

Two chemotypes of essential oils produced by the same *Juniperus communis* L. growing wild in Lithuania

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It was found for the first time that needles and berries of the same junipers growing wild in Lithuania produced essential oils of different chemotypes. The *Juniperus communis* L. var. *communis* with leaves (needles) producing sabinene-chemotype essential oils were found only in three localities from the 34 investigated habitats, beside the plants with needles biosynthesizing α -pinene-chemotype oils. The dominant compounds in four from 49 (including earlier results) investigated needle essential oils were sabinene (34.1–40.8%), α -pinene (11.7–27.8%) and terpinen-4-ol (6.9–9.3%), while in the rest needle oils the main component was α -pinene (41.2–66.5%). The first major constituent of all berry essential oils under study was α -pinene (21.0–67.4 %). The second and third main constituents in unripe berry oils from bushes with needle oils of sabinene chemotype were sabinene (6.3–19.6%), myrcene (4.3–12.8%) and terpinen-4-ol (13.1%) and in the ripe berry oils myrcene (7.8–18.7%) and terpinen-4-ol (3.2–9.6%). The content of sabinene in all ripe berry oils was only 0.4–2.9%.

Key words: *Juniperus communis*, Cupressaceae, essential oil composition, needle oils rich in sabinene, berry oils rich in α -pinene, myrcene, terpinen-4-ol

INTRODUCTION

J. communis (Cupressaceae) essential oils of berries and branches with berries are used for healing various diseases and for the preparation of meals and beverages [1–3]. Their healing power, odour and taste depend on the composition of essential oils. Essential oils of ripe berries containing 20–30% of α -pinene, 1.0–12% of β -pinene, 1.0–35% of myrcene, 2.0–12% of limonene and 0.5–10% of terpinen-4-ol were recommended for pharmaceutical uses [3].

According to R. P. Adams, in the north and middle European countries *J. communis* var. *communis* is growing up to 600 m above sea level. *J. communis* var. *saxatilis* grows in higher areas [4–6]. The territory of Lithuania is lower than 400 m above sea level. *J. communis* var. *communis* is the only species of the genus *Juniperus* growing wild in Lithuania [4, 7, 8].

The leaf (needle) essential oils of *J. communis* var. *communis* are mostly of α -pinene chemotype [4, 6, 9, 10]. The needle, unripe and ripe berry essential oils of twelve junipers collected in twelve localities of Lithuania were of α -pinene (38.5–66.5%) chemotype [11–14].

Some needle essential oils of *J. communis* from Scandinavian countries, Poland and Italy were sabinene chemotype

beside most frequent α -pinene chemotype [9, 15–19]. The juniper berry essential oils of sabinene chemotype had been found only in high (~2000 m) mountains [3, 20, 21]. All berry essential oils in lower localities were of α -pinene chemotype [9, 15, 16, 20, 22, 23].

The aim of this investigation was to test whether there are any differences in the composition of essential oils of *J. communis* var. *communis* growing wild in Lithuania.

MATERIALS AND METHODS

Samples of needles, unripe and ripe berries from 37 individual juniper (*J. communis* L. var. *communis*) plants were collected in 2003–2008 in 22 localities. Voucher specimens have been deposited in the Herbarium of the Institute of Botany (BILAS numbers are presented in Table 1).

The essential oils were prepared by hydrodistillation (3 h) of fresh needles, unripe and ripe berries in an apparatus according to [24]. The ratio of unripe, ripe berries and water was 1 : 10, and of needles and water 1 : 20. Oil yields from needles (~0.37%), unripe (~1.2%) and ripe berries (~0.9%) were obtained using 50 g of plant material and expressed in v/w% of dry weight.

The essential oils were analysed by GC and GC / MS. The separation was performed on a fused silica capillary column

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Table 1. *Juniperus communis* L. plants growing wild in Lithuania, collected in 2003–2008

