Monoterpenoids (including monoterpene hydrocarbons and oxygenated monoterpenes) were the major (94.2%) class of volatile oil components, followed by a minor proportion of sesquitepenoids (2.55%) (Fig. 1). Monoterpene hydrocarbons (60.6%) and oxygenated monoterpenes (33.6%) were found to be the principle subclass of identified components (Fig. 2). The major monoterpene hydrocarbons of volatile oil in amounts greater than 1% were γ-terpinene (42.2%), p-cymene (6.5%), α-terpinene (5.1%), myrcene (2.3%), limonene (1.1%) and α-thujene (1%). Carvacrol (31.9%) was the only representative of its group, i. e. oxygenated monoterpenes, with a content of >1%. Other monoterpenoids were present

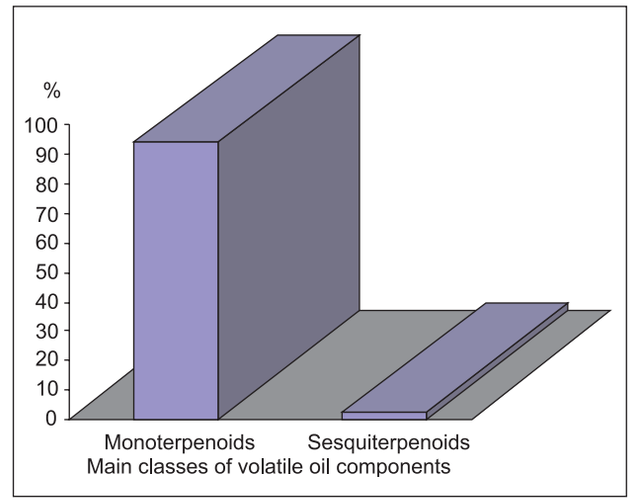

Fig. 1. Main classes of *Satureja sahendica* Bornm. volatile oil components from Iran

Table. **Volatile oil components of *Satureja sahendica* Bornm. from Iran**

No	Compound	RI	%
1	**α-Thujene**	0930	**1**
2	α-Pinene	0939	0.6
3	Camphene	0954	0.1
4	β-Pinene	0979	0.6
5	3-p-Menthene	0988	0.1
6	**Myrcene**	0991	**2.3**
7	α-Phellandrene	1003	0.6
8	**α-Terpinene**	1017	**5.1**
9	**p-Cymene**	1025	**6.5**
10	**Limonene**	1029	**1.1**
11	Δ-3-Carene	1031	0.12
12	(E)-β-Ocimene	1050	0.2
13	**γ-Terpinene**	1060	**42.2**
14	cis-Sabinene hydrate	1070	0.2
15	Terpinolene	1089	0.1
16	trans-Sabinene hydrate	1098	0.3
17	Nonanal	1101	tr
18	Camphor	1146	0.4
19	Terpinene-4-ol	1177	0.3
20	α-Terpineole	1189	0.1
21	Pulegone	1237	0.1
22	Carvone	1243	0.1
23	Carvacrol methyl ether	1245	0.1
24	Chavicol	1250	tr
25	Thymol	1290	0.2
26	**Carvacrol**	1299	**31.9**
27	Eugenol	1359	tr
28	n-Tetradecane	1405	tr
29	(E)-Caryophyllene	1419	0.2
30	α-trans-Bergamotene	1435	0.3
31	(E)-β-Farnesene	1457	0.1
32	(E)-β-Ionone	1489	tr
33	**β-Bisabolene**	1506	**1.4**
34	(Z)-α-Bisabolene	1507	0.1
35	β-Sesquiphellandrene	1523	0.1
36	Spathulenol	1578	0.1
37	Caryophyllene oxide	1583	0.2
	Total		96.9

Compounds are reported according to their elution order on a non-polar column.
tr = trace (<0.1%).

