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Chemical composition of unripe and ripe berry essential oils of *Juniperus communis* L. growing wild in Vilnius district

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Unripe and ripe berries from five individual plants of *Juniperus communis* L. growing wild in Vilnius district were collected in four localities in 2003. Essential oils obtained by hydrodistillation were analysed using the GC and GC/MS methods. All oils were of α-pinene (39.7–64.9%) chemotype. Myrcene was the second major constituent (4.8–19.6%). α-Cadinol (2.7–7.1%) was the third main compound in eight essential oils and the fourth in two oils. The amounts of α-pinene, sabinene, β-pinene and bornyl acetate decreased during ripening of berries. An opposite correlation was determined for myrcene, terpinen-4-ol and α-terpineol. Monoterpene hydrocarbons (61.4–80.8%) prevailed in the essential oils. The part of hydrocarbons decreased markedly in berries of four from five juniper plants during ripening. The major part (81.5–88.6%) of essential oils comprised compounds (including esters) with four carbon skeletons: 2.6-dimethyloctane, menthane, pinane and cadinane. The identified compounds made up 94.8–99.4% of the essential oils.

Key words: *Juniperus communis* L., Cupressaceae, composition of essential oils, α-pinene chemotype, α-pinene, myrcene, α-cadinol

INTRODUCTION

Juniperus communis L. is only one species of the genus *Juniperus* growing wild in Lithuania [1]. This species is spread mainly in the northern hemisphere and it is a plant of the section *Juniperus* (syn. sect. *Oxycedrus*).

Juniper berries (cones) and twigs with berries are used for healing, in cosmetics, in food and drink production in the world [2, 3] and in Lithuania [4–6]. Essential oil of berries or twigs with berries have nearly the same healing properties as the extracts, decoctions, tinctures and other preparations of juniper [2–11]. The healing power of berry essential oils is higher than that of twigs with berries [7, 8]. The volatile compounds of berries exhibited stimulant, antimicrobial, antirheumatic, diuretic, stomachic, antiseptic, nervine, sudorific and a lot of other activities [2–11].

The chemical composition of juniper essential oils depended on the hydrodistillation conditions and time [12, 13]. Ripe berry essential oils in Poland [11] and Montenegro (altitude ~1000 m) [13] contained α-pinene (39.2–39.9%) and myrcene (15.7–18.2%) as two main constituents (Table 1). The third main compound in the above oils was sabinene (17.8%) and terpinen-4-ol (5.5%). Sabinene was the second major constituent in the juniper berry oils (21.8–28.0%) given in [14] and the first one in samples from Iran (36.8%) [2]. Essential oils from ripe (black) and unripe (green) berries contained α-pinene (30.5–49.4%) as the first major constituent and myrcene (9.3–27.5%) as the third one [14]. The amount of α-pinene was lower in ripe berry oil (30.5%) than in unripe ones (49.4%). An opposite correlation was determined for myrcene (Table 1). The amount of myrcene increased about three times during the ripening of berries [14]. α-Pinene (19.9%) and limonene (10.6%) were second and third main compounds in the ripe berry essential oil from Iran [2]. Myrcene (4.8%) occupied only the fifth place in the above oil.

Two commercial essential oils of junipers purchased from a Polish producer (Herbapol) originated from two different batches [11]. The composition of these oils differed markedly (Table 1). The first three major constituents, α-pinene, myrcene and terpinen-4-ol, of one commercial oil were the same as in the essential oil of Polish juniper ripe berries, but the content of these compounds differed 1.5–3 times (Table 1) [11]. The second commercial essential oil contained only two constituents from five major ones of other oils [11].

