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α-Pinene chemotype of leaf (needle) essential oils of *Juniperus communis* L. growing wild in Vilnius district

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The chemical composition of seven leaf (needle) essential oils produced by individual plants of *J. communis* growing wild in Vilnius district was determined by GC and GC/MS. α-Pinene dominated in all oils (38.5–59.9%). The second main compound in six oils was β-phellandrene (4.1–11.4%) and α-cadinol in one oil (8.7%). The third major constituent in four oils was α-cadinol (3.3–8.0%) and δ-cadinene (6.2%), sabinene (4.3%), δ-3-carene (3.6%) in other oils. According to the ratios of mono- and sesquiterpenoids, the leaf oils may be divided into two groups: I ~5:1 (4 oils) and II ~2:1 (3 oils). The identified 143 constituents comprised 96.2–99.4% of the leaf essential oils.

Key words: *Juniperus communis* L., Cupressaceae, composition of essential oil, α-pinene chemotype, α-pinene, β-phellandrene, α-cadinol, δ-cadinene

INTRODUCTION

The autors of [1] proposed that *Juniperus communis* L. are of recent origin after the late Pleistocene period (*ca*. 12,000 BP) in the northern hemisphere. The above regularity possibly exists for wild juniper in Lithuania [2]. The leaf essential oils from the eastern hemisphere *J. communis* were analysed in Croatia, Greece, Iran, Italy and Sweden (Table 1) [3–6]. The essential oils from Iran and Italy contained sabinene (40.7–41.3%), α-pinene (13.4–19.9%) and terpinen-4-ol (8.7–12.3%) as major constituents. The oil from Croatia also included these compounds as the main constituents, but their contents were lower (Table 1). α-Pinene (41.3%), sabinene (17.4%), limonene (4.2%) and terpinen-4-ol (2.8%) dominated in the essential oil from Greece. The leaf essential oil from Sweden markedly differed from the oil from Croatia, Iran, Italy and Greece. Sabinene and terpinen-4-ol were not presented among the five main constituents in the oil from Sweden. The above oil included limonene, β-phellandrene, δ-3-carene beside α-pinene and myrcene as the major constituents (Table 1).

The clustering data of RAPD molecular markers showed that the *communis* complex formed three groups: (1) *J. communis* var. *communis* and *J. communis* var. *saxatilis*, (2) *J. communis* var. *sibirica* (syn. *J. sibirica*) and (3) *J. communis* var. *oblonga* (syn. *J. oblonga*) [6]. *J. sibirica* earlier was often included in the species *J. communis* var. *montana* [7]. The main compounds in the leaf oils of *J. sibirica* from Italy [4] and of *J. oblonga* from Russia (Stavropol) [6] were α-pinene, sabinene and terpinen-4-ol as in Croatian oil of *J. communis* (Table 1) [5]. More than half of the essential oils of *J. communis* presented in Table 1 contained terpinen-4-ol as the third main constituent. The second major constituent in the leaf oils was sabinene or α-pinene (except Swedish oil, Table 1), while in that possition in the juniper berry essential oils was myrcene in Lithuania [8], Poland [9] and other countries [10]. The amounts of myrcene in the leaf oils were markedly smaller than in berries. Myrcene was found only in several leaf oils as the fourth or fifth major constituent (Table 1).

The chemical composition of several leaf and berry essential oils was similar, but phytotherapeutists frequently recommend berry oils and sometimes oils of twigs with berries for healing [11–16]. The other bioactive juniper preparations mostly had nearly the same healing power as the juniper essential oils [3, 17–19]. Most constituents of leaf essential oils are bioactive [14, 16, 20–31]. The main constituent, α-pinene, exhibited antimicrobial and antifungal properties [20, 24]. cis-Verbenol (a metabolite of α-pinene) in human organism inhibited bone resorption [16]. Both α- and β-pinenes were used for synthesis of pheromones [32]. Limonene, myrcene, δ-cadinene, farnesene, β-caryophyllene and farnesol have antitumor activity and some of them are used in cancer therapy [21–24]. Antimicrobial activity was determined for limonene, δ-3-carene, terpinen-4-ol, α-terpineol and β-caryophyllene beside α-pinene [24, 28, 31]. Limonene, myrcene, γ-terpinene, p-cymene

