Chemotypes of the essential oils of *Achillea millefolium* L. ssp. *millefolium* growing wild in Eastern Lithuania

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In 1999 and 2000, twenty samples of inflorescences and leaves of *Achillea millefolium* L. ssp. *millefolium* with white flowers were collected in 11 habitats in Eastern Lithuania. Essential oils were analyzed by GC and GC/MS. According to the major component the essential oils were distributed into six chemotypes: β-pinene (10 samples, 10.2–17.2%), 1,8-cineole (3 samples, 8.8–9.9%), borneol (3 samples, 11.5–13.2%), camphor (1 sample, 13.1%), nerolidol (2 samples, 8.5–9.3%) and chamazulene (1 sample, 20.1%). The second major constituents in the oils of β-pinene chemotype were 1,8-cineole (8 samples, 6.7–11.8%) or borneol (2 samples, 7.6–8.0%) and in those of borneol – 1,8-cineole (1 sample, 9.5%) or β-pinene (1 sample, 12.6%), or camphor (1 sample, 7.2%). No essential oils of borneol chemotype have been found in formerly investigated plants of yarrow. The inflorescences and the leaves formed the same chemotype of essential oils in 6 habitats from the 11 investigated. Eight samples of essential oils did not contain chamazulene, 1 sample contained only traces of this component, 10 samples contained 0.7–4.8% and only one sample 20.1%. The 56 constituents found in the essential oils made up 88.5–99.5%.

Key words: *Compositae*, *Achillea millefolium* L. ssp. *millefolium,* chemical composition of essential oil, β-pinene, 1,8-cineole, borneol, camphor, chamazulene, nerolidol, inflorescences, leaves

INTRODUCTION

The papers on *Achillea millefolium* L. were reviewed in [1]. Essential oils only of all aerial parts were investigated in a large part of the above papers. The oils can be distributed into the following chemotypes according to the first major constituents: chamazulene, sabinene, β-pinene, 1,8-cineole, linalool, α (*cis*)-thujone, β (*trans*)-thujone, ocimene, camphor, ascaridole, caryophyllene oxide, β-eudesmol, and α-bisabolol.

The composition of essential oils of flowers and leaves of *A. millefolium* was compared by [2–5]. The oils of both parts of plants in Portugal, Norway and Estonia (one sample) were of the same chemotype, while the oils of separated parts of plants from Estonia (another sample) and Canada were of different chemotypes.

Essential oils of leaves and flowers in Portugal were of 1,8-cineole (24.5–28.7%) chemotype [2]. The second major component of inflorescence oil was sabinene (15.4%), of leaf oil – sabinene hydrate (*trans* + *cis*, 14.8%), but the amounts of compounds with sabinane carbon skeleton were equal in both parts of plants (20.2%). Azulenes were not found in the essential oils.

In Norway, plants contained essential oils of sabinene chemotype in leaves and inflorescences according to the data of headspace chromatographic analysis [3]. Chamazulene has been found in insignificant amounts.

The essential oils of leaves and flowers were of β-pinene (35.9–37.1%) chemotype in one sample from Estonia [4]. The second main constituent was 1,8-cineole and the oil contained only 0.2–0.4% of chamazulene. Flowers of the other sample produced essential oil of chamazulene chemotype (31.5%). The second major component was β-pinene (28.9%). The leaf oil was of β-pinene (30.3%) chemotype while chamazulene (6.6%) was only the third main constituent next to α-pinene (8.1%).

The similar regularities were noticed in *A. millefolium* from Canada [5]. The flower oil was of chamazulene (26.7%) chemotype with germacrene D (21.6%) and camphor (8.0%) as the second and the third main constituents. The leaf oil contained camphor (16.8%) as a major component, β-pinene (13.9%), chamazulene (11.1%) and germacrene D (10.8%) were other main constituents.

In essential oils from cell suspension cultures of *A. millefolium* ssp. *millefolium* were found some compounds that were not detected in plant oil [6].

Four chemotypes (β-pinene, 1,8-cineole, chamazulene and nerolidol) of oils of *A. millefolium* ssp. *millefolium* were found in wild-growing plants of Vilnius after investigation of inflorescences and leaves collected in 9 habitats [1].

The essential oils under study were distributed into six chemotypes. The borneol chemotype had not been described earlier.