It has been shown [15] that the *J. oxycedrus* ssp. *badia* (syn. *J. badia*) species genetically is very close to *J. communis*. Three samples of essential oils were

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Table 1. **The major constituents (%) of essential oils from ripe (R) and unripe (U) juniper berries**

Juniper species (Place of origin)	Berries	The first	The second	The third	The fourth	The fifth	Ref
J. communis L. (Poland)	R*	α-pinene, 39.9	myrcene, 15.7	terpinen-4-ol, 5.5	limonene, 4.5	α-terpineole, 3.9	[11]
	?**	α-pinene, 60.1	myrcene, 5.5	terpinen-4-ol, 2.9	caryophyllene, 2.5	limonene, 1.9	
	?**	α-pinene, 22.9	p-cymene, 9.7	limonene, 6.5	β-pinene, 5.6	bornylacetate, 3.2	
J. communis L. (Montenegro, altitude 1000 m)	R	α-pinene, 39.2	myrcene, 18.2	sabinene, 17.8	limonene, 5.2	germacrene D, 3.8	[13]
J. communis L.	R	α-pinene, 30.5	sabinene, 28.0	myrcene, 27.5	limonene, 3.1	β-pinene, 1.7	[14]
	U	α-pinene, 49.4	sabinene, 21.8	myrcene, 9.3	β-pinene, 2.1	limonene, 1.2	
J. communis L. (Iran, altitude 2000 m)	?	sabinene, 36.8	α-pinene, 19.9	limonene, 10.6	germacrene D, 8.1	myrcene, 4.8	[2]
J. oxycedrus ssp. *badia* (Spain, altitude 850 m)	U	α-pinene, 64.9	myrcene, 4.4	germacrene D, 4.1	β-pinene, 2.4	γ-muurolene, 2.2	[3]
	U	α-pinene, 65.1	myrcene, 4.2	limonene, 2.0	β-pinene, 1.9	manoyl oxide, 1.1	
	R	α-pinene, 23.1	γ-muurolene, 4.5	germacrene D, 4.2	myrcene, 3.7	(E)-pinocarveol, 3.5	
	U	germacrene D, 39.5	α-pinene, 18.6	myrcene, 6.8	δ-cadinene, 3.9	α-humulene, 2.9	
J.oxycedrus ssp. *macrocarpa* (Italy)	?	α-pinene, 53.0	α-terpineol, 6.9	myrcene, 6.0	allo-aromadendrene, 5.1	limonene, 3.3	[17]
	?	α-pinene, 85.1	myrcene, 2.8	β-pinene, 2.6	limonene, 1.3	pinocarvone, 0.9	
	?	α-pinene, 50.3	allo-aromadendrene, 3.6	myrcene, 2.9	limonene, 2.8	aristolene oxide, 2.8	

Notes: * – commercial berries, ** – commercial oils, ? – not indicated in papers.

prepared from unripe berries collected in different localities of Spain and one oil from ripe berries of the above juniper species (Table 1) [3]. α-Pinene (64.9–65.1%) and myrcene (4.2–4.4%) were two major constituents in unripe berry oils from two localities. The essential oil of unripe berries from the third locality contained germacrene D (39.5%) as the first major constituent, α-pinene (18.6%) as the second and myrcene (6.8%) as the third one. The above three compounds were present in the essential oil of *J. oxycedrus* ssp. *oxycedrus* species as the main constituents [16]. The ripe berries of *J. oxycedrus* ssp. *badia* biosynthesized α-pinene (23.1%), γ-muurolene (4.5%), germacrene D (4.2%) and myrcene (3.7%) as the main constituents of essential oils. *J. oxycedrus* ssp. *macrocarpa* species are also genetically close to *J. communis* [15]. The berry essential oils of *J. oxycedrus* ssp. *macrocarpa* in Italy were of α-pinene (50.3–85.1%) chemotype (Table 1) [17]. Myrcene (2.8–6.0%) was the second or the third main compound in these oils.

The chemical composition of unripe and ripe berry essential oils of *J. communis* growing wild in Vilnius district are presented in this paper.

MATERIALS AND METHODS

Samples of juniper (*J. communis* L.) were collected in 2003 in four localities in Vilnius district: A (Druþilai), B (Pagiriai), C (Rûdininkø forest), D^1 (Bezdonys, small shrub), D^2 (Bezdonys, big shrub). Voucher specimens were deposited in the Herbarium of the Institute of Botany (BILAS numbers: A-68341, B-68344, C-68342, D^1-68351, D^2-68350). Essential oils were prepared by hydrodistillation of 5–10 g fresh ripe (black) and unripe (green) berries. The berries and water ratio was 1:10, essential oils were collected in 2 ml of a 1:1 hexane:diethyl ether mixture. The yield of essential oils of unripe berries was ~1.2% and of ripe berries ~0.9%.