Table 1. **The major constituents (%) of leaf (needle) essential oils of juniper communis complex plants**

Juniperus species (origin)	Ref.	The first	The second	The third	The fourth	The fifth
J. communis (Iran, altitude 2100 m)	[3]	Sabinene, 40.7	α-Pinene, 12.5	Terpinen-4-ol, 12.3	trans-Sabinene hydrate, 3.8	α-Phellandrene, 3.7
J. communis (Italy)	[4]	Sabinene, 41.3	α-Pinene, 13.4	Terpinen-4-ol, 8.7	Myrcene, 3.6	Limonene, 3.0
J. communis (Croatia)	[5]	α-Pinene, 16.9	Sabinene, 12.1	Terpinen-4-ol, 7.7	β-Phellandrene, 7.3	Widdrene, 6.4
J. communis (Greece)	[4]	α-Pinene, 41.3	Sabinene, 17.4	Limonene, 4.2	Terpinen-4-ol, 2.8	Myrcene, 2.7
J. communis (Sweden)	[6]	α-Pinene, 56.8	β-Phellandrene, 6.9	Limonene, 6.9	Myrcene, 5.2	δ-3-Carene, 4.7
J. communis var. *sibirica* (Mongolia, altitude 2500 m)	[6, 7]	α-Pinene, 58.2	Germacrene D-4-ol, 6.8	β-Pinene, 4.7	Myrcene, 4.5	δ-Cadinene, 2.6
J. communis var. *sibirica* (Italy)	[4]	α-Pinene, 30.5	Sabinene, 12.4	Terpinen-4-ol, 8.3	δ-Cadinene, 2.6	α-Cadinol, 2.3
J. communis var.*oblonga* (Russia, Stavropol)	[6]	α-Pinene, 21.7	Sabinene, 13.4	Terpinen-4-ol, 6.4	Myrcene, 3.8	Limonene, 2.4
						(E,E)-Farnesol, 3.3

and α-pinene are antioxidants [25]. β-Phellandrene is a natural insecticide [30]. Myrcene, α- and β-pinene, sabinene, β-phellandrene, limonene, p-cymene, β-farnesene and β- caryophyllene are repellents or deterrents of herbivorous insects [24]. Several of the above compounds are pheromones and / or kairomones [24]. Antifungal activity was found in compounds with cadinane carbon skeleton [29]. Terpinen-4-ol exhibited a cardiovascular effect [26] and antiulcer activity [27].

The chemical composition of leaf essential oils of seven *J. communis* individual plants growing wild in Vilnius district were investigated in this study.

MATERIALS AND METHODS

Samples of individual juniper (*J. communis* L.) plants were collected in 2003 in six localities in Vilnius district: A (Bezdonys), B (Lazdënai), C (Druþilai), D (Pagiriai), E (Rûdininkai), F (Nemenèinë) and G (Bezdonys). Voucher specimens have been deposited in the Herbarium of the Institute of Botany (BILAS numbers: A-68350, B-68355, C-68341, D-68344, E-68342, F-68354 and G-68351). The essential oils were prepared by hydrodistillation (3 h) of 10 g of fresh needles. The ratio of needles and water was 1:20, essential oils were collected in 2 ml of the mixture of hexane: diethyl ether = 1:1. The yield of the essential oils of fresh needles was ~0.37%.

Analyses of the essential oils were carried out by GC and GC/MS. The separation was performed on a silica capillary column CP-Sil8CB (50 m × 0.32 mm; film thickness 0.25 μm) using an HP 5890II chromatograph equipped with FID. The GC oven temperature was programmed as follows: from 50 °C (isothermal for 5 min) increased to 90 °C at a rate of 2 °C/min and to 240 °C at a rate of 15 °C/min, and the final temperature was kept for 4 min. The temperatures of the injector and the detector were 240 °C and 250 °C, respectively. The flow rate of carrier gas (helium) was 1 ml/min. Analyses by GC/MS were carried out by HP 5890 gas chromatograph equipped with HP 5971 mass selective detector and HP 7673 split/splitless injector. Mass spectra in electron mode were generated at 70 eV.