MATERIALS AND METHODS

The aerial parts (~35 cm) of plants (0.1–1 kg) growing wild in 11 localities of Eastern Lithuania (indicated here by alphabetic symbols, A–M) were collected in August 1999 (with b) and 2000: Af, Al – Rastinėnai (Vilnius district); Bf, Bl – Rūdninkai (Šalčininkai district); Cf, Gf, Gl – Pažeimenė (Švenčionys district); Df, Dl – Juodupė (Rokiškis district); Ff, Fl – Skersabaliai (Vilnius district); Hf, Hl – Vievis (Vilnius district); Mf (b) – Verkšionys (Vilnius district); Jf, Jl – Mikailiškės (Vilnius district); Kf, Kl – Pakretonė (Švenčionys district); Lf – Rokantiškės (Vilnius city). The inflorescence oil is indicated by a second letter f and the leaf oil by the second letter l.

Voucher specimens were deposited in the Herbarium of the Institute of Botany (BILAS), Vilnius, Lithuania (numbers: 59431, 59432, 59437, 59438, 59441, 59444, 595446–59449).

All samples were collected at a full flowering stage. The plants were dried at room temperature (20–25 °C); flowers were separated from stems and leaves before drying. Essential oils were prepared by hydrodistillation of 15–50 g of air-dried plants.

The analyses of the essential oils were carried out by GC and GC-MS. A HP 5890 II chromatograph equipped with FID and a HP-FFAP capillary column (30 m × 0.25 mm) was used for quantitative analysis.

Analyses by GC-MS were performed using an HP 5890 chromatograph interfaced to an HP 5971 mass spectrometer (ionization voltage 70 eV) and equipped with a CP-Sil 8 CB capillary column (50 m × 0.32 mm). The oven temperature was kept at 60 °C for 2 min, then programmed from 60 to 160 °C at a rate of 5 °C min^{-1}, kept for 1 min, then programmed from 160 to 250 °C at a rate of 10 °C min^{-1} and isothermal at 250 °C for 2 min, using He as the carrier gas (2.0 ml min^{-1}). The temperatures of the injector and detector were 250 °C and 280 °C, respectively.

The percentage composition of essential oils was computed from GC peak areas without correction factors. Qualitative analysis was based on a comparison of retention times and indexes on both columns and mass spectra with corresponding data in the literature [7–10] and computer mass spectra libraries (Wiley and NBS 54K).

The following mass spectral data of unknown components were recorded, m/z (relative intensity):

Unknown 1: 218 (3), 187 (7), 163 (7), 145 (11), 136 (100), 117 (25), 105 (40), 91 (79), 79 (68), 69 (54), 55 (50), 41 (79).

Unknown 2: 220 (16), 202 (14), 177 (13), 159 (79), 131 (32), 119 (64), 109 (75), 93 (79), 91 (100), 79 (65), 67 (50), 55 (58), 41 (78).

Unknown 3: 207 (3), 177 (3), 159 (7), 145 (3), 126 (29), 108 (75), 93 (58), 79 (36), 67 (32), 55 (36), 43 (100).

RESULTS AND DISCUSSION

Different chemical composition of some essential oils of *A. millefolium* was found in the inflorescence and leaf oils in Vilnius [1] and in Eastern Lithuania (Tables 1 and 2). Eighteen samples collected in Vilnius were distributed into three groups with the following major constituents: β-pinene/1,8-cineole (9

Table 1. **Chemical composition of essential oils (%) of β-pinene chemotype of *Achillea millefolium* growing wild in Eastern Lithuania**

Compound	RI	Af	Al	Bf	Bl	Cf	Df	Dl	Ff	Interval	Mean
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
α-Pinene	939	4.1	3.4	4.8	3.4	4.2	4.3	2.2	4.1	2.2–4.8	3.8
Camphene	953	1.5	1.6	1.3	1.1	0.8	1.7	1.1	1.6	0.8–1.7	1.3
Sabinene	976	1.7	2.2	0.9	2.1	7	7.2	6.5	13	0.9–13	5.1
β-Pinene	980	**14.2**	**14**	**15.5**	**15.2**	**10.2**	**17.2**	**15.6**	**13.6**	**10.2–17.2**	**14.4**
Myrcene	991	0.7	2.9	0.5	1.1	0.5	1	1.3	1.1	0.5–2.9	1.1
α-Terpinene	1018	0.8	tr.	1.1	0.2	0.4	0.8	1.9	0.9	tr.–1.9	0.8
p-Cymene	1026	0.6	1.3	1	1.2	0.5	4	3	0.3	0.5–4	1.5