Analyses of the essential oils were carried out by GC and GC-MS. The separation was performed on a CP-

Sil8CB silica capillary column (50 m × 0.32 mm; film thickness 0.25 μm). A HP 5890II chromatograph was equipped with FID. The GC oven temperature was programmed as follows: from 50 °C (isothermal for 5 min) increased to 90 °C at the 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 with an HP 5890 gas chromatograph equipped with an 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 [18] and the computer mass spectra libraries (Wiley and NBS 54K).

RESULTS AND DISCUSSION

The unripe (U, green) and ripe (R, black) berries were collected from the same individual *J. communis* plant in four (A–D) localities of Vilnius district. Essential oils obtained by hydrodistillation contained ~200 of constituents. One hundred nine compounds were identified (Table 2). Fifty one constituents were biosynthesized by all investigated juniper plants.

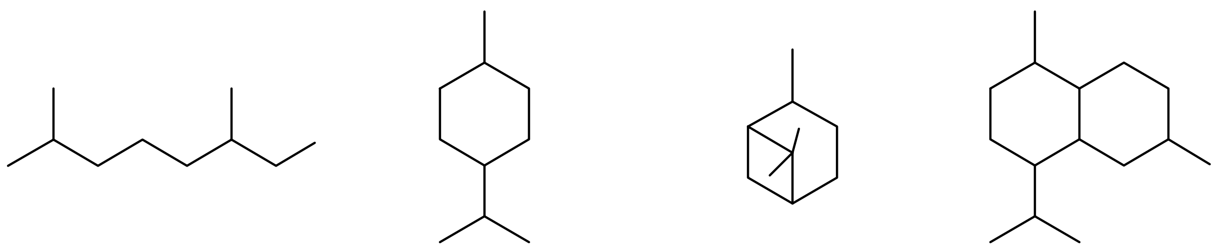
All investigated essential oils were of α-pinene chemotype. α-Pinene (39.7–64.9%) was the first major constituent (Tables 2 and 3). Essential oils of ripe berries contained smaller amounts of α-pinene than those of unripe ones. The content of this compound during the ripening of berries in A, C and D^2 plants markedly (10–15%) decreased. The second main compound in all essential oils was myrcene (Table 2; 4.8–19.6%). Only one unripe berries oil (D^1U) contained nearly the same quantity of myrcene (4.8%) and α-cadinol (4.5%), which were the second and third major constituents. The amount of myrcene increased during the ripening of juniper berries.

α-Cadinol (2.7-7.1%) was the third main constituent in eight and the fourth in two essential oils (Tables 2 and 3). The other compounds with cadinane carbon skeleton δ-cadinane (Table 3; CR, D^1U, D^1R; 2.1–2.5%) and epi-α-cadinol (BU, CU, CR; 1.8-3.2%) were in the fourth or fifth place among the major constituents. α-Cadinol was not found or present in small amounts (frequently <1%) in formerly investigated leaf and berry oils of *J. communis* and of other *Juniperus* section species plants [2, 3, 15, 17]. Only plant leaves of two species of this section, *J. sibirica* and *J. formasana*, produced essential oils with 2.2–2.3% of α-cadinol [15, 19]. Juniper leaves and berries frequently contained the same compounds in markedly different amounts [2, 3, 17]. Essential oils of several species of the *Sabina* section of the genus *Juniperus* and of a lot of conifers contained large amounts of α-cadinol or/and compounds with cadinane carbon skeleton [19–21]. Compounds with the cadinane skeleton comprised about one third of *J. recurva* (sect. *Sabina*) leaf essential oil from India [19].

β-Pinene in four oils (AU, BU, BR, CU; 2.0–2.5%) and β-phelandrene in three samples (AU, D^2U, D^2R; 1.8–2.5%) were among five main constituents (Table 3). Sabinene, limonene, β-pinene, terpinen-4-ol, α-terpineol, bornyl acetate and germacrene D were identified among the predominant constituents of *J. communis* berry essential oils, besides α-pinene and myrcene most frequently (Table 1) [2, 11, 13, 14]. The third major constituent, besides α-cadinol, in two ripe berry oils under study contained a menthane carbon skeleton: in AR sample it was terpinen-4-ol (Tables 2 and 3; 6.1%) and in BR one α-terpineol (3.4%). The content of the latter compound was 3.5% in the AR essential oil and it was in the fifth place. Terpinen-4-ol (1.8%) was only the seventh in the BR sample.