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 times, retention indexes and mass spectra with corresponding data in the literature [33] and the computer mass spectra libraries (Wiley and NBS 54K).

RESULTS AND DISCUSSION

Seven leaf (needle) essential oils of *J. communis* individual plants growing wild in six habitats of Vilnius district contained ~200 constituents. One hun-

dred forty three compounds were identified in the oils (Table 2). All samples under study included 85 identified constituents. Twenty eight new constituents were found in the leaf oils (Table 2) beside compounds identified in the berry essential oils of juniper from Vilnius district [8]. The constituents characteristic only of the leaf oils, δ-2-carene (0.2–0.4%), (E)-β-ocimene (tr–0.3%), isopentyl butanoate (tr–0.1%), isopentyl 2-methyl butanoate (tr–0.1%), cis-3-hexenyl benzoate (tr–0.1%), n-hexadecane (tr–0.1%) and 14-hydroxy-α-humulene (tr–0.2%) were found in all investigated oils. Another 21 compounds were identified in one or several leaf oils.

According to the amounts of mono- and sesquiterpenoids, the leaf essential oils may be divided into two groups. The samples A–D contained 74.4–82.7% of monoterpenoids while the oils E–G included only 52.3–62.2% of these compounds. The quantities of sesquiterpenoids were markedly higher in the leaf oils E–G (28.1–42.2%) than in the samples A–D (12.5–20.1%). The ratios of the amounts of mono- and sesquiterpenoids were ~5:1 (A–D, the first group) and ~2:1 (E–G, the second group).

α-Pinene dominated in the leaf essential oils (Tables 2 and 3, 38.5–59.9%). The largest amounts of compounds with pinane carbon skeleton were found in samples A–C (51.4–61.0%). The leaf oils E–G included smaller amounts of the above compounds (40.3–42.6%). The essential oil D (46.7%) was in-between the oils A–C and E–G.

The second main compound in six out of seven leaf essential oils was β-phellandrene (4.1–11.4%), while this position in the juniper berry oils was taken up by myrcene (4.8–19.6%) [8]. β-Phellandrene (among four major constituents) was identified in juniper leaf oils from Sweden and Croatia (Table 1) [5, 6]. Myrcene was the fourth in the leaf oil B (3.0%) and the fifth in the samples A and C (2.3%). This compound was the fourth major constituent in the juniper leaf essential oils from Sweden [6] and Italy [4] (Table 1). The leaf oil D (19.7%) contained the largest amount and the oil F (7.7%) included the smallest quantity of compounds with menthane carbon skeleton (which have both phellandrenes). The amounts of the above constituents in other five leaf oils varied from 12.8 to 16.0%.

Table 2. **Chemical composition (%) of leaf (needle) essential oils of *Juniperus communis* L. growing wild in Vilnius district**

Compounds	RI	A	B	C	D	E	F	G
2-Hexanal	854	0.1	0.1	0.1	tr	0.3	tr	0.1
Xylene	855			0.1	tr	tr		
Tricyclene	927	tr	0.1	0.1	tr	0.1	tr	0.1
α-Thujene	931	tr	tr	0.1	0.1	tr	tr	tr
α-Pinene	**939**	**49.0**	**59.9**	**54.6**	**43.5**	**41.2**	**38.5**	**40.2**
Camphene	954	0.3	0.4	0.4	0.5	0.3	0.3	0.3
Verbenene	968	0.2	tr	0.2	0.1	0.2	0.2	tr
Sabinene	975	1.5	1.3	**3.0**	**4.3**	1.2	0.9	1.2
β-Pinene	980	0.8	0.8	1.1	2.1	0.8	0.9	0.6
Myrcene	991	**2.3**	**3.0**	**2.3**	2.5	2.2	1.6	2.2
δ-2-Carene	1001	0.4	0.3	0.3	0.4	0.2	0.3	0.3
α-Phellandrene	1003	2.8	2.3	1.2	2.5	1.7	1.1	1.3
δ-3-Carene	1011	1.6	0.5	**3.6**	2.8	3.0	2.7	1.1
α-Terpinene	1017	tr	tr	0.3	0.5	tr	0.1	tr
p-Cymene	1025	0.1	0.3	0.2	0.1	0.2	0.2	0.2
β-Phellandrene	**1029**	**9.1**	**8.3**	**4.1**	**5.7**	**6.6**	**4.6**	**11.4**
Limonene	1030			2.1	2.0	**3.3**		
(E)-β-Ocimene	1050	tr	tr	tr	0.3	tr	tr	tr
γ-Terpinene	1060	0.1	0.1	0.4	1.0	0.1	tr	0.1
Isopentyl butanoate	1058	0.2	0.1	0.5	tr	0.8	0.1	0.1
cis-Sabinene hydrate	1068			0.1	0.2			
Terpinolene	1089	1.2	1.2	1.4	2.0	1.1	1.0	1.5
trans-Sabinene hydrate	1097			0.1	0.2		tr	
Linalool	1098	tr	tr	0.1	tr	0.1	tr	tr
n-Undecane	1100	tr	tr				tr	tr
Isopentyl 2-methyl butanoate	1101	tr	0.1	tr	0.1	tr	tr	0.1
cis-Thujone	1102				0.1			
Isopentyl isovalerate	1103	0.1	0.3	0.1	tr	0.4	0.2	0.2
3-Methyl-3-butenyl 3-methyl butanoate	1115	0.1	0.2	0.1	0.3	0.3	0.1	0.1

