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Composition of the Essential Oil from the Lemon Balm Growing in the Neighborhood of Krasnoyarsk as Indicated by Gas Chromatography–Mass Spectrometry Data

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Abstract—Essential oil has been isolated from the above-ground part of the lemon balm growing in the neighborhood of Krasnoyarsk by the method of exhaustive water and steam distillation. Forty seven components, each with a content of more than 0.1% of whole oil, have been identified by GC-MS. The main oil components are citronellol (36.71%) and geraniol (27.20%). The oil also contains ten components with a content of more than 1% of the sum of all oil components: benzyl alcohol (1.67%), linalool (1.75%), citronellal (1.44%), neral (3.33%), geranial (4.39%), caryophyllene (3.73%), caryophyllene oxide (1.40%), dibutyl phthalate (1.36%), butylisobutyl ester of phthalic acid (2.45%), and phytol (2.55%). The composition of lemon balm oils from different regions of the world has been compared.

Keywords: Melissa officinalis, essential oil, composition

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INTRODUCTION

Siberia is the largest region of Russia, which disposes a great variety of medicinal plants that have long been used in folk medicine. More than 500 species of medicinal plants growing in our forests, steppes, and on meadows are known.

The curative properties of medicinal plants are explained by the fact that their leaves, stems, flowers, and fruits contain vitamins, as well as astringent, odorous, and other substances producing the medicinal and prophylactic action.

Lemon balm (*Melissa officinalis* L.) has a 2000-year history of application in folk and scientific medicine; it has been used in the pharmacopoeia of many countries of the world, including the Russian Federation. It has been introduced into the State Register of remedies [1, 2]. A thousand years ago, Avicenna pointed to the curative properties of this plant in the Canon of medicinal science and called balm "delights of life." The founder of medicinal chemistry (iatrochemistry) Paracelsus highly appreciated lemon balm and considered this plant as the "golden drug" of all remedies [3].

Lemon balm, a species of the genus *Melissa* (the family Lamiaceae), is a perennial perfume and spicy herbaceous plant with a strongly branching rhizome (figure). In the literature, other names of the plant are encountered, such as lemon herb, lemon mint, dragonhead, thurible, and apiary. The generic name Melissa is translated from the ancient Greek as "honey-bee," indicating a direct relation of the plant to bee-keeping [4].

The origin of lemon balm is believed to be the costal area of the Mediterranean Sea up to Persia, the costal areas of the Black Sea, and Southwest Asia. Wild lemon balm is distributed in Middle and Southern Europe, the Balkans, Iran, South Africa, North America, India, the Ukraine, the Caucasus, and Middle Asia [5, 6]. Lemon balm was grown in pre-revolutionary Russia and the former Soviet Union. Nowadays lemon balm is cultivated in many countries, including Russia (Krasnodar krai, Samar oblast) and Lithuania. It also grows well in the wild form on forest edges, forest ravines, and gorges and prefers clay and loam soils with sufficient moisture, sun-lit and protected from cold northern winds. In some countries, its natural habitat reaches 1000 m above sea-level. In Siberia, the plant blooms in June–August, and the fruits mature in August–September.

Considering the fact that the composition of the essential oil of lemon balm growing in the Siberian region has not been described in the literature, it was important to study it and compare the content of some terpenoids in plants growing in different areas.

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Table 1. Composition of the essential oil from the above-ground part of lemon balm growing in the neighborhood of Krasnoyarsk

Retention time, min	Linear index of retention	Component	Content, % of whole oil
7.38	971	Sabinene	0.18
9.10	1021	Meta-cymene	0.44
10.70	1032	Benzyl alcohol	1.67
11.03	1041	Phenylacetaldehyde	0.24
12.05	1072	*trans*-Furanolinalool oxide	0.25
12.61	1088	*cis*-Furanolinalool oxide	0.14
13.03	1098	Linalool	1.78
13.19	1102	2-Acetyl-5-methylfuran	0.13
14.06	1125	*trans*-Pink oxide	0.13
14.39	1137	*trans*-Pinocarveol	0.21
14.61	1143	neo-isopulegol	0.15
14.77	1147	*trans*-Photocitral	0.35
14.91	1153	Citronellal	1.44
15.65	1172	1-(3-Methylphenyl)ethanol	0.35
15.95	1181	Isogeranial	0.22
16.22	1190	α-Terpineol	0.97
16.79	1204	*trans*-Photonerol	0.47
17.75	1232	Citronellol	36.71
18.05	1241	Neral	3.33
18.68	1257	Geraniol	27.20
19.07	1271	Geranioal	4.39
19.18	1274	Citronellyl formate	0.12
19.36	1282	Neryl formate	0.16
19.71	1290	Menta-1,8-dien-2-ol acetate	0.12
20.06	1302	Geranyl formate	0.13
20.42	1311	Vinylguaiacol	0.14
21.68	1350	Naphthalene	0.19
21.90	1356	Geranic acid	0.44
22.70	1384	Geranyl acetate	0.18
22.85	1386	β-Burbonene	0.56
23.85	1420	Caryophyllene	3.73
24.89	1451	α-Chimachalen	0.37
24.97	1456	β-(E)-farnesene	0.28
25.79	1481	1-Ethyl-3,5-Diisopropylbenzene	0.13
25.88	1486	B-(E)-ionone	0.13
27.01	1526	δ-Cadinene	0.16
28.61	1577	Megastigmatrienone	0.12
28.76	1585	Caryophyllene oxide	1.40
31.21	1670	Caryophylla-3,8(13)-dien-5-β-ol	0.16
31.47	1682	E-asarone	0.20
35.73	1845	Hexahydro farnesyl acetone	0.20
37.47	1918	Not identified	0.79
37.60	1921	Methyl palmitate	0.76
38.19	1947	*cis*-11-Hexadecenoic acid	0.72
38.47	1958	Dibutyl phthalate	1.36
38.58	1962	Phthalic acid butyl isobutyl ester	2.45
41.85	2100	5-Dodecyldihydro-2(3H)-furanone	0.13
42.08	2110	Phytol	2.55
		In all	98.43
		Identified in all	97.64