The amounts of sabinene (except D^1U, D^1R), β-pinene and bornyl acetate decreased during the ripening of berries as did the amount of the first major constituent, α-pinene. An opposite process was identified for limonene in plants A–C, for terpinen-4-ol and α-terpineol in all plants as for the second main compound myrcene.

The largest amounts of monoterpene hydrocarbons were found in four unripe berry essential oils (Table 2, AU, BU, CU, D^2U; 69.5–80.8%). Ripe berries of the above plants contained smaller



1 2 3 4

Scheme. The main carbon skeletons of wild *Juniperus communis* L. essential oil constituents: *1* – 2,6-dimethyloctane, *2* – menthane, *3* – pinane, *4* – cadinane.

Table 2. **Chemical composition (%) of unripe (U) and ripe (R) berry essential oils of five individual *Juniperus communis* L. plants growing wild in four localities (A–D) of Vilnius district**

Compounds	RI	AU	AR	BU	BR	CU	CR	D^1U	D^1R	D^2U	D^2R
Xylene	855	0.2	0.2	0.8		0.6		0.2	2.5	0.5	4.2
Tricyclene	927	tr		0.2	tr	tr	tr	0.1	0.2	0.2	0.1
α-Pinene	939	**57.6**	**40.9**	**48.1**	**39.7**	**59.1**	**43.5**	60.2	59.2	**64.9**	**51.9**
Camphene	954	0.4	0.3	0.6	0.3	0.7	0.2	0.4	0.5	0.8	0.5
Verbenene	968							0.1	0.1	0.1	0.3
Sabinene	975	1.9	0.8	1.5	0.9	1.5	1.1	1.1	1.3	1.6	1.0
β-Pinene	980	2.1	1.1	2.5	2.1	2.0	1.6	1.6	1.5	2.2	1.4
Myrcene	991	**11.2**	**14.5**	**10.2**	**11.8**	**12.8**	**19.6**	**4.8**	**6.2**	**6.1**	**7.0**
α-Phellandrene	1003	tr	tr	0.1	0.5	tr	tr	0.1	0.1	0.4	0.3
δ-3-Carene	1011			0.9	1.2			tr	0.2	0.1	0.4
α-Terpinene	1017	0.1	tr	0.1	0.2	tr	tr	tr	0.2	tr	tr
p-Cymene	1025	tr	0.1	tr	0.2	tr	tr	tr	2.0	tr	0.5
β-Phellandrene	1029	2.5	0.3	1.9	1.2	0.8	0.4	0.7	0.5	2.1	1.8
Limonene	1030	2.0	2.9	1.9	2.1	1.1	2.4	1.1	1.3	1.6	1.7
γ-Terpinene	1060	0.3	tr	tr	0.2	tr	0.4	0.1	tr	tr	tr
Terpinolene	1089	1.1	0.5	1.5	1.4	0.1	0.1	0.6	0.5	0.7	0.4
p-Cymenene	1091		tr		0.2		tr		tr		tr
Linalool	1098	tr	tr	0.2	0.5		tr	tr	tr		
endo-Fenchol	1117	tr	tr		0.1						tr
α-Campholenal	1126	tr	0.4	tr	0.4			0.1	0.3	tr	0.3
trans-Pinocarveol	1139	tr	0.2		0.5				0.2		0.1
Camphor	1143	0.1	0.2	tr	tr		tr		0.1		tr
trans-Verbenol	1145		0.9	tr	0.5				0.2		tr
Pinocarvone	1165		tr		0.1						tr
Borneol	1169		0.8		1.1		0.1	tr	0.3		0.8
p-Mentha-1.5-dien-8-ol	1170		0.8		0.9				0.2		0.2
Terpinen-4-ol	1177	2.1	**6.1**	0.6	1.8	0.1	0.4	0.3	0.4	0.2	0.6
m-Cymen-8-ol	1180		tr		0.1						
p-Cymen-8-ol	1183		0.4	0.1	0.8		tr	tr			0.1
α-Terpineol	1189	0.4	3.5	1.2	**3.4**	0.1	0.5	0.1	0.3	0.2	1.1
Myrtenol	1196		0.2		0.6				0.2		0.1
Verbenone	1205		0.6	tr	1.1				0.3		0.2
trans-Carveol	1217				0.2						
Citronellol	1226	tr	0.2	0.3							
Carvone	1242			tr	0.2			tr			tr
cis-Myrtanol	1254				0.2						
trans-Myrtanol	1260				0.3						
Methyl citronellate	1261	1.1	0.9	0.7	1.5	0.9	1.3	0.8	0.7	0.4	0.2
Bornyl acetate	1288	1.8	1.2	1.4	0.9	1.2	0.8	0.8	0.7	1.1	0.7
Thymol	1290										0.6
p-Cymen-7-ol	1291							tr	0.1		tr
2-Undecanone	1294	0.2	tr	tr	0.1		tr	0.2	0.1		
trans-Pinocarvyl acetate	1298	0.1		0.3	0.3				0.1		
cis-Pinocarvyl acetate	1309								tr		
Myrtenyl acetate	1327	tr		tr				tr			tr
δ-Elemene	1339	tr									tr
α-Terpinyl acetate	1350	0.1	0.1	0.2	0.2			0.1		tr	
α-Cubebene	1352							0.1	tr	tr	tr
Citronellyl acetate	1353	0.1	0.1	tr	0.1					0.1	
α-Copaene	1377	tr	tr	tr	0.1	tr	tr	0.1	0.1	0.1	0.1
trans-Myrtanol acetate	1387	tr	tr	0.1	0.1	tr	tr	0.2	0.1	tr	tr
β-Bourbonene	1388				tr		tr			tr	tr
β-Cubebene	1389	tr	tr	tr	0.1	tr	0.1	tr	tr	tr	tr
β-Elemene	1391	0.4	0.4	0.6	0.5	0.8	0.5	1.0	0.3	0.4	0.2
Longifolene = Junipene	1408	tr		0.3	0.1			0.1	0.1	0.3	0.2
β-Caryophyllene	1418	0.2	0.3	0.1	0.4	0.2	0.1	0.2	0.1	0.1	0.1
E-α-Ionone	1430						tr	0.2	tr		tr