Table 2 continued

α-Campholenal	1126	0.2	0.1	0.2	0.1	tr	0.1	tr
trans-Limonene oxide	1137			0.1				
trans-Pinocarveol	1139	0.2	tr	0.2	tr	tr	0.1	0.2
trans-p-Menth-2-en-1-ol	1140	tr			0.2			0.1
Camphor	1143		0.1	tr	0.1	0.1	tr	
trans-Verbenol	1145	0.1	tr	0.2	tr	tr	tr	0.1
Citronellal	1153			0.2	0.1	tr		
Pinocarvone	1165	tr	tr	0.1			tr	
Borneol	1169	tr	0.1	0.1	0.1	0.1	0.1	0.1
p-Mentha-1.5-dien-8-ol	1170	0.4	tr	0.3	tr	0.1	tr	0.1
Terpinen-4-ol	1177	0.5	0.3	1.5	2.8	0.3	0.2	0.3
m-Cymen-8-ol	1180	0.1		0.1	0.1	tr		tr
p-Cymen-8-ol	1183	0.1	tr	0.1	0.1	0.1	tr	0.2
α-Terpineol	1189	1.2	0.4	0.6	2.0	1.1	0.2	0.4
Myrtenol	1196	0.2	tr	0.2	0.1	0.1	tr	0.1
trans-dihydro-Carvone	1200	tr	tr			0.1	tr	0.2
Verbenone	1205	0.2						
trans-Piperitol	1208	tr			0.1			0.1
trans-Carveol	1217	0.1	tr		tr		tr	
Citronellol	1226			0.2		0.1	0.1	
cis-para-Mentha-(7), 8-dien-2-ol	1231	tr	tr		0.1	tr		0.1
Thymol methyl ether	1235	tr	tr	tr	0.2	0.2	tr	
trans-Chrysanthenyl acetate	1238	0.2		0.2			0.2	
Carvone	1242	tr		0.1	0.1	tr		
cis-Myrtanol	1254			0.1	0.1			0.1
trans-Myrtanol	1260	0.1	0.1	0.1			tr	tr
Methyl citronellate	1261	0.3	0.1	0.4	0.7	0.7	tr	0.3
Bornyl acetate	1288	0.6	0.9	0.8	1.4	0.7	0.7	0.9
p-Cymen-7-ol	1291	0.1	tr				tr	0.1
2-Undecanone	1294			0.2	0.1	0.1		0.1
Carvacrol	1298	0.2	0.1	tr	tr	tr	0.1	tr
n-Tridecane	1300	0.1	0.1				tr	0.1
cis-Pinocarvyl acetate	1309	0.1	tr	0.5	0.4	0.1	0.2	0.6
Isoamyl benzyl ether	1310			tr	tr	tr		
trans-Carvyl acetate	1337		tr	0.2			tr	tr
δ-Elemene	1339	0.1	0.1	0.2	0.2	0.1	0.4	0.2
α-Terpinyl acetate	1350	tr	tr	0.3	0.4	0.1	0.3	tr
α-Cubebene	1352	0.1	0.1			0.1	tr	0.1
Citronellyl acetate	1353	tr	tr	0.1	tr	tr	0.2	tr
α-Copaene	1377	0.2	0.1	tr	0.1	0.1	0.1	0.1
trans-Myrtanol acetate	1387	0.4	0.1	0.5	0.5	0.3	0.2	0.6
b-Bourbonene	1388	0.1	0.1	tr	tr	tr	0.1	0.1
b-Cubebene	1389	0,1	0.1	0.1	0.1	0.1	0.2	0.1
β-Elemene	1391	0.6	0.5	0.4	0.8	1.3	1.6	0.9
Longifolene = Junipene	1408	0.1	0.1	tr	tr	tr	tr	tr
β-Caryophyllene	1418	0.2	0.1	0.3	0.4	0.3	0.6	0.1
2,5-dimethoxy-p-cymene	1423	tr	tr	tr	tr	0.1	tr	tr
α-Ionone	1430	tr	tr	tr	tr	tr	tr	tr
β-Gurjunene	1432	0.1	0.1	0.1	0.1	tr	0.2	0.1
γ-Elemene	1437	0.9	0.5	0.3	1.0	0.1	0.7	0.6
cis-Muurola-3,5-diene	1450	0.1	tr	tr	tr	0.2	0.2	0.1
trans-Muurola-3,5-diene	1454	0.1	0.1	tr	0.1	0.1	0.1	0.2
α-Humulene	1455	0.2	0.2	0.3	0.4	0.3	0.6	0.2
(E)–β–Farnesene	1457	tr	tr	tr	tr	tr	0.1	tr
cis-Muurola-4(14), 5-diene	1467	0.1	0.2	0.1	0.1	0.3	0.5	0.3
trans-Cadina-1(6), 4-diene	1477	0.2	0.1	tr	0.1	0.2	0.3	0.2

