UDC 581.135.51:582.924

Composition of the Essential Oils of Some Species Belonging to Genus *Agastache* Clayton ex Gronov (Lamiaceae) Cultivated under the Conditions of the Middle Ural

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(Received March 25, 2013; revised May 30, 2013)

Abstract

Using the technique of gas chromatography-mass spectrometry, essential oil composition was studied for species *Agastache rugosa*, *A. scrophulariifolia*, *A. foeniculum*, *A. urticifolia*, *A. mexicana*, cultivated under the conditions of the Middle Ural. It has been found that there prevail menthone (42.2 %) and isomenthone (18.8 %) therein.

Key words: *Agastache rugosa*, *A. scrophulariifolia*, *A. foeniculum*, *A. urticifolia*, *A. mexicana*, essential oil, gas chromatography-mass spectrometry

INTRODUCTION

Genus *Agastache* Clayton ex Gronov (giant-hyssop) belongs to tribe *Nepetae* Benth. Sem. Lamiaceae and includes 21 species of two sections [1]. The representatives of the genus are common in North America and Southeast Asia. In the territory of Russia there ranges only *A. rugosa* (Fisch. Et Mey.) O. Kuntze (m. Wrinkled) which grows in the Far East [2].

The species belonging to genus *Agastache* are known as valuable essential oil, medicinal and flavouring spice plants [3–5]. The aerial part thereof contains essential oil (about 2 %) with a strong mint-anise odour that is used as a flavouring or spice in food industry as well as in perfume and cosmetic industry [3]. The main active ingredients of the giant-hyssop are presented by essential oil, flavonoids and microelements. Infusions and decoctions made of the plant are used in the case of chill, gastrointestinal diseases. The essential oil exerts antimicrobial, analgesic, antispasmodic, immunostimulant and radioprotective effects [6–9].

According to the opinion of the authors of [10], for the Middle Ural it could be recommended to cultivate *A. foeniculum*, *A. rugosa*, *A. urticifolia* as mono- and polycarpic one- or biannual plants and *A. scrophulariifolia*, *A. mexicana* as monocarpic biannial plants. These species pass through a full development cycle, give mature seeds, renew themselves *via* self-seeding, and hibernate in winter without any shelter.

Among the essential oils inherent in species *A. rugosa*, *A. mexicana*, *A. scrophulariifolia*, *A. foeniculum*, introduced on the southern coast of Crimea, there are about 19 components identified. There prevail methyl chavicol, limonene, isomenthone and pulegone among them. Depending on prevailing either component, appropriate chemotypes can be discriminated [9, 11].

Essential oil species inherent in *A. foeniculum* (Pursh.) O. Kuntze *Agastache foeniculum* (synonym *Lophanthus anisatus* Benth. or Lofant anise) are most comprehensively studied, they contain up to 94 % of phenol methyl chavicol, a valuable component of the essential oil species inherent in giant-hyssop [11, 12].

However, when transferring the plants into unusual growth conditions in the course of introduction under the influence of environmental factors there could change metabolic processes and lose valuable metabolites, which was mentioned in the literature on repeated occasions.

The purpose of this work consisted in studying the composition of essential oils inherent in five species belonging to genus *Agastache* cultivated under the conditions of the Middle Ural.

MATERIALS AND METHODS

As the material for the research work, we used the aerial parts of plants belonging to genus *Agastache* cultivated on the introduction site of the Botanical Garden, Ural Branch of the RAS (Table 1). The plants were grown from seed obtained from different botanical gardens in Europe, as well as those reproduced in recent years under the conditions of the Middle Ural (Botanical Garden, Ural Branch of the RAS).

The raw material was harvested at the flowering stage. The essential oil was obtained from dry raw material using a Clevenger method described by the authors of [13]. The yield of essential oil was determined as a percentage with respect to the mass of bone-dry raw material. The componential composition was investigated by means of gas chromatography-mass spectrometry using a Hewlett Packard 5890/II gas chromatograph with a quadrupole mass spectrometer (HP MSD 5971) as a detector. A HP-5 quartz column was used (5 % diphenyl and 95 % dimethylsiloxane copolymer), 30 m long, with an internal diameter of 0.25 mm and stationary phase film thickness amounting to 0.25 μm. The evaporator temperature was equal to 280 °C, the sample volume being of 1 μL, input flow split amounting to 100 : 1. Programming the column temperature regime was as it follows: 50 °C (2 min), 50–240 °C (4 °C/min), 240–280 °C (20 °C/min), 280 °C (5 min). As the carrier gas we used helium, with a constant flow rate amounting to 1 mL/min. The mass spectra were registered using a HP MSD 5971 quadrupole mass spectrometer with electron impact ionization, the energy of ionizing electrons being of 70 eV. The componential content was calculated from the gas chromatographic peak areas without using any correction factors. The qualitative analysis was based on comparing the retention indices (RI) and total mass spectra with the atlas of mass spectra [14].