Table 2 (*continued*)

β-Gurjunene	1432					tr		0.1		tr	
γ-Elemene	1437	0.2	0.2	0.1	0.3	tr	tr	2.6	0.9	0.1	0.1
cis-Muurola-3,5-diene	1450	tr		tr	tr	tr	tr	0.1	tr	0.1	tr
trans-Muurola-3,5-diene	1454	tr		tr		tr	tr	tr	0.1	tr	tr
α-Humulene	1455	0.3	0.4	0.3	0.5	0.2	0.3	0.3	0.1	0.2	0.1
E-β-Farnesene	1457	tr		tr	0.2	tr	tr	0.2	tr	tr	tr
cis-Muurola-4(14),5-diene	1467	0.1	tr	0.1	0.1	0.1	tr	0.2	0.1	0.2	0.1
trans-Cadina-1(6),4-diene	1477	tr	tr	0.1	0.1	tr	0.1	0.1	0.1	0.1	0.1
γ-Muurolene	1480	0.1	0.2	0.2	0.3	0.2	0.3	0.3	0.3	0.2	0.1
Germacrene D	1485	0.9	0.6	0.7	0.8	1.2	0.4	1.0	0.2	1.2	0.2
Citronellyl isobutanoate	1487		0.2		0.1				0.1		0.1
E-β-Ionone	1489				0.1		0.2		0.1		0.1
β-Selinene	1490				0.1		0.1	0.1		tr	
trans-Muurola-4(14),5-diene	1494	tr		0.1	0.1		0.1	0.3	0.1	0.2	0.1
Bicyclogermacrene	1499	0.5		0.3	0.4	0.4		0.6		0.2	
α-Muurolene	1500	0.5	0.4	0.5	0.4	0.4	0.5	0.7	0.6	0.3	0.3
β-Bisabolene	1509	tr		0.1	0.2		tr	0.2		0.2	0.1
γ-Cadinene	1513	0.2	0.5	0.4	0.7	0.6	0.6	1.0	0.7	0.6	0.5
endo-1-Bourbonanol	1520	0.2	0.2	0.2	0.1	0.2	0.1	0.2	0.1	0.2	0.1
β-Sesquiphellandrene	1523	0.4	0.2	0.8	0.2	0.5	0.4	0.4	0.2	0.3	0.1
δ-Cadinene	1524	1.2	1.6	1.3	1.4	1.6	2.1	2.4	2.5	1.2	1.3
Citronellyl butanoate	1532	0.1	0.2	0.7	0.2	0.5	0.1	0.2	0.1	0.1	0.1
Cadina-1(2),4-diene	1535	tr	tr	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1
α-Cadinene	1539	0.1	0.1	0.1	0.3	0.1	0.1	0.4	0.3	0.2	0.2
α-Calacorene	1542		tr		0.1		tr	tr	0.1	tr	0.1
Elemol	1550	1.2	0.8	1.3	0.4	0.6	0.5	1.2	0.6	0.6	0.3
Germacrene B	1558	0.1	0.1	tr	0.3		0.1	1.3	0.4	tr	0.2
Germacrene D-4-ol	1577	0.9	1.1	1.4	0.2	1.7	1.0	1.4	0.4	0.5	0.5
Spathulenol	1578	tr	tr	0.2	0.9	0.1	0.9	0.1	0.3	0.1	0.7
Caryophyllene oxide	1583		0.5	0.2	0.4		0.4		0.2	0.1	0.3