Sample No.	Locality	Voucher specimen number in BILAS
1	Druskininkai district, Leipalingis (A)	68885
2	Kaunas district, Arlaviškės (B)	68345
3	Vilnius district, near Lake Baldis (C1)	68352
4	Vilnius district, near Lake Baldis (C2)	68881
5–7	Vilnius district, ~0.5 km to the northwest of Lake Baldis	68882
8	Vilnius district, Dukštos	68331
9, 10	Šalčininkai district, Gelūnai	68332, 68333
11	Molėtai district, Suginčiai	68334
12	Molėtai district, Plavėjai	68335
13	Trakai district, 12 km to the southeast of Rudiškės village	68336
14	Trakai district, 5 km to the south of Paluknis	68337
15–19	Kaunas district, Arlaviškės	68346
20, 21	Anykščiai district, Svėdasai	68343
22	Vilnius district, 4 km to the east of Nemenčinė	68353
23	Vilnius district, ~2 km to the northwest of Bezdonys	68868
24, 25	Vilnius district, ~2.5 km to the west of Bezdonys	68869, 68870
26, 27	Vilnius district, ~5 km to the southwest of Bezdonys, near Lake Tapeliai	68871, 68872
28, 29	Vilnius district, ~2 km to the southwest of Bezdonys railway station	68875, 68876
30	Vilnius district, 6 km to the east of Bezdonys	68880
31, 32	Ignalina district, 5 km to the southwest of Dūkštas	68356, 68884
33	Varėna district, ~2.5 km to the east of Zervynos	68873
34	Varėna district, ~4.5 km to the east of Zervynos	68874
35, 36	Anykščiai district, ~3.5 km to the northeast of Svėdasai	68877, 68878
37	Vilnius district, ~3 km to the northwest of Šilėnai village	68879

DB-5 (50 m × 0.32 mm; film thickness 0.25 µm) and DB-5 Wax (50 m × 032 mm, film thickness 0.25 µm) with an HP 5890II chromatograph equipped with FID. The GC oven temperature was programmed as follows: from 60 °C (isothermal for 3 min) increased to 160 °C at the rate of 5 °C/min (isothermal for 1 min) and to 250 °C at the rate of 10 °C/min, and the final temperature was kept for 3 min. The temperature of the injector and detector were 250 °C. The flow rate of the carrier gas (helium) was 1 ml/min. Analyses by GC / MS were carried out with a HP 5890 gas chromatograph equipped with an HP 5971 mass selective detector and HP 7673 split / splitless (splitless 0.75 min) injector. Mass spectra in electron mode were generated at 70 eV, 0.97 scans / second, mass range 35–650 m/z.

The percentage composition of the essential oils was computed from GC peak areas without correction factors. Qualitative analysis was based on a comparison of retention indexes and mass spectra with corresponding data in the literature [25] and the computer mass spectra libraries (Wiley and NBS 54K).

RESULTS AND DISCUSSION

Thirty-seven plant samples of *J. communis* var. *communis* were collected in 22 localities. Results are summarized in Tables 2 and 3. We found that 1–4 samples (Table 1: A, B, C1 and C2) of needle essential oils were of sabinene chemotype. Table 2 contains detailed data on these four samples. The content of

dominant sabinene (Table 2; 34.1–40.8%) in the needle essential oils under study exceeded the quantities of the second major compound α -pinene (11.7–27.8%). The third main constituent was terpinen-4-ol (6.9–9.3%) in these needle oils. The composition of the berry essential oils markedly differed from that of the needle oils. The prevailed constituent in all berry oils was α -pinene (20.3–50.6%). For better evidence, the distribution of the main compounds of leaf, unripe and ripe berry oils is presented in Figure. The unripe berry essential oils from A, B, C1 and C2 samples contained sabinene (6.3–12.3%) in the second or third position. The rest oils in this study (for samples 5–37 only characteristic compounds were identified) and formerly [11–14] analysed unripe berry oils from juniper with needles biosynthesizing α -pinene chemotype oils included only 1.5–1.9% of sabinene (Tables 2 and 3). The ripe berry essential oils were similar in all investigated plants (Table 3) and were rich in α -pinene. The content of sabinene in all ripe berry oils varied from 0.4 to 2.9%.

The content of compounds with sabinane and pinane carbon skeletons in needle, unripe and ripe berry essential oils of different chemotypes varied markedly (Table 4). The needle oils included 36.5–46.0% constituents with the sabinane carbon skeleton (SCS) and 13.0–28.9% with the pinane carbon skeleton (PCS). An opposite ratio of the corresponding compounds were found in unripe (6.7–15.3% of SCS and 24.6–50.8% of PCS) and ripe berry (2.1–3.5% of SCS and 22.6–41.4% of PCS) essential oils.