γ-Muurolene	1478	0.2	0.2	0.1	0.2	0.3	0.5	0.4
Germacrene D	1485	0.8	0.4	0.5	0.9	1.0	2.1	0.4
trans-β-Ionone	1489	0.1	0.1					0.2
β-Selinene	1490			0.1	0.1	0.2	0.3	
epi-Cubebol	1493	0.5	0.3			0.6		0.5
trans-Muurola-4(14), 5-diene	1494	0.3	0.2	0.1	0.2	0.3	0.4	0.4
Bicyclogermacrene	1499			0.2	0.4		1.0	
α-Muurolene	1500	0.4	0.6	0.2	0.3	0.7	0.8	1.0
α-Bisabolene	1504	0.1				0.5		
β-Bisabolene	1509						0.2	
γ-Cadinene	1513	0.3	0.7	0.2	0.6	1.2	1.3	1.5
Cubebol	1514	0.3						
endo-1-Bourbonanol	1520	0.1	0.2	0.1	0.2	0.2	0.1	0.1
β-Sesquiphellandrene	1523			0.2	0.2		0.1	
δ-Cadinene	1524	2.0	**2.6**	0.8	1.5	**4.2**	**6.2**	**6.1**
Citronellyl butanoate	1532	0.2	0.1	0.1	0.1	0.2	0.1	
Cadina-1(2), 4-diene	1535	0.2	0.1	0.1	0.1	0.2	0.3	0.3
α-Cadinene	1539	0.3	0.3	0.1	0.2	0.3	0.4	0.5
α-Calacorene	1542	0.1	0.1	tr	tr	tr	0.1	0.1
Elemol	1550	0.8	0.3	0.7	0.8	0.5	0.6	0.5
Germacrene B	1558	0.6	0.2	0.3	0.6	0.1	0.5	0.4
cis-3-Hexenyl benzoate	1570	0.1	tr	0.1	0.1	tr	0.1	tr
Germacrene D-4-ol	1577	0.6	0.7	0.8	1.2	2.1	2.1	**2.6**
Spathulenol	1578	0.5	0.2	0.3	0.2	0.3	1.1	0.2
Caryophyllene oxide	1581	0.4		0.2	0.1		0.1	
Ethyl dodecanoate	1594	tr	0.1	tr		0.3		tr
Salvial-4(14)en-1-one	1595	0.1	tr	tr	tr			
Longiborneol = Juniperol	1599	0.1		tr	tr	0.1	0.1	
n-Hexadecane	1600	0.1	0.1	0.1	tr	0.1	tr	tr
β-Oplopenone	1607	0.1	0.1	0.1	tr	0.1	tr	0.1
Humulene epoxide II	1608	0.3	tr	0.3	0.2	tr	2.1	0.1
1,10-di-epi-Cubenol	1616	0.2	0.2	0.1	0.1	0.2		0.3
1-epi-Cubenol	1629	0.8	0.3	0.2	0.2	0.3	0.3	0.4
γ-Eudesmol	1632	0.2	tr	tr	0.1	0.1		0.1
Epi-α-Cadinol	1640	1.0	1.5	0.7	1.1	2.2	0.4	2.5
epi-a-Muurolol	1642	1.3	1.0	0.4	0.5	1.0	1.0	1.2
α-Muurolol	1645	0.4	0.5	0.2	0.2	0.5	0.8	1.0
α-Cadinol	**1654**	**3.3**	**4.0**	**1.6**	**1.8**	**6.4**	**8.7**	**8.0**
14-hydroxy-9-epi-(E)-Caryophyllene	1670	0.4	0.2	0.1	0.1	0.5	0.2	0.2
Epi-α-Bisabolol	1685			1.0	0.5		1.3	
Eudesma-4(15), 7-dien-1-β-ol	1688	0.1	0.1	0.1	0.2	0.3		0.1
(Z, E)-Farnesol	1697			0.6	0.4		0.1	
Eudesm-7(11)-en-4-ol	1700	0.2	tr	tr	0.1	0.5	0.1	0.1
14-hydroxy-α-Humulene	1714	0.2	0.1	0.1	0.1	tr	**6.2**	0.1
(E, E)-Farnesol	1722	0.2		0.1	0.2		0.1	tr
Benzyl benzoate	1760			tr	0.1	tr	0.3	
14-hydroxy-α-Muurolene	1780	0.2	0.1	0.1	0.1	0.1	0.4	tr
Ethyl tetradecanoate	1793					0.1	0.1	
n-Octadecane	1800	tr	tr	tr	tr	tr	0.6	
Cyclopentadecanolide	1834	0.1	0.1	0.1	tr	tr	0.5	tr
n-Nonadecane	1900	tr			tr		0.1	
Sandaracopimara-8(14), 15-diene	1969	tr				tr	2.1	
Manoyl oxide	1998	tr	tr	tr	tr	0.1	1.1	tr
epi-13-Manoyl oxide	2017	tr	0.1	tr	tr	0.1	0.1	tr
Abitatriene	2057	0.1	tr	tr	tr	0.1		0.1
Abitadiene	2088	0.2	tr	0.1	tr	0.2		tr
Sandaracopimarinal	2185					tr	0.1	
4-epi-Abietal	2299	0.2	0.1	0.2	0.1	0.1	tr	0.2