Table 1 continued

1	2	3	4	5	6	7	8	9	10	11	12
1.8-Cineole	1033	8	7.8	10.1	11.8	7.7	9.3	6.7	9.4	6.7–11.8	8.9
γ-Terpinene	1062	2.1	0.9	3.3	1.3	1.8	2.6		2.1	0–3.3	1.8
Terpinolene	1088	0.3	tr.	0.6	0.1	0.3	0.5	tr.	0.6	tr.–0.6	0.3
Camphor	1143	4.9	3.8	2.8	2.8	0.6	4.7	6.6	3.6	0.6–6.6	3.7
cis-Chrysanthenol	1162	0.4	tr.	0.5	0.9	0.1	0.1	0.3		0–0.9	0.3
Borneol	1165	3.8	4.9	2.3	3.9	0.4	2.5	4.3	1.5	0.4–4.9	3.0
Terpinen-4-ol	1177	3.9	1.8	3.6	1.7	0.9	5.3	7.6	5.9	0.9–7.6	3.8
α-Terpineol	1189	1.7	1.7	3	1.5	1.3	1.3	0.6	2.3	0.6–3	1.7
Bornyl acetate	1285	1.6	1.2	2	2.1	1.2	0.6	0.9	1.2	0.6–2.1	1.4
α-Cubebene	1351	0.1	0.2	0.1	0.1	0.2	0.5	0.4	0.4	0.1–0.5	0.3
β-Bourbonene	1384	0.4	0.4	0.2	0.3	0.4	tr.	tr.		0–0.4	0.2
β-Caryophyllene	1418	7.1	5.3	5.7	5.6	7.5	3.7	3	3.7	1.5–7.5	5.2
α-Humulene	1454	1.3	0.9	0.9	0.9	1.3	0.8	0.5	0.7	0.5–1.3	1.0
Germacrene D	1480	2.8	3.2	2.4	2.1	6.3	2.3	1.8	3.3	1.8–6.3	3.0
Bicyclogermacrene	1494	0.4	0.3	0.5	0.3	1.2	0.5	0.3	0.3	0.3–1.2	0.5
α-Muurolene	1499	tr.		0.2	0.1	0.4	0.1	tr.	0.2	0–0.4	0.1
β-Bisabolene	1509			0.1	0.1	0.6			0.7	0–0.7	0.2
Sesquicineole	1514			0.6	0.5	1.2	0.2	tr.	0.2	0–1.2	0.3
δ-Cadinene	1524	1.8	0.8	1	0.9	2.8	0.7	1	1.1	0.7–2.8	1.3
trans-Nerolidol	1564	7.8	4.4	4.6	2.7	5.5	2.6	2.7	3.5	2.6–7.8	4.2
Spathulenol	1576	0.6	5.7	0.7	2.4	0.5	0.7	2.1	0.8	0.5–5.7	1.7
Caryophyllene oxide	1581	2.9	5.7	2.7	5.1	3.3	1.6	5.7	2.2	1.6–5.7	3.7
Viridiflorol	1590	0.9	0.8	1.1	0.7	0.4	1	2.5	1	0.4–2.5	1.1
Humulene epoxide	1606	0.3	0.9	0.5	0.9	0.5			0.5	0–0.9	0.5
10-epi-γ-Eudesmol	1619	1.1	1.7	2.1	1.9	4.2	0.8	2.3	tr.	tr.–4.2	1.8
1-epi-Cubenol ?	1627	1.6	2.1	0.9	1.4	2	1.5	0.3	1.3	tr.–2.1	1.4
Unknown 1	1635	0.9	0.9	0.8	1.3	0.8	0.2	0.8	0.6	0.2–1.3	0.8
τ-Cadinol	1640	0.8	0.6	1.1	1	0.8	0.3	1.8	0.6	0.3–1.8	0.9
Himachalol ?	1647					2.1	0.8	0.4	0.9	0–2.1	0.5
Selin-11-en-4-α-ol	1652	4.1	4.7	3.2	3.6	2.3	0.8	2.4	1.5	0.8–4.7	2.8
14-Hydroxy-9-epi-β-caryophyllen	1664	3.1	2.4	2.1	1.8	1.7	0.4	1.2	0.5	0.4–3.1	1.7
α-Bisabolene oxide	1682			2.7	2.4	0.3	0.5	tr.	0.8	0–2.7	0.8
Unknown 2	1685	0.9	0.7	0.8	0.9	1.4	0.7	1.1	1.4	0.7–1.4	1.0
Unknown 3	1689	0.7	0.5	0.7	0.8	1	tr.	1.6	tr.	tr.–1.6	0.7
E, E-Farnesol ?	1722					0.2	0.6	0.6	0.1	0–0.6	0.2
Chamazulene	1725	4.1	2.8	3.4	2.7	4.8				0–4.8	2.2
Total		94	92.5	92.4	90.9	91.6	84.4	91.1	87.5	84.4–94	90.6
Monoterpene hydrocarbons		26	26.3	29	25.7	25.7	39.3	31.6	37.3	25.7–39.3	30.1
Oxygenated monoterpenes		24.3	21.2	24.3	24.7	12.2	23.8	27	23.9	12.2–27	22.6
Sesquiterpene hydrocarbons		13.9	11.1	11.1	10.4	20.7	8.6	7	10.4	7–20.7	11.7
Oxygenated sesquiterpenes		25.7	31.1	24.6	27.4	28.2	12.7	25.5	15.9	12.7–28.2	23.9