TABLE 1

Characteristics of the species under investigation belonging to genus *Agastache*

Kinds of seed	Origin	Yield of essential oil, %
Section *Agastache* Lint et Epling, subsection *Agastache* Clayton ex Gron.		
Agastache rugosa (Fisch. et Mey.) O. Kuntze	Germany	0.53
A. scrophulariifolia (Willd.) O. Kuntze	France	2.40
A. foeniculum (Pursch) O. Kuntze	Finland	0.83
Section *Agastache*, subsection *Oxyodontae* (Briq.) A. Budantz. comb. nov.		
A. urticifolia (Benth.) O. Kuntze	France	0.56
Section *Brittonastrum* (Briq.) Lint et Epling		
A. mexicana (Humbold, Bonpland et Kunth) Lint et Epling	Sweden	1.20

TABLE 2

Composition of essential oil inherent in genus *Agastache*

RI	Components	Component content, %				
		A. rugosa	*A. urticifolia*	*A. foeniculum*	*A. mexicana*	*A. scrophulariifolia*
979	Octen-3-ol	0.6	0.7	0.6	0.4	0.3
1100	Linalool	–	0.2	0.1	–	0.1
1154	Menthone	31.8	23.0	34.3	42.2	34.7
1165	Isomenthone	12.3	9.9	14.4	18.8	15.8
1199	Methyl chavicol	1.9	1.0	3.2	3.8	8.1
1219	*trans*-Carveol	–	0.2	0.2	0.2	0.1
1241	Pulegone	8.5	5.6	9.1	7.3	8.8
1245	Carvone	–	–	0.3	0.3	0.4
1255	Piperitone	1.7	0.6	1.2	–	1.5
1315	Car-3-ene-5-on	–	0.3	0.4	0.3	–
1359	Eugenol	–	0.3	–	–	–
1382	*trans*-Sabine propionate	–	0.3	0.2	0.2	2.7
1406	Methyl eugenol	4.8	3.6	3.1	1.1	1.7
1481	Methyl vanillin	–	–	0.2	–	–
1488	*B*-(*E*)-ionone	–	0.4	–	–	–
1509	δ-Amorphene	–	0.2	–	–	–
1580	Spathulenol	2.1	5.4	0.9	0.9	1.1
1586	Caryophyllene oxide	–	0.6	–	0.3	0.5
1641	Caryophyllene-4(12)8(13)-diene-5α-ol	0.6	1.5	0.3	0.3	0.4
1641	Caryophyllene-4(12),8(13)-diene-5β-ol	–	–	–	0.8	–
1658	α-Cadinol	0.4	1.8	–	–	0.2
1676	Caryophyllene 3,8(13)-diene-5β-ol, (3*Z*)-	–	0.8	0.9	–	0.3
1662	Caryophyllene 3,8(13)-diene-5α-ol, (3*Z*)-	1.4	–	–	–	0.9
1688	Eudesma-4(15),7-diene-1α-ol	–	0.3	–	–	–
1741	Oplopanon	–	0.7	–	0.2	–
1813	Cariolan-1,9β-diol	1.2	–	–	0.3	–
2000	*n*-Eucosane	1.5	–	–	–	0.7
2300	*n*-Tricosane	–	–	0.7	–	–
2600	*n*-Hexacosane	–	–	–	0.5	–

Note. Dash means that the content of the component does not exceed 0.05 %.

RESULTS AND DISCUSSION

The essential oil species obtained exhibited a mint flavour. The absence of a sharp smell of anise could be explained by a low content of methyl chavicol that is noted in the oil species inherent in plants taken from other regions [9, 11]. The analysis of the essential oil yield from the aerial parts of the plant species under investigation demonstrated (see Table 1) that the highest concentration of the essential oils under the Middle Ural growth conditions is inherent in plant species *A. scrophulariifolia* (essential oil yield amounting to 2.40 %) and *A. mexicana* (essential oil yield 1.20 %). A lower content of essential oil species is inherent in *A. rugosa*, *A. urticifolia* and *A. foeniculum*.