Table 2. Content of the main components of the essential oil from lemon balm growing in the areas of different countries

Component	Content, % of whole oil				
	Ukraine [13]	Tajikistan [14]	Turkey [15]	Italia [16]	Russia (the present work)
Neral	6.00	31.50	12.22	–	3.28
Citronellol	–	–	25.24	6.20	36.71
Citronellal	4.03	2.80	5.86	39.60	1.48
Geranial	8.21	43.20	38.13	–	4.39
Geraniol	–	0.20	4.95	5.70	27.22
Caryophyllene	2.49	4.00	–	0.60	3.73
Caryophyllene oxide	10.26	0.40	–	0.20	1.40
Linalool	–	–	2.74	0.70	1.78

EXPERIMENTAL

The plant raw material examined in the present work, the above-ground part of lemon balm, was gathered in August, 2013, in the neighborhood of Krasnoyarsk during flowering when the content of essential oil is the greatest. The herb was cut at a distance of 8–10 cm from the ground. The raw material was laid out in a thin layer and air-dried in the shade [7].

The essential oil was obtained by exhaustive water and steam distillation [8] for 20 h until all volatile components were completely extracted from the original raw material; a weighed portion of air-dried material was 1200–1500 g. The density and the refractive index of the resulting oil were determined using high-precision devices of the Mettler Toledo company [8].

The composition of essential oil was determined by an Agilent Technologies 7890 A gas chromatograph with an Agilent Technologies 5975 C mass spectrometer as a detector. The product being analyzed (essential oil) with a volume of 10 μL was dissolved in 500 μL of *n*-hexane, and 100 μL of a hexane solution of a mixture containing equal weight amounts of normal hydrocarbons from C_8 to C_{24} with a total concentration of 0.1% mass was added. The analysis was carried out using a quartz capillary column HP-5ms with a length of 30 m and an internal diameter of 0.25 mm. The immobile phase was 5% diphenyl–95% dimethylsiloxane, and the thickness of the immobile phase film was 0.25 μm. The following temperature regime of chromatography was used: the initial temperature of the column 50°C (2 min), 50–240°C (4°/min), 240–280°C (20°/min), and 280°C (5 min). The temperature of the evaporator was 280°C, the temperature of the ionization chamber was 170°C, and the ionization energy was 70 eV [9].

Single components were identified by determining the linear indices of the retention of each component and by comparing these values and the entire mass spectra with the reported data [9–11]. With the full coincidence of mass spectra and linear retention indices, the identification was considered to be completed. The quantitative analysis was carried out from the areas of the corresponding peaks on the chromatogram constructed with the full ion current.

RESULTS AND DISCUSSION

The yield of the oil was determined from the results of three experiments to be $0.59 \pm 0.06\%$. The essential oil collected in the upper part of the Clevenger nozzle is a pale yellow oily liquid. The density and the index of refraction of the oil are 0.8453 g/cm^3 and 1.4742, respectively.

It was found by GC-MS that the essential oil of the lemon balm growing in the neighborhood of Krasnoyarsk contains no less than 54 individual components of which 48 components have a concentration of more than 0.1% of the whole oil; 47 components of these compound were identified in the present work (Table 1).

As seen from the data, the major components of the oil are two alcohols: citronellol and geraniol; their content is more than 27% of the whole oil. The oil also contains ten components, each with a content of more than 1%; caryophyllene, neral, phytol, phthalic acid butyl isobutyl ester, and geranial are contained in maximum amounts.

It has been found earlier that the area of natural habitat markedly affects the composition of biologically active compounds of wild plants [12]. Therefore, it was of interest to compare the content of the main components of essential oil from lemon balm growing in the neighborhood of Krasnoyarsk and in other regions (Table 2).

It is seen from these data that the composition and the content of different components of lemon balm essential oil obtained in different regions are different. Thus, the main component of oil from Tajikistan and Turkey is geranial, whereas in the oil from Italy this component is absent. The major component of the oil from Italy is citronellal (39.60%), whereas its content in other oils is no higher than 6%. The oil from the

Lemon balm (*Melissa officinalis* L) during flowering.

Ukraine and Tajikistan contains no citronellol, whereas the content of this component in the oil from Turkey and Krasnoyarsk is 25% and about 37%, respectively.

Note that, in the lemon balm essential oil from Iran, only 12 components have been identified; the major component is *trans*-carveol whose content is 28.9% of the whole oil [17].

It is also seen from the data in Table 2 that the essential oil from Krasnoyarsk was studied most extensively, since it contains all major components listed in the table.

CONCLUSIONS

Thus, the results allow us to conclude that the essential oil from lemon balm growing in the neighborhood of Krasnoyarsk may be of commercial interest as a source for obtaining geraniol and citronellol, which are the dominant components of the oil.

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