Table 2 continued

Total	96.2	99.4	96.9	97.9	97.4	98.3	98.1
Monoterpene hydrocarbons	69.2	78.2	75.4	70.4	62.2	52.3	60.4
Oxygenated monoterpenes	5.2	2.3	7.3	9.9	4.2	2.6	4.3
Monoterpenoids (C10)	74.5	80.5	82.7	80.3	66.4	54.9	64.7
Sesquiterpene hydrocarbons	7.9	7.6	4.6	8.4	12.0	19.8	14.3
Oxygenated sesquiterpenes	12.2	9.8	7.9	8.4	16.1	22.6	18.1
Sesquiterpenoids (C15)	20.1	17.4	12.5	16.7	28.1	42.4	32.3
C10 + C15	94.6	97.9	95.2	97.0	94.5	97.2	97.0
2,6-Dimethyloctane skeleton	2.6	3.1	3.1	3.5	3.0	1.9	2.6
Pinane skeleton	51.4	61.0	57.8	46.7	42.6	40.3	42.4
Menthane skeleton	16.0	12.8	13.0	19.7	15.0	7.7	15.7
Cadinane skeleton	11.3	12.7	5.0	7.2	18.7	28.2	24.5

Notes. RI – retention indexes on nonpolar column; tr – traces; A–G indicate localities.