Table 2. The chemical composition (%) of leaf, unripe and ripe berry essential oils of *J. communis* L. growing wild in Lithuania^a

Compound	RI	A			B			C1			C2		
		Leaves	Unripe	Ripe									
2-Hexenal	855	0.1	3.2	0.2	0.1	—	—	tr	tr	0.1	tr	—	0.1
α-Thujene	930	2.7	1.1	0.5	0.4	0.1	0.1	0.5	0.4	—	0.1	0.2	0.3
α-Pinene	939	11.7	22.2	36.4	17.9	50.6	38.7	19.5	43.5	21.0	27.8	34.8	22.3
Camphene	954	tr	0.1	0.3	tr	0.3	0.2	—	0.1	0.4	0.2	—	0.3
Verbenene	968	tr	—	0.1	—	—	0.1	—	—	—	—	—	0.2
Sabinene	975	40.8	12.3	1.6	37.9	6.3	2.9	34.1	8.2	2.5	38.7	10.2	2.9
β-Pinene	979	0.5	2.0	2.8	tr	0.2	0.7	0.4	0.1	0.5	0.5	2.2	0.4
Myrcene	991	3.9	7.1	11.5	2.6	19.6	18.7	3.1	13.5	17.4	2.9	6.0	7.8
δ-2-Carene	1002	—	—	—	—	—	—	0.4	—	—	—	—	—
α-Phellandrene	1003	0.3	0.2	0.2	0.8	0.1	tr	0.3	0.1	—	tr	1.2	0.2
δ-3-Carene	1011	1.8	tr	tr	1.4	0.1	0.1	0.4	0.1	—	0.2	—	—
α-Terpinene	1017	3.0	1.9	1.0	2.0	0.4	0.5	2.5	0.2	0.5	1.2	0.9	1.1
p-Cymene	1025	0.5	0.1	0.4	0.2	tr	0.3	0.4	0.1	0.3	0.1	0.1	1.3
Limonene	1029	2.6	1.8	2.5	2.6	2.7	2.7	2.4	2.5	1.1	2.1	2.2	2.3
β-Phellandrene	1030	0.8	0.5	1.2	1.0	0.2	0.6	1.1	0.3	1.1	0.9	0.5	0.2
(E)-β-Ocimene	1050	0.1	—	—	0.1	—	—	0.3	—	—	0.1	—	—
γ-Terpinene	1060	4.1	3.3	1.8	3.2	0.8	0.9	3.9	1.0	1.9	2.2	1.7	1.6
cis-Sabinene hydrate	1070	1.1	0.8	0.1	0.6	0.2	0.5	0.7	0.2	—	0.4	0.1	—
cis-Linalool oxide	1072	—	—	—	—	0.2	—	—	0.1	—	—	tr	—
Terpinolene	1089	3.3	2.0	1.3	2.4	1.2	1.5	2.9	1.4	0.6	1.5	1.7	1.2
p-Cymenene	1091	—	—	—	—	—	—	—	—	0.2	—	—	—
Linalool	1097	—	0.2	0.5	0.1	0.1	1.2	—	tr	—	—	—	—