Note. A capital letter indicates the habitat where plants were collected in 2000, f – inflorescence, l – leaf, tr. – traces.

samples), chamazulene /1,8-cineole or β-pinene (5 samples), nerolidol/β-pinene (4 samples) [1]. Four chemotypes were identified according to the first main constituent – β-pinene, 1,8-cineole, chamazulene and nerolidol.

Twenty samples of the oils of inflorescences and leaves collected in 11 habitats of Eastern Lithuania contained a large group (11 samples) with β-pinene/1,8-cineole as major constituents (Tables 1 and 2, A-H habitats). Eight samples (A–F) were of β-pine-

Talle 2. **Chemical composition of essential oil (%) of 1,8-cineole (Gl, Hf, Hl), borneol (Jl, Jf, Kf0, camphor (Kl), β-pinene (Lf, Ll), nerolidol (Gf, Fl) and chamazulene (Mf b) chemotypes of *Achillea millefolium* growing wild in Eastern Lithuania**

Compound	RI	Gl	Hf	Hl	Jf	Jl	Kf	Kl	Lf	Ll	Gf	Fl	Mf(b)
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*
α-Pinene	939	1.9	6.7	2.3	4.7	2.3	4.3	3.7	3.2	4	2.7	2.3	4.6
Camphene	953	1	1.8	0.4	1.7	1.1	1.5	2.5	2.1	2.3	0.9	0.9	
Sabinene	976	4.5	3.7	2.5	4.3	1.5	3.1	3.6	1.9	1.5	7.1	5.4	3.2
β-Pinene	980	7.3	9.5	6.6	6.5	4	12.6	4.5	**12.3**	**12.1**	9.1	7	15.1
Myrcene	991	0.6	1.1	0.4	0.7	0.3	0.8	0.6	3.3	7.8	1.2	0.2	0.9
α-Terpinene	1018	0.4	0.6	0.2	0.4	0.7	tr.	0.4	0.3	1.5	0.5	0.6	0.5
p-Cymene	1026	2.3	0.8	1.3	1.5	1	1.2	0.7	0.5	2.2	0.7	0.7	0.3
1.8-Cineole	1033	**9.6**	**9.9**	**8.8**	9.5	5.3	12.5	8.8	6.4	3.1	6.4	4.5	6.4
γ-Terpinene	1062	1.2	2.2	0.8	1	2.1	0.2	1.3	1.9	0.3	1.5	1.9	0.4
Terpinolene	1088	0.5	0.3	0.1	0.2	0.4		0.4	0.2	0.1	0.3	0.4	0.3
trans-Pinocarveol	1139			tr.	0.3	tr.			0.1	1.1			0.7
Camphor	1143	5.9	2	2.4	4.1	7.2	7.2	**13.1**	3.5	3.6	1.8	0.9	0.5
cis-Chrysanthenol	1162	2.4	2	2	3.8	2.4	0.3	0.4	tr.	0.3		1.2	tr.
Borneol	1165	2.4	2	2.5	**11.5**	**13.1**	**13.2**	12.8	7.6	8	2.7	3.7	1.2
Terpinen-4-ol	1177	1.7	1.9	1.3	2.6	1.9	4.5	2.2	2.2	2	2	1.6	2.3
α-Terpineol	1189	0.5	0.8	0.6	1.9	1.4	2.2	0.5	1.1	0.8	0.6	0.4	2.1
cis-Crysanthenyl acetate	1262				2.8	1.4	0.8	0.9	tr.	tr.			