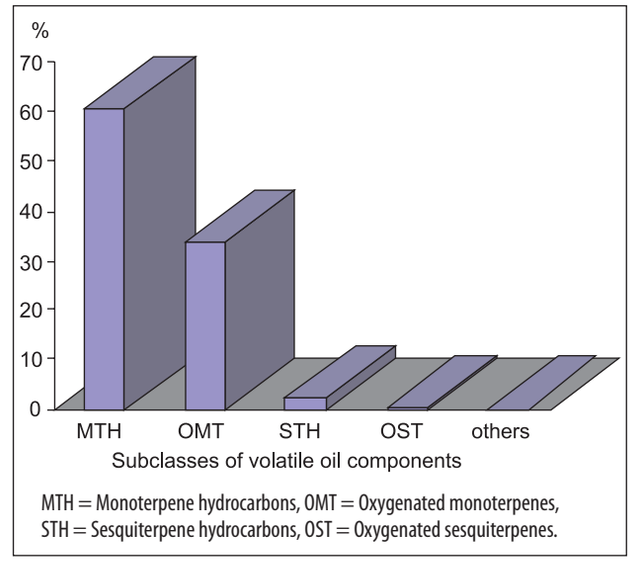

Fig. 2. Major subclasses of *Satureja sahendica* Bornm. volatile oil components from Iran

in amounts lesser than 1% (Table). In particular, γ-terpinene and carvacrol (Sum 74.1%) comprised about 77% of the identified components and were the most abundant components of the oil. Monoterpene alcohols (33%) had a great share in the chemical profile of volatile oil with carvacrol as a highlighted one and terpinene-4-ol (0.3%), thymol (0.2%) and α-terpineol as minor followers. In contrast with monoterpene alcohols, monoterpene ketones, pulegone (0.1%) and carvone (0.1%), had a minor share in the identified volatile oil components. Considering the monoterpenoid profile of the present experiment and reports of other scientists from Iran [5, 7, 8], it seems that there is a significant qualitative and quantitative differences between volatile oil components. These differences are more appreciable with respect to carvacrol. This monoterpene alcohol comprised about 33% of the total oil (Table). Meanwhile, in the previous reports its maximum amount did not exceed 2%. Sesquiterpenoids (all C_{15} compounds) with eight constituents had a negligible part in the chemical profile of the oil, except for β-bisabolene (1.4%) (Table). However, taking into account the sesquiterpenoids, there is some differences between our findings and reports of other scientists [5, 7, 8] as well. In total, comparison of the volatile compounds of *Satureja sahendica* Bornm. oil with previously reported data showed notable chemical differences among the oils. On the contrary, a literature survey showed that there is a partial chemical profile similarity between the volatile components of *S. sahendica* from Maragheh District of Northwest Iran and *S. boissieri* and *S. hortensis* from Turkey [10] and Iran [11], respectively. Those papers reported carvacrol and γ-terpinene as the main components of volatile oil as well. These chemical variations among the same and the different species of *Satureja* seem to be mainly due to the divergent climatological and geographical conditions (light quality and quantity, soil type, water availability and relative humidity) of wild habitats and field-grown plants in different localities. These diverse environmental conditions regularly alter plant responses and their internal phytochemical pathways in a way that the chemical profile of the plant harmoniously promotes the survival and adaptation of a plant, especially in wild habitats. These conditions, beside the different harvesting time, plant parts used for extraction and extraction procedure, affect the chemical profile and ultimately the biological activity of aromatic herbs and their applicability in food and pharmaceutical industries. It is likely that *Satureja sahendica* Bornm. plants studied in the present experiment might be a unique chemotype of this plant owing to its distinct volatile oil profile. However, this claim needs further comparative studies based on phytochemical surveys.

CONCLUSIONS

The chemical composition of the volatile oil of wild *Satureja sahendica* Bornm. plants distributed in Northwest Iran is characterized by the presence of significant amounts of γ-terpinene and carvacrol. The results showed considerable chemical profile differences between our finding and reports of other researches from Iran. In conclusion, it can be claimed that *Satureja sahendica* Bornm. plants studied in this experiment can be either a valuable source of monoterpenoids γ-terpinene and carvacrol or a suitable substituent for *S. hortensis* in meeting the progressive demands of food and pharmaceutical industries.