trans-Sabinene hydrate	1098	1.0	1.1	—	0.4	0.1	—	0.5	tr	—	0.3	0.1	—
Isoamyl-2-methylbutyrate	1100	0.3	—	—	0.1	—	—	—	—	—	—	—	—
α-Thujone	1102	0.2	—	—	tr	—	—	0.1	—	—	0.4	—	—
p-Mentha-1,3,8-triene	1110	—	—	—	tr	0.1	0.4	—	—	—	—	—	0.2
β-Thujone	1114	—	—	—	—	—	—	0.4	—	—	0.2	—	—
3-Methyl-3-butenoxy isovalerate	1115	0.4	0.1	—	—	—	—	—	0.2	—	—	0.1	—
α-Fenchol	1117	—	—	0.1	—	—	0.2	—	—	tr	—	—	—
cis-p-Mentha-2-en-1-ol	1122	0.2	0.8	0.4	0.5	0.1	0.2	0.6	0.2	—	0.3	0.1	tr
α-Campholenal	1126	—	—	0.2	—	—	0.2	—	—	0.2	—	—	0.7
cis-p-Mentha-2,8-dien-1-ol	1137	—	—	0.2	—	—	—	—	—	—	—	—	0.2
trans-Pinocarveol	1139	0.4	—	0.3	tr	—	0.3	—	—	0.1	—	—	0.8
trans-p-Menth-2-en-1-ol	1140	0.8	0.7	—	—	—	—	0.5	0.3	—	—	0.2	—
3-Methyl-2-butenoxy-2-methyl butanoate	1141	0.5	tr	—	0.3	—	—	—	—	—	—	—	—
trans-Verbenol	1145	0.1	tr	0.2	tr	tr	0.2	—	tr	—	tr	—	0.2
Camphor	1146	—	—	0.1	—	—	0.2	—	tr	—	0.1	—	0.2
Camphephen hydrate	1152	—	—	0.1	—	—	tr	—	—	—	tr	—	tr
p-Menth-1(7),2-en-8-ol	1156	tr	—	—	—	—	—	tr	—	tr	—	—	tr
Sabina ketone	1159	0.1	—	—	—	—	—	—	—	—	—	—	0.1
Borneol	1169	—	tr	1.1	0.1	tr	1.1	—	0.1	0.8	0.1	—	0.7
p-Menta-1,5-dien-8-ol	1170	tr	—	0.5	—	tr	0.7	—	tr	1.0	—	—	1.4
Terpinen-4-ol	1177	9.3	13.1	8.7	7.1	2.4	3.2	7.9	3.5	9.6	6.9	5.4	7.1
p-Cymen-8-ol	1183	tr	0.1	0.6	0.1	tr	0.4	0.1	0.2	0.1	0.1	0.1	2.3
α-Terpineol	1189	0.9	1.1	4.3	0.6	0.5	2.0	0.6	0.7	2.9	0.6	0.7	5.0
Myrtenol	1196	—	—	0.6	—	—	0.3	0.1	—	0.1	0.1	—	0.6
cis-Piperitol	1197	0.2	0.3	0.2	0.2	tr	—	0.1	tr	0.1	0.1	—	0.2
Dodecane	1200	—	—	—	—	—	—	0.1	—	—	tr	—	—