The leaf essential oil F contained α-cadinol as the second major constituent (Tables 2 and 3, 8.7%). Four leaf oils (A, B, E, G) included α-cadinol (3.3–8.0%) as the third main compound. The amounts of this compound in the essential oils of the first group (A–D) were only 1.6–4.0% while those in oils of the second group (E–G) varied within 6.4–8.7%. The oils E–G were characterized by larger contents of oxygenated sesquiterpenoids (Table 2: A–D, 7.9–12.2%; E–G, 16.1–22.6%) included more compounds with cadinane carbon skeleton than did samples A–D (Table 2: A–D, 5.0–12.7%; E–G, 18.7–28.2%). δ-Cadinene and epi-α-cadinol (both cadinane carbon skeleton) were among the five major constituents in the leaf essential oils E–G (Table 3). δ-Cadinene was the third main constituent in sample F (6.2%) and the fourth in the leaf oils E (4.2%) and G (6.1%). epi-α-Cadinol took only the fifth place between major constituents in the essential oil F (3.7%). The largest amount of constituents with cadinane carbon skeleton (28.2%) and sesquiterpenoids (42.4%) was produced by juniper F (Table 2). The ratios of the content of compounds with pinane and cadinane carbon skeletons differed in the leaf essential oils A–D (~5:1) and E–G (~2:1) as the ratios of mono- and sesquiterpenoids.

Sabinene was the third main constituent in the leaf oil D (Table 3, 4.3%) and the fourth in the sample C (3.0%). The amounts of this compound in other essential oils (A, B, E, F, G) did not exceed 1.5%. δ-3-Carene took the third (3.6%) and the fourth (2.8%) places in the oils C and D, respectively.

The first place among the main constituents of the investigated leaf essential oils was taken only by α-pinene, the second one was occupied by β-phellandrene in six oils and by α-cadinol in one oil. The third place was engaged by α-cadinol in four oils, by sabinene, δ-3-carene and δ-cadinene in other oils. The fourth and fifth major constituents in six out of seven leaf essential oils differed (Table 3). The fourth place was taken by α-phellandrene

Table 3. **Five major constituents (%) of leaf essential oils of *Juniperus communis* L. growing wild in Vilnius district**

Compound	A	B	C	D	E	F	G
α-Pinene	49.0 (I)	59.9 (I)	54.6 (I)	43.5 (I)	41.2 (I)	38.5 (I)	40.2 (I)
β-Phellandrene	9.1 (II)	8.3 (II)	4.1 (II)	5.7 (II)	6.6 (II)	4.6 (IV)	11.4 (II)
α-Cadinol	3.3 (III)	4.0 (III)	1.6	1.8	6.4 (III)	8.7 (II)	8.0 (III)
Sabinene	1.5	1.3	3.0 (IV)	4.3 (III)	1.2	0.9	1.2
δ-3-Carene	1.6	0.5	3.6 (III)	2.8 (IV–V)	3.0	2.7	1.1
δ-Cadinene	2.0	2.6 (V)	0.8	1.5	4.2 (IV)	6.2 (III)	6.1 (IV)
α-Phellandrene	2.8 (IV)	2.3	1.2	2.5	1.7	1.1	1.3
Myrcene	2.3 (V)	3.0 (IV)	2.3 (V)	2.5	2.2	1.6	2.2
Terpinen-4-ol	0.5	0.3	1.5	2.8 (IV–V)	0.3	0.2	0.3
Limonene	–	–	2.1	2.0	3.3 (V)	–	–
Germacrene D-4-ol	0.6	0.7	0.8	1.2	2.1	2.1	2.6 (V)
epi-α-Cadinol	1.0	1.5	0.7	1.1	2.2	3.7 (V)	2.5

Notes. Notation is the same as in Table 2; the number in parentheses indicates the position of the major terpenoids.