Received 18 March 2009
Accepted 1 April 2009

References

1. V. Mozaffarian, *A Dictionary of Iranian Plant Names* (in Persian), Farhang Moaaser Publishing Company, Iran (2004).
2. A. Ghahreman, *Plant Systematics: Cormophytes of Iran* (in Persian), Iran University Press, Tehran (1993).
3. Botanic Garden and Botanical Museum Berlin-Dahlem, Freie Universität Berlin [www. bgbm.org/herbarium/access.cfm].
4. A. Ghahreman, *Flora of Iran* (in Persian). Research Institute of Forest and Rangeland, Tehran (1988).
5. F. Sefidkon, Z. Jamzad, M. Mirza, *Food Chem.*, **88**, 325 (2004).
6. D. T. Momeni, N. Shahrokhi, *Essential Oils and Their Therapeutic Actions* (in Persian), Tehran University Publications, Iran (1998).
7. A. Tabatabaei-Raisi, A. Delazar, A. Khalighi, B. Kaviani, D. Hashemabadi, *Int. J. Botany*, **4(2)**, 245 (2008).
8. A. Tabatabaei-Raisi, A. Khalighi, A. Kashi, S. Asnaashari, S. Bamdad Mogadam, A. Delazar, *Pharm. Sci.*, **3**, 1 (2007).
9. R. P. Adams, *Identification of Essential Oil Components by Gas Chromatography / Quadrupole Mass Spectroscopy,* Allured Publishing Corp., Carol Stream, IL, USA (2004).
10. M. Kurcuoglu, G. Tumen, K. H. C. Baser, *Khim. Prir. Soedin*, **37(4)**, 280 (2001).
11. Z. F. Baher, M. Mirza, M. Ghorbanli, M. Rezaii, *Flavour Frag. J.*, **17(4)**, 275 (2002).

Mohammad Bagher Hassanpouraghdam, Mohammad Safi Shalamzari, Mohammad Ali Aazami, Atefeh Mohajjel Shoja

γ-TERPINENO IR KARVAKROLIO TURINTIS *SATUREJA SAHENDICA* BORNM. ETERINIS ALIEJUS IŠ ŠIAURĖS VAKARŲ IRANO MARAGHEH APYLINKIŲ

S a n t r a u k a

Dujų chromatografijos–masių spektrometrijos metodu buvo tiriamas Šiaurės vakarų Irano Maragheh apylinkių *Satureja sahendica* Bornm. eterinis aliejus, gautas ore džiovintų antžeminių augalo dalių hidrodistiliavimo būdu. Identifikuoti 37 junginiai, sudarantys 96,9 % aliejaus. Pagrindinę identifikuotų komponentų klasę sudaro monoterpenoidai (įskaitant monoterpeninius angliavandenilius ir deguonies turinčius monoterpenus) (94,2 %). Seskviterpenoidai (visi C_{15} junginiai) sudaro 2,5 %. Eteriniame aliejuje daugiausia nustatyta monoterpeninių angliavandenilių (60,6 %) ir deguonies turinčių monoterpenų (33,6 %). Iš monoterpeninių angliavandenilių daugiausia yra γ-terpineno (42,2 %), p-cimeno (6,5 %), α-terpineno (5,1 %), mirceno (2,3 %), limoneno (1,1 %) ir α-tujeno (1 %). Pagrindinį deguonies turinčių monoterpenų kiekį sudaro karvakrolis (31,9 %). Tarp seskviterpenoidų didžiausią kiekį sudaro β-bisabolenas (1,4 %). Apskritai ištirtasis *Satureja sahendica* Bornm. eterinis aliejus turi daug monoterpenoidų bei žymesnius γ-terpineno ir karvakrolio kiekius.