Table 2 (continued)

Compound	RI	A			B			C1			C2		
		Leaves	Unripe	Ripe									
<i>trans</i> -Dihydro carvone	1201	—	—	0.3	—	—	tr	—	—	—	—	—	0.6
Verbenone	1205	—	—	0.8	—	—	0.6	—	—	0.8	—	—	1.6
<i>trans</i> -Piperitol	1208	0.3	0.3	—	0.1	—	—	0.2	0.1	—	tr	—	—
<i>trans</i> -Carveol	1217	—	tr	0.1	—	tr	0.1	—	0.1	—	—	—	0.1
<i>endo</i> -Fenchyl acetate	1220	—	—	—	tr	tr	—	—	tr	—	—	—	—
Citronellol	1226	—	—	0.4	tr	tr	0.4	—	tr	—	—	—	tr
Nerol	1229	—	—	—	—	—	0.1	—	—	—	—	—	—
Methyl thymol	1235	tr	—	—	tr	—	—	0.2	tr	—	0.2	—	tr
<i>trans</i> -Chrysanthenyl acetate	1238	0.1	0.1	0.1	—	tr	—	—	—	—	—	—	—
Carvacrol, methyl ether	1245	0.1	tr	—	0.1	—	—	0.2	tr	—	0.1	—	—
Piperitone	1253	tr	tr	—	tr	—	—	tr	—	—	—	—	—
Methyl citronellate	1261	0.3	0.7	0.8	0.1	1.8	0.6	—	0.9	0.1	tr	0.3	0.5
Geranal	1267	—	—	—	—	0.1	—	—	tr	—	—	—	—
α -Terpinen-7-al	1285	—	—	—	0.1	—	—	—	—	—	—	—	0.1
Bornyl acetate	1289	0.3	0.6	0.9	0.5	1.3	1.1	0.6	1.1	0.7	0.5	1.1	0.9
Thymol	1290	tr	tr	0.1	—	—	—	—	—	tr	—	tr	0.1
<i>trans</i> -Sabinyl acetate	1291	—	—	—	0.1	—	—	0.2	—	—	0.1	—	—
(2E, 4Z)-Decadienal	1293	tr	—	—	tr	—	—	—	—	—	—	—	—
2-Undecanone	1294	—	—	—	—	—	0.1	0.1	—	—	0.1	—	0.1
Thujanol acetate	1295	—	—	—	—	—	—	0.1	—	—	0.1	—	—
<i>trans</i> -Pinocarvyl acetate	1298	0.1	0.2	—	—	—	tr	—	0.1	—	—	—	—
Terpinen-4-ol acetate	1299	tr	—	—	tr	—	—	0.1	—	—	0.4	—	—
Tridecane	1300	—	—	tr	—	—	—	0.1	—	—	—	—	—
Myrtenyl acetate	1327	tr	tr	0.1	0.1	tr	0.1	1.2	0.1	0.1	—	—	0.1
δ -Elemene	1338	0.1	0.1	0.1	0.1	0.1	0.1	0.7	0.2	0.1	0.4	—	0.1
<i>trans</i> -Carvyl acetate	1342	—	tr	—	—	tr	—	—	tr	—	—	—	—
α -Terpinyl acetate	1349	0.1	0.3	0.4	tr	0.1	—	0.2	0.2	—	0.1	0.2	0.1
Citronellyl acetate	1353	tr	tr	tr	0.2	0.3	0.1	0.1	0.2	0.1	0.1	tr	0.3
Neryl acetate	1362	—	—	—	0.1	—	—	—	—	—	—	—	—
α -Copaene	1377	tr	tr	tr	tr	—	tr	0.1	tr	0.1	tr	—	0.1
Geranyl acetate	1379	—	—	—	—	—	0.1	0.1	—	—	tr	—	tr
<i>trans</i> -Myrtanol acetate	1387	0.1	0.1	tr	0.1	tr	—	0.6	tr	—	0.5	—	tr
β -Elemene	1391	0.2	0.3	0.3	0.5	0.3	0.2	0.3	0.2	0.3	0.4	0.4	0.3
Longifolene	1408	—	—	tr	tr	—	0.2	—	—	tr	—	—	0.1
β -Caryophyllene	1418	0.1	0.1	0.3	0.2	0.5	0.1	0.1	0.4	0.2	0.2	0.3	0.2
β -Ylangene	1421	0.1	0.1	—	—	—	—	—	—	—	—	—	—
β -Gurjunene	1434	—	tr	—	—	tr	tr	0.1	tr	—	tr	tr	tr
γ -Elemene	1437	tr	—	0.1	0.3	0.3	1.1	0.9	0.5	1.1	0.1	0.3	0.2
(Z)- β -Farnesene	1443	tr	—	0.1	—	0.1	—	—	0.1	—	—	—	—
<i>cis</i> -Muurola-3,5-diene	1450	tr	tr	—	0.1	—	—	tr	—	—	tr	—	—
<i>trans</i> -Muurola-3,5-diene	1454	tr	tr	tr	0.1	tr	tr	tr	tr	—	tr	—	tr
α -Humulene	1455	0.1	0.1	0.3	0.2	0.5	0.2	0.2	0.4	0.3	0.3	0.3	0.2
(E)- β -Farnesene	1457	—	—	—	tr	—	0.3	tr	—	tr	tr	0.1	—
<i>cis</i> -Muurola-4(14),5-diene	1467	tr	tr	tr	0.2	tr	—	0.1	0.1	tr	—	0.1	tr
<i>trans</i> -Cadina-1(6),4-diene	1477	tr	tr	tr	tr	0.1	tr	tr	tr	tr	tr	—	0.1
γ -Murolene	1480	tr	0.1	tr	0.2	0.1	0.1	0.1	tr	0.4	0.1	0.1	0.1
Germacrene D	1485	0.1	0.5	0.4	0.2	0.4	0.3	0.7	0.5	0.7	0.5	1.8	0.6
Citronellyl isobutyrate	1487	—	—	—	—	—	—	—	—	0.5	—	—	—