(A, 2.8%) and terpinen-4-ol (D, 2.8%) beside earlier mentioned compounds β-phellandrene (F, 4.6%), sabinene (D, 3.0%), δ-cadinene (E, 4.2%; G, 6.1%) and myrcene (B, 3.0%). The fifth main compound was limonene (E, 3.3%), epi-α-cadinol (F, 3.7%), germacrene D-4-ol (G, 2.6%), myrcene (A and C, 2.3%), δ-cadinene (B, 2.6%) and δ-3-carene (D, 2.8%). Eleven constituents given in Table 3 were identified in all leaf essential oils under study. Limonene (2.0–3.3%) was found only in three leaf oils (C–E). This compound (3.0–6.9%) was among the five main constituents in the juniper leaf essential oils from Sweden, Greece and Italy (Table 1) [4, 6]. The composition of two oils, C and D (with limonene), containing α-pinene, β-phellandrene, sabinene, δ-3-carene among the main constituents (Tables 2 and 3), was similar to that of the leaf oil from Sweden (Table 1) [6].

The chemical composition of juniper leaf essential oil of one plant (bush) was not characteristic of the population. The composition of the leaf oil produced by juniper A (big bush, tree-like) and G (small bush) growing in the same habitat differed markedly (Tables 2 and 3). The leaf oil A contained larger amounts of α-pinene (Table 2, A – 49.0 and G – 40.2%), compounds with pinane carbon skeleton (51.4 and 42.4%), monoterpenoids (74.4 and 64.7%) and smaller quantities of α-cadinol (3.3 and 8.0%), δ-cadinene (2.0 and 6.1%), constituents with cadinane skeleton (11.3 and 24.5%) and sesquiterpenoids (20.1 and 32.4%) than did the essential oil G. The further investigation of several juniper plants from one locality may give more information about the variability of the essential oil composition in the population.

The identified constituents comprised 96.2–99.4% of the leaf essential oil of *J. communis*. The sum of mono- and sesquiterpenoids made up 94.6–97.9% of the oils. The amounts of diterpenoids were 0.1–0.6%. The other organic compounds comprised 0.5–2.3% of the samples.

CONCLUSIONS

According to the ratios of amounts of mono- and sesquiterpenoids, the leaf essential oils may be divided in two groups. The ratio ~5:1 was determined for the oils A–D and ~2:1 was found for the samples E–G. Similar ratios were established for the amounts of compounds with pinane and cadinane carbon skeletons in the juniper oils. Despite the marked variability of the content of mono- (54.9–82.7%) and sesquiterpenoids (12.5–42.4%), the sums of the above terpenoids were close (94.6–97.9%). α-Pinene dominated in the investigated leaf essential oils studied. The second position was occupied by β-phellandrene in six oils and by α-cadinol in one oil. The third place was engaged by α-cadinol in four oils and by sabinene, δ-3-carene and δ-cadinene in other oils.

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VILNIAUS RAJONE AUGANÈIØ KADAGIØ (*JUNIPERUS COMMUNIS* L.) LAPØ (SPYGLIØ) ETERINIØ ALIEJØ CHEMINË SUDËTIS

Santrauka

2003 m. surinkti spygliai ðeðiose Vilniaus rajono augavietëse nuo septyniø atskirø kadagio (*Juniperus communis* L.) krûmø. Hidrodistiliacijos bûdu gauti eteriniai aliejai buvo analizuoti dujø chromatografijos ir dujø chromatografijos/masiø spektrometrijos metodais. Visi aliejai buvo α-pineno (38,5–59,9%) chemotipo. Antrasis vyraujantis komponentas šešiuose aliejuose buvo β-felandrenas (4,1–11,4%) ir viename aliejuje α-kadinolis (8,7%). α-Kadinolis (3,3–8,0%) buvo treèias svarbus junginys keturiuose aliejuose, o δ-kadinenas (6,2%), sabinenas (4,3%) ir δ-3-karenas (3,6%) kituose tirtuose aliejuose. Priklausomai nuo mono- ir seskviterpenoidø kiekiø santykio kadagio spygliø eteriniai aliejai gali bûti skirstomi á dvi grupes: I ~5:1 (4 aliejai) ir II ~2:1 (3 aliejai). Identifikuoti ðimtas keturiasdeðimt trys junginiai sudaro 96,2–99,4% eteriniø aliejø.