β-Oplopenone	1607	tr	0.1	0.1	0.1		0.4		tr	tr	0.2
Humulene epoxide II	1608		0.6	0.1	0.9		0.3		0.3	tr	0.6
1,10-di-epi-Cubenol	1616	tr	0.1	0.1	tr	0.1	0.1	0.1	0.1	0.1	0.1
1-epi-Cubenol	1629	0.1	0.3	0.3	0.2	0.1	0.4	0.2	0.1	0.2	0.6
γ-Eudesmol	1632	0.1	0.2	0.1	0.3	tr	tr	0.1	0.3	0.1	0.2
epi-α-Cadinol	1640	1.5	2.8	2.0	1.1	1.8	3.2	1.6	1.2	1.3	2.4
epi-α-Muurolol	1642	0.3	1.0	0.8	1.3	1.0	1.6	0.7	0.5	1.0	1.9
α-Muurolol	1645	0.1	0.2	0.2	0.2	0.1	0.2	0.3	0.2	0.3	0.2
α-Cadinol	1654	**2.8**	**4.2**	**4.1**	**2.7**	**4.4**	**7.1**	**4.5**	**3.6**	**3.2**	**5.8**
Selin-11-en-4-a-ol	1660				0.4	0.3	0.2			0.2	0.3
14-hydroxy-9-epi-(E)-Caryophyllene	1670	tr	0.3	tr	0.5	0.2	1.8	0.1	0.3	0.1	0.5
Sesquiterpene alcohol M222	1675				0.4	0.3	0.2		0.2	0.2	0.3
epi-α-Bisabolol ?	1685				0.4		0.5			0.3	
Eudesm-7(11)-en-4-ol	1700	0.1	0.3	0.1	0.2	0.1	0.2	0.3	0.1	0.1	0.2
trans-α-Atlantone ?	1779	0.5	0.3	0.5			0.2			tr	0.2
14-hydroxy-α-Muurolene	1780	0.5	0.2	0.4	0.2	0.2	0.2	0.1	0.1	0.2	0.1
n-Octadecane	1800	tr	0.4	tr	tr						
Cyclopentadecanolide	1834	0.1	0.3	0.1	0.2	tr	0.2	tr	0.1	0.1	tr
n-Nonadecane	1900		0.4			0.2					
Abietatriene	2057	tr	tr	0.1	tr	tr	tr	0.1	tr	0.1	tr
Abietadiene	2088	tr	tr	0.1	tr	tr	tr	0.1	tr	0.1	tr
Total		99.2	98.2	94.8	97.8	99.4	98.6	99.3	97.2	98.9	96.9
Monoterpene hydrocarbons		79.2	61.4	69.5	62.0	78.1	69.3	70.9	73.8	80.8	67.3
Oxygenated monoterpenes		5.9	17.0	5.8	16.2	2.8	3.2	2.6	4.4	2.1	5.2
Sesquiterpene hydrocarbons		5.2	5.0	6.2	7.9	6.4	6.1	14.2	7.5	6.3	4.4
Oxygenated sesquiterpenes		8.4	13.5	12.2	11.4	11.3	19.8	11.0	8.8	8.9	15.8

Notes. RI – retention indexes on nonpolar column; tr – traces; A–D indicated localities; unripe (U) and ripe (R) berries.