Table 2 (continued)

Compound	RI	A			B			C1			C2		
		Leaves	Unripe	Ripe									
(E)- β -Ionone	1489	tr	—	—	tr	—	tr	—	—	tr	—	0.2	0.4
β -Selinene	1490	—	—	—	0.1	tr	—	tr	tr	—	tr	—	—
epi-Cubebol	1493	tr	0.1	—	0.1	0.1	—	tr	0.1	—	0.2	0.2	—
trans-Muurola-4-(14),5-diene	1494	0.3	—	—	0.2	—	0.1	—	—	tr	tr	—	0.1
Bicyclogermacrene	1499	—	—	—	—	0.1	0.2	—	tr	—	—	—	—
α -Murolene	1500	0.2	0.2	0.3	0.5	0.1	0.2	0.4	0.1	0.9	—	0.2	0.6
β -Bisabolene	1506	tr	tr	—	0.2	—	—	—	—	—	—	—	—
γ -Cadinene	1514	0.1	0.2	0.2	0.6	0.2	0.3	0.2	0.2	1.1	0.1	1.2	1.8
endo-1-Bourbonalol	1520	tr	0.2	—	—	0.2	0.1	—	0.2	0.1	—	—	—
δ -Cadinene	1523	0.7	1.2	0.9	1.8	0.5	0.1	0.8	0.7	2.9	0.7	0.6	2.7
Citronellyl butyrate	1532	0.2	0.5	0.2	—	0.1	0.1	0.2	0.1	0.3	0.2	0.6	0.1
10-epi-Cubebol	1534	—	—	—	—	0.2	—	—	—	0.1	—	—	—
trans-Cadina-1,4-diene	1535	tr	tr	—	0.1	tr	0.1	tr	tr	tr	—	0.2	0.1
α -Cadinene	1539	tr	tr	0.1	0.3	0.1	0.2	0.2	tr	0.5	—	—	0.1
cis-Sesquibabinene hydrate	1544	—	—	—	—	—	—	0.1	—	—	0.1	—	—
α -Calacorene	1546	—	—	—	tr	—	0.1	0.1	—	0.2	—	—	0.1
Elemol	1550	0.2	0.4	0.2	0.3	0.8	0.4	0.6	0.7	0.5	0.4	0.8	0.5
Germacrene B	1561	tr	0.1	0.1	0.2	0.2	0.6	0.5	0.3	0.4	0.4	0.2	0.2
(E)-Nerolidol	1563	—	tr	—	—	tr	—	—	—	—	—	—	—
(Z)-3-Hexenyl benzoate	1566	—	—	—	0.1	tr	—	0.1	tr	—	—	0.2	—
Germacrene D-4-ol	1576	0.5	0.4	0.6	0.7	0.6	—	—	0.5	0.2	0.2	—	0.4
Spathulenol	1578	0.3	0.4	0.3	0.2	0.2	0.7	0.7	0.3	1.2	0.6	1.0	0.5
Caryophyllene oxide	1583	0.1	0.1	0.2	0.4	—	0.3	tr	tr	0.9	tr	—	0.2
Viridiflorol	1593	0.6	0.8	—	—	—	—	—	—	—	—	—	—
Salvial-4(14)en-1-one	1595	—	—	—	—	—	—	—	—	0.4	—	—	—
Ethyl dodecanoate	1595	tr	tr	—	—	0.1	0.1	0.1	0.1	—	0.1	—	0.1
β -Oplopenone	1607	—	0.1	0.1	—	—	—	—	—	0.1	—	—	—
Humulene epoxide II	1608	0.2	0.2	0.2	—	—	0.4	—	—	1.2	—	—	0.2
1,10-di-epi-Cubenol	1619	—	0.2	0.1	0.1	—	—	—	—	0.3	—	—	tr
1-epi-Cubenol	1629	0.1	0.1	0.2	0.3	0.4	0.4	0.1	0.3	0.8	0.4	0.2	0.3
γ -Eudesmol	1632	tr	tr	0.1	—	—	0.3	0.1	—	0.5	—	tr	0.2
epi- α -Cadinol	1640	0.2	0.8	1.1	0.9	0.1	0.7	—	0.1	2.1	0.4	0.2	0.7
epi- α -Murolol	1642	0.3	0.7	0.9	0.7	1.1	0.6	0.8	1.0	2.4	0.5	3.0	0.6
α -Murolol	1646	0.1	0.3	0.7	0.5	0.1	0.3	tr	0.1	1.2	0.4	1.2	0.4
α -Cadinol	1654	1.0	2.8	4.4	3.5	1.6	2.3	1.3	2.3	7.6	1.1	5.9	6.4
Selin-11-en-4- α -ol	1660	—	—	0.1	—	0.1	—	—	0.1	—	—	—	tr
14-hydroxy-9-epi- β -Caryophyllene	1670	tr	0.3	0.3	0.2	—	0.1	0.2	tr	1.1	0.2	—	0.2
n-Tetradecanol	1673	—	—	—	—	—	—	—	—	1.5	—	—	—
Khusinol	1680	—	tr	—	—	tr	—	—	tr	—	—	—	—
Eudesma-4(15),7-dien-1- β -ol	1688	—	tr	0.5	0.1	—	0.2	—	—	0.8	—	—	0.7
Shyobunol	1689	—	—	—	—	—	—	0.4	—	—	—	0.9	—
(6Z, 2Z)-Farnesol	1697	tr	0.1	tr	—	—	—	—	—	—	—	—	tr
Eudesm-7(11)-en-4-ol	1700	—	tr	0.5	—	—	—	0.3	—	—	0.1	—	0.2
14-hydroxy- α -Humulene	1714	—	—	0.1	0.1	—	0.3	0.2	tr	tr	—	0.1	0.3
Nootkatol	1715	—	0.1	0.1	—	tr	tr	—	—	—	—	—	—
Olopantanone	1740	—	—	—	—	—	0.5	—	—	—	—	—	—
17-hydroxy- δ -Cadinene	1803	—	—	—	—	—	tr	—	—	—	tr	tr	0.1