Bornyl acetate	1285	1.6	4.7	3.7	1.1	1.9	0.5	0.7	3.3	3.6	2.2	1.6	tr.
α-Cubebene	1351		0.2	0.3	0.8	0.2		0.1	0.3	0.1	tr.	0.2	0.2
β-Bourbonene	1384	0.1	tr.	0.2	tr.	0.2			tr.	tr.		0.2	0.4
β-Caryophyllene	1418	2.6	2.6	6.5	3.5	1.9	2.5	0.7	5.8	1.9	3.2	5.5	8
α-Humulene	1454	0.4	0.5	0.4	0.7	0.3	0.3	0.2	1.1	0.1	0.3	0.4	1.5
Germacrene D	1480	3.6	2.5	2.7	1.7	0.9	1.8	0.3	3.2	0.5	2.5	2.7	4.6
Bicyclogermacrene	1494	0.5	0.2	0.5	0.4	0.2	0.3	0.4	0.7	0.1	0.6	0.4	0.4
α-Muurolene	1499	0.2		0.2	0.3	0.3					0.3	0.5	
β-Bisabolene	1509	0.4		0.3	0.3	0.3	0.3		0.1		0.5	1.2	0.1
Sesquicineole	1514	0.3	0.2	0.2	0.2	0.2	0.2	0.1	0.2		0.1	0.4	0.4
δ-Cadinene	1524	1.3	0.6	1	0.6	0.6	0.5	0.3	1.4	0.8	1.5	1.9	2.1
***trans*-Nerolidol**	1564	2.6	4.5	6.4	4.8	4.6	4.7	2.6	7.4	3.2	**9.3**	**8.5**	6.4
Spathulenol	1576	3.3	0.5	2	0.5	1.3	1.1	tr.	0.7	2.8	0.7	2.7	
Caryophyllene oxide	1581	4.9	2.8	6.3	3.1	4.7	1.9	3.5	4	7.1	2.8	6	2.5
Viridiflorol	1590	1.5	1.6	1.8	1.5	1.1	0.7	0.2	1.1	1.5	1.8	5.1	1
Humulene epoxide	1606		tr.					1.4	0.5	1.1	0.7	1.1	0.4
10-epi-γ-Eudesmol	1619	2.4	1	2.5	1.4	1.8	0.9	1.2	4.2	5.5	1.5	0.5	tr.
1-epi-Cubenol ?	1627	3.1	7.6	5.1	0.6	1.5	0.8	1.9	0.5	2.6	1.6	3	2.1
Unknown 1	1635	1.5	1	2	1.1	1.6	0.6	1.2	1.5	1.2	1	1.5	1.3
τ-Cadinol	1640	0.9	0.6	1.1	0.7	0.9	0.3	tr.	1.3	0.3	0.9	1.6	0.4
Himachalol ?	1647	1	0.5	1.1	2.7	0.8	1.4	2.1		tr.	1.4	2.5	1.1
Selin-11-en-4-α-ol	1652	5.9	2.4	4.1	4.2	3.3	2.2	3.6	2.6	2.1	5.9	3	2
14-Hydroxy-9-epi-β-caryophyllene	1664	1.5	1.1	1.8	0.3	1.5	0.7	1.2	3.8	1.3	1.2	0.2	1.1
α-Bisabolene oxide	1682	4.1		2.8	0.2	1.5		0.6	0.1	tr.	5.9	0.6	1.1
Unknown 2	1685	0.9	1.4	1.4	0.9	1	0.8	1.5	1.2	0.3		1.6	2.2
Unknown 3	1682	1.2		1.2	0.7	0.4	1	1.6	1.5	0.4	1.2	1.2	1
E, E-Farnesol ?	1722	0.2	0.4	0.5	0.6	0.8	0.3	tr.	0.4	tr.	1.7	0.7	
Chamazulene	1725	1.2	tr.	0.8	0.7	1.3					0.9		**20.1**
Total		88.0	82.2	89.1	91.1	81.2	88.2	81.8	93.5	87.2	87.2	86.5	98.9
Monoterpene hydrocarbons		19.7	26.7	14.6	21.0	13.4	23.7	17.7	25.7	31.8	24.0	19.4	25.3
Oxygenated monoterpenes		24.1	23.3	21.3	37.6	34.6	41.2	39.4	24.2	22.5	15.7	13.9	13.2