In the oil composition of the samples under investigation there have been 29 compounds identified (Table 2).

The main components of essential oil of the aerial parts of plants *A. rugosa* are presented by menthone (31.8 %), isomenthone (12.3 %), pulegone (8.5 %), methyl eugenol (4.8 %), spathulenol (2.1 %), methyl chavicol (1.9 %) and piperitone (1.7 %). In the course of comparing the samples under investigation with plant species A. rugosa taken from other regions, it was found that under the conditions of the southern coast of Crimea the essential oil species exhibit an increase in the content of methyl chavicol up to 89.6 %, as well as a decrease in the content of menthone (0.4 %) and isomenthone (1.1 %) [9]. In the non-chernozem zone of Russia, where mineral fertilizers and growth regulators were used, the essential oil exhibit isomenthone (70.0 %), citral (10.0 %), methyl chavicol (15.0 %) and pulegone (5.5 %) to prevail [15].

The main components of oil inherent in *A. urticifolia* are presented by menthone (23.0 %), isomenthone (9.9 %), pulegone (5.6 %), methyl eugenol (3.6 %), spathulenol (5.4 %), methyl chavicol (1.0 %) and piperitone (0.6 %). Comparing to the rest samples we studied, the *A. urticifolia* exhibits a higher content of spathulenol.

The oil of *A. foeniculum* is characterized by prevailing menthone (34.3 %), isomenthone (14.4 %), pulegone (9.1 %), methyl chavicol (3.2 %), methyl eugenol (3.1 %), piperitone (1.2 %) and spathulenol (0.9 %). Its componential composition is significantly different from that for oil inherent in *Agastache* growing in the Astrakhan Region [16]: the latter is characterized by dominated by prevailing chavicol (62.1 %), methyl eugenol (24.0 %) and limonene (8.1 %), those were not found in our samples. Within the areas of industrial cultivation in India and Iran the methyl chavicol content in the oil of the plants ranges within 87.5–91.7 %, whereas the content of limonene amounts to 2.4–5.5 %. [17]

A. mexicana is typically characterized by the same dominant components such as menthone (42.2 %), isomenthone (18.8 %), pulegone (7.3 %), methyl chavicol (3.8 %), methyl eugenol (1.1 %) and spathulenol (0.9 %). Another ratio between these components is observed for the samples of oil from *A. mexicana* taken from the Nikitsky Botanical Garden, wherein there prevail methyl chavicol (84.3 %), limonene (6.6 %), linalool (2.0 %), linalyl acetate (1.0 %) and 1,8-cineole (1.0 %) [9].

Oil species inherent in *A. scrophulariifolia* are characterized by prevailing menthone (34.7 %), isomenthone (15.8 %), pulegone (8.8 %), methyl chavicol (8.1 %), methyl eugenol (1.7 %), piperitone (1.5 %) and spathulenol (1.1 %). Under the conditions of the southern coast of Crimea the oil of plant *A. scrophulariifolia* is characterized by prevailing methyl chavicol (85.6 %), 1,8-cineole (4.0 %), limonene (4.1 %), linalool (1.6 %) and linalyl acetate (0.6 %) [9].

The dominant components of the essential oils (menthone, isomenthone, methyl chavicol, pulegone, piperitone, methyl eugenol, spathulenol) are noted for all the species under investigation as well as for plant species introduced on the southern coast of the Crimea [9]. At the same time, there is a significant difference in the quantitative content of these components. So, the content of the most valuable and dominant component of essential oil inherent in the *Agastache* such as methyl chavicol could decrease down to 1 % (*A. urticifolia*). The predominant components of the species under investigation are presented by menthone (up to 42.2 %) and diastereomeric forms of isomenthone (up to 18.8 %), which is typical for the species belonging to genus *Mentha* L. [18]. The dominance of these monocyclic terpene ketones as earlier noted for some cultivar samples of *A. foeniculum* and *A. rugosa*, which made it possible to distinguish an isomenthone chemotype [9]. A significant part in the essential oil of all the species under investigation is presented by pulegone (up to 9.1 %).

CONCLUSION

Thus, all the samples of plant species belonging to genus *Agastache* we studied exhibit a similar componential composition, but they differ in the ratio between individual compounds. Under the conditions of the Middle Ural, changing the relative content of the main components is observed, with prevailing menthone and isomenthone.

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