Table 2 (continued)

Compound	RI	A			B			C1			C2		
		Leaves	Unripe	Ripe									
Nootkatone	1806	–	0.1	0.1	–	tr	0.1	–	0.1	–	–	–	–
Cyclopentadecanolid	1834	tr	0.1	0.2	tr	tr	0.4	0.1	tr	0.2	tr	0.2	0.3
Manool oxide	1987	0.2	0.1	–	–	–	–	tr	–	–	–	0.1	tr
epi-13-Manool oxide	2010	–	–	–	–	–	–	tr	–	–	–	0.1	tr
Abietatriene	2057	–	–	0.1	–	tr	0.1	0.1	0.1	tr	tr	0.1	0.1
Octadecanol	2078	tr	–	tr	–	–	–	–	–	–	–	–	–
Abietadiene	2088	tr	–	tr	tr	–	tr	0.1	tr	tr	tr	0.1	0.1
Sandaracopimaral	2185	–	–	0.1	–	–	tr	–	–	–	–	–	–
dehydro-Abietal	2275	–	–	–	–	–	tr	tr	tr	tr	tr	0.1	tr
Total		98.9	90.1	98.5	97.9	98.9	95.7	98.7	89.7	97.6	98.5	91.1	87.1

^a tr – traces (<0.05%), letters indicate localities (see Table 1).

Table 3. Comparison of the content (%) of characteristic compounds in essential oils of wild *J. communis* L.^a

Compound	Needles		Unripe berries		Ripe berries	
	Pinene chemotype (n = 45)	Sabinene chemotype (n = 4)	Pinene chemotype (n = 23)	Sabinene chemotype (n = 4)	Pinene chemotype (n = 45)	Sabinene chemotype (n = 4)
α-Pinene	41.2–66.5	11.0–27.8	42.4–67.4	22.2–50.6	21.0–51.9	20.3–38.7
β-Pinene	tr–3.9	tr–0.5	1.2–2.5	0.1–2.2	0.3–2.1	0.4–2.8
Limonene	0–3.3	2.1–2.6	1.1–2.0	1.8–2.7	1.1–5.3	1.1–2.7
Sabinene	0.9–9.1	34.1–40.8	1.5–1.9	6.3–12.3	0.4–2.5	1.6–2.9
Myrcene	2.1–4.7	2.6–3.9	4.3–12.8	6.0–19.6	3.6–19.6	7.8–18.7
β-Phellandrene	2.2–12.5	0.8–1.1	0.7–2.5	0.2–0.9	0.2–1.8	0.2–1.2
Terpinen-4-ol	tr–2.8	6.9–9.3	0.1–2.1	2.4–13.1	0.4–9.6	3.2–9.6
α-Cadinol	1.0–8.7	1.0–3.5	2.8–8.2	1.6–5.9	1.4–9.6	2.3–7.6

^a n – the number of essential oils (including earlier investigated oils [11–14]), tr – traces (<0.05%).

Table 4. The content (%) of terpenoid groups in *J. communis* L.^a essential oils

Groups of compounds	Needles (sabinene chemotype)				Unripe berries (α-pinene chemotype)				Ripe berries (α-pinene chemotype)			
	A	B	C1	C2	A	B	C1	C2	A	B	C1	C2
Monoterpene hydrocarbons	76.1	72.4	72.1	78.5	54.6	82.6	71.5	61.7	61.6	68.4	47.5	42.3
Oxygenated monoterpenes	15.9	10.9	15.6	12.0	20.9	7.2	8.2	8.8	22.3	14.0	17.5	24.0
Sesquiterpene hydrocarbons	2.0	6.0	5.5	3.1	3.0	3.5	3.7	6.1	3.0	4.5	9.2	8.0
Oxygenated sesquiterpenes	3.5	8.0	4.7	4.6	8.2	5.5	5.9	13.5	11.1	8.0	21.6	12.1
Aliphatic monoterpenoids	4.5	3.1	3.7	3.3	8.4	22.1	14.8	6.9	13.4	21.2	18.4	8.7
Pinane skeleton	13.0	18.1	21.7	28.9	24.6	50.8	43.8	37.0	41.4	41.0	22.6	26.2
Cadinane skeleton	3.0	10.1	4.1	3.8	6.6	4.3	5.0	13.1	9.1	5.8	20.5	14.3
Menthane skeleton	26.5	20.8	24.2	16.7	26.4	8.5	10.9	14.9	24.1	13.5	19.4	25.3
Sabinane skeleton	46.0	39.4	36.5	40.3	15.3	6.7	8.8	10.6	2.1	3.5	2.5	3.3

^a Letters indicate growth localities.