Table 2 continued

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Sesquiterpene hydrocarbons		9.1	6.6	12.1	8.3	4.9	5.7	2.0	12.6	3.5	8.9	13.0	37.4*
Oxygenated sesquiterpenes		35.3	25.6	40.3	23.5	27.0	17.6	22.7	31.0	29.4	37.7	40.2	23.0

Note. A capital letter indicates the habitat where plants were collected in 2000, with b – in 1999; f – inflorescence, l – leaf, tr. – traces.
* Including chamazulene.

ne chemotype (10.2–17.2%) and 3 ones (Gl, Hf, Hl) – of 1,8-cineole chemotype (8.8–9.9%).

Beside the 43 compounds listed in Table 1, 10 more constituents were found in some essential oils: α-thujene (tr.–0.8%, Af, Al, Bf, Bl, Df, Ff); *trans*-pinocarveol (tr.–0.5%, Al, Bf, B1, Gl, Hf, Hl); *cis*-chrisanthenyl acetate (tr.–0.8%, Af, Al, Bf, Bl, Dl, Df, Hf); myrtenol (tr.–1.8%, Bf, Bl, Ff, Gl, Hf, Hl); *trans*-carveol (tr.–2.1%, Bf, Bl, Df, Ff); geranyl acetate (tr–0.7%, Af, Al, Bf, Bl, Df); β-isocomene (tr.–3.1%, Af, Cf, Df, Dl, Ff); β-ionone (tr.–0.4%, Bl, Gl) and *trans*-arteannuic alcohol (tr.–4.3%, Df, Dl, Hf, Hl). The first four above compounds were identified mainly in both parts of plants growing in the same habitat. β-Ionone was found only in leaves in 4 localities. The total sum increased up to 99.5% in the presence of the above additional constituents.

The β-pinene chemotype of *A. millefolium* essential oils with different other main constituents is widespread in Europe. This chemotype with 1,8-cineole as a second major component in oils was carefully investigated in North European countries, Norway and Estonia [3, 4]. The above data were similar to those in Eastern Lithuania (Table 1).

Six samples comprised the borneol/1,8-cineole/β-pinene group (Table 2, J, K, L habitats). Borneol as a first main component was present in 3 samples of oils from J and K habitats. Inflorescence and leaf oils from L habitat were of β-pinene chemotype with borneol as a second major constituent. One sample of leaf oil was of camphor chemotype (Kl, 13.1%) with about the same level of the second constituent, borneol (12.8%).

The plants with the volatile oils of this group were found in 3 from 11 habitats. Four samples from 2 habitats (Kf, Kl, Lf and Ll) did not contain chamazulene. Small quantities of chamazutene (0.7–1.3%) were found in 2 samples from one habitat (J).

Nine constituents were identified in the volatile oils of this group in addition to those listed in Table 2 (Jf, J1, Kf, K, Lf, Ll): α-thujene (tr., Jf, Jl); myrtenol (tr.–1.5%, Kf, Kl, Lf, Ll); dihydrocarveol (0.5–0.4%, Jf, Jl); *trans*-carveol (0.3–0.4%, Jf, Jl); geranyl acetate (0.1–0.8%, Jf, Kf); β-isocomene (tr.–0.3%, Lf, Ll and Kf); β-ionone (0.3–0.4%, JJ, Rl, Lf, Ll); β-selinene (0.5–1.1%, Lf, Ll) and *trans*-arteannuic alcohol (0.5–0.8%, Jf, Jl). Two compounds, dihydrocarveol and β-selinene, were not found in other groups. The total sums of all components were 81.2–95% in this group.

There are no literature data on yarrow essential oil of borneol chemotype.

Essential oil rich in borneol (15.0%, the second major constituent) was found in Yugoslavia with camphor as the third major component (12.7%). The oils of borneol chemotype under study were also rich in camphor (Table 2, Jl, Jf, Kf). Camphor as the first main constituent of oil from all parts of plants was found in Portugal [12]. The second constituent of the above oil was 1,8-cineole, while in the oil under study – borneol (Table 2, Kl).