Only thirty from 133 identified constituents were found in all A – C2 oils (Table 2). Monoterpene hydrocarbons were the largest group of compounds in the above oils (72.1–78.5% in needle oils, 54.6–82.6% in unripe and 42.3–68.4% in ripe berry oils) (Table 4). The variability of the content of compound groups was lowest in the needle oils and the largest in the unripe berry oils. The identified constituents of essential oils of separate juniper parts comprised 87.1–98.9% (Table 2).

Junipers with needles producing essential oils of sabinene chemotype comprised <10% of the investigated plants.

Unripe and ripe berries of these plants biosynthesized oils of α-pinene chemotype. All parts of the rest ~90% of analysed junipers produced α-pinene-chemotype essential oils.

Myrcene, terpinen-4-ol, β-pinene and limonene content in ripe berry oils from juniper with needles producing essential oils rich in sabinene (Figure, Table 2) satisfied pharmaceutical recommendations [3]. Only α-pinene in two from four ripe berry oils (Table 2) exceeded the recommended limit. About ~60% of ripe berry oils from juniper with needles producing essential oils rich in α-pinene contained a larger quantity of this compound.

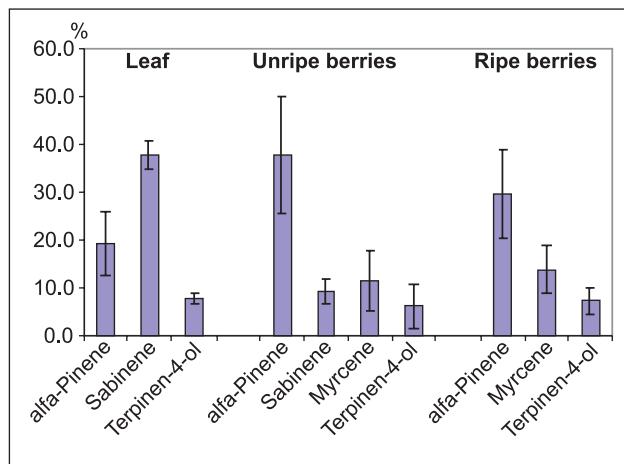


Figure. The mean values of major constituents in junipers producing two chemotypes of essential oils

CONCLUSIONS

It was found for the first time that needles produced essential oils of sabinene chemotype and berries of α -pinene chemotype from the same juniper growing wild in Lithuania. The *Juniperus communis* L. var. *communis* with leaves (needles) producing sabinene-chemotype essential oils were found only in three localities from the 34 investigated habitats, beside plants with needles biosynthesizing α -pinene-chemotype oils.

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DVIEJŲ CHEMOTIPŲ ETERINIAI ALIEJAI, BIOSINTETINAMI TO PATIES LIETUVOJE AUGANČIO LAUKINIO KADAGIO (*JUNIPERUS COMMUNIS* L.)

S a n t r a u k a

Pirmą kartą buvo nustatyta, kad iš to paties kadagio spyglių ir uogų išskirti eteriniai aliejai yra skirtingo chemotipo. Trijose iš trisdešimt keturių augaviečių rasti *Juniperus communis* L. var. *communis*, kurių spygliuose sintetinasi sabineno chemotipo eteriniai aliejai. Visų kitų tirtų kadagijų spyglių aliejai buvo α -pineno chemotipo. Keturiuose iš keturiasdešimt devynių (išskaitant ir anksčiau tirtus) kadagio spyglių eterinių aliejų vyravo sabinenas (34,1–40,8 %), α -pinenas (11,7–27,8 %) ir terpinen-4-olis (6,9–9,3 %). α -Pinenas (41,2–66,5 %) buvo pagrindinis komponentas visuose kituose spyglių aliejuose. Visuose tirtuose uogų eteriniuose aliejuose vyravo α -pinenas (21,0–67,4 %). Neprinokusią uogą aliejuoose nuo krūmų su spygliais, sintetinčiais sabineno chemotipo aliejus, kiti vyraujantys junginiai buvo sabinenas (6,3–19,6 %), mircenas (4,3–12,8 %) ir terpinen-4-olis (13,1 %), o prinokusią uogą aliejuo-se – mircenas (7,8–18,7 %) ir terpinen-4-olis (3,2–9,6 %). Visuose prinokusiu uogą aliejuoose buvo 0,4–2,9 % sabineno.