Only 2 samples from the 20 investigated were of nerolidol chemotype (Table 2, Gf, Kl), while 4 samples from 18 were in Vilnius [1].

In addition to the compounds given in Table 2 (Fl, Gf), 4 more constituents were identified as well: myrtenol (0.9%, Gf); sabinyl acetate (~0.2%, Gf); β-isocomene (tr.–0.4%, F1, Gf); β-selinene (1.2%, Fl). The total sums of all components were 87.2–97% in this group.

trans-Nerolidol was not found as the main constituent in earlier investigated yarrow oils.

Nerolidol (5.7%) was found in the oils from Iran as the third main component beside α-bisabolol (22.9%) and spathulenol (12.4%) as the first and second major constituent [5]. The amount of nerolidol was higher in the essential oils under study (Table 2, Gf, Kl).

Only one sample of inflorescence essential oils was of chamazulene chemotype (Table 2, Mf(b), 20.1%). Volatile oils of this chemotype were found in a lot of world countries [1, 4, 5, 13, 14].

Eleven from 20 samples of the oils under study contained low amounts of chamazulene (< 5%). Ten samples contained 0.7–4.8% of chamazulene, one sample contained traces, and 8 samples did not contain this compound.

In all books published in Lithuania (for example, [15–17]) the composition of the oils of *A. millefolium* was presented by data (1971) of plants from Institute of Botany [13]. The inflorescences of these plants contained large amounts of chamazulene. The data (1987) of plants from another habitat in Lithuania showed only traces of this compound in oil [14].

High levels of chamazulene were very rare in the oils of Lithuania (Tables 1 and 2). More plants containing > 8% of chamazulene in the oils were found in different habitats of Vilnius [1]. A lot of investigators connect the healing power of *A. millefolium* plants and their essential oils with chamazulene. Seven authors cited in [1] show that 1,8-cineole, β-pinene, α-pinene, camphor, borneol, β-caryophyllene, nerolidol and caryophyllene oxide, the constituents of yarrow under study (Table 1, 2), exhibit different bioactivity. The healing power of plants and their oils are dependent on the above compounds beside chamazulene.

Volatile oils of inflorescences and leaves of the same chemotype were found in 6 habitats from 11 investigated (Tables 1, 2). The β-pinene chemotype of both parts of the same plants was found in 4 habitats (A, B, D, L), 1,8-cineole (H) and borneol (J) chemotypes – each in one habitat.

CONCLUSION

Six chemotypes of essential oils from inflorescences and leaves of *A. millefolium* were found in investigated plants from 11 habitats in Eastern Lithuania: β-pinene (10 samples), 1,8-cineole (3 samples), borneol (3 samples), camphor (1 sample), nerolidol (2 samples) and chamazulene (1 sample). The same chemotype of inflorescence and leaf oil was found in 6 habitats.

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LAUKINIŲ KRAUJAŽOLIŲ *ACHILLEA MILLEFOLIUM* L. SSP. *MILLEFOLIUM,* AUGANČIŲ RYTŲ LIETUVOJE, ETERINIŲ ALIEJŲ CHEMOTIPAI

S a n t r a u k a

Buvo tiriami baltai žydinčių kraujažolių, surinktų 11 augimviečių, žiedynų ir lapų eteriniai aliejai. Ištirta 20 bandinių, pagal pirmąjį pagrindinį komponentą jie suskirstyti į šešis chemotipus: β-pineno (10 bandinių, 10,2–17,2%), 1,8-cineolio (3 bandiniai, 8,8–9,9%), borneolio (3 bandiniai, 11,5–13,2%), kamparo (1 bandinys, 13,1%), nerolidolio (2 bandiniai, 8,5–9,3%) ir chamazuleno (1 bandinys, 20,1%). Antrasis komponentas buvo 1,8-cineolis (8 bandiniai, 6,7–11,8%) arba borneolis (2 bandiniai, 7,6–8,0%) β-pineno chemotipo eteriniuose aliejuose ir 1,8-cineolis (1 bandinys, 9,5%) arba β pinenas (1 bandinys, 12,6%), arba kamparas (1 bandinys, 7,2%) borneolio chemotipe.

Skirtinga eterinių aliejų cheminė sudėtis sąlygoja nevienodas augalų bei jų eterinių aliejų gydomąsias savybes.