Table 3. **Five major constituents (%) of berry essential oils of *J. communis* growing wild in Vilnius district**

Compounds	AU	AR	BU	BR	CU	CR	D^1U	D^1R	D^2U	D^2R
α-Pinene	**57.6 (I)**	**40.9 (I)**	**48.1 (I)**	**39.7 (I)**	**59.1 (I)**	**43.5 (I)**	**60.2 (I)**	**59.2 (I)**	**64.9 (I)**	**51.9(I)**
Myrcene	**11.2 (II)**	**14.5 (II)**	**10.2 (II)**	**11.8 (II)**	**12.8 (II)**	**19.6 (II)**	**4.8 (II)**	**6.2 (II)**	**6.1 (II)**	**7.0 (II)**
α-Cadinol	**2.8 (III)**	**4.2 (IV)**	**4.1 (III)**	**2.7 (IV)**	**4.4 (III)**	**7.1 (III)**	**4.5 (III)**	**3.6 (III)**	**3.2 (III)**	**5.8 (III)**
Terpinen-4-ol	2.1	**6.1 (III)**	0.6	1.8	0.1	0.4	0.3	0.4	0.2	0.6
α-Terpineol	0.4	**3.5 (V)**	1.2	**3,4 (III)**	0.1	0.5	0.1	0.3	0.2	1.1
β-Pinene	**2.1 (V)**	1.1	**2.5 (IV)**	**2.1 (V)**	**2.0 (IV)**	1.6	1.6	1.5	**2.2 (IV)**	1.4
β-Phellandrene	**2.5 (IV)**	0.3	1.9	1.2	0.8	0.4	0.7	0.5	**2.1 (V)**	**1.8 (V)**
δ-Cadinene	1.2	1.6	1.3	1.4	1.6	**2.1 (V)**	**2.4 (V)**	**2.5 (IV)**	1.2	1.3
epi-α-Cadinol	1.5	2.8	**2.0 (V)**	1.1	**1.8 (V)**	**3.2 (IV)**	1.6	1.2	1.3	**2.4 (IV)**
γ-Elemene	0.2	0.2	0.1	0.3	tr	tr	**2.6 (IV)**	0.9	0.1	0.1

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

Table 4. **The amounts (%) of compounds with four main carbon skeletons and their mean content in three groups**

Carbon skeletons	AU	AR	BU	BR	Mean	CU	CR	Mean	D^1U	D^1R	D^2U	D^2R	Mean
2,6-dimethyloctane (Dmo)	12.5	15.9	12.1	14.1	**13.7**	14.2	21.0	**17.6**	5.8	7.0	6.7	7.3	**6.7**
Pinane (Pi)	59.8	43.9	51.0	45.5	**50.1**	61.1	45.1	**53.1**	62.1	61.9	67.2	54.0	**61.3**
Cadinane (Cn)	7.5	11.6	10.8	9.3	**9.8**	10.8	16.7	**13.8**	13.2	10.8	9.5	14.0	**11.9**
Menthane (Me)	8.6	14.7	7.6	13.4	**11.1**	2.2	4.2	**3.2**	3.1	5.6	5.2	7.3	**5.3**
(Dmo)+(Pi)+ +(Me)+(Cn)	88.4	86.1	81.5	82.3	**84.6**	88.3	87.0	**87.7**	84.2	85.3	88.6	82.6	**85.2**

Note. Notation is the same as in Table 2.

amounts of monoterpenes (61.4–69.3%). The amounts of other three groups (oxygenated monoterpenes, sesquiterpene hydrocarbons and oxygenated sesquiterpenes) were markedly smaller than those of monoterpene hydrocarbons.

Fourteen compounds with the pinane carbon skeleton (Scheme, 3) formed the largest part of monoterpenoids (Table 4, 43.9–67.2%). Ripe berry essential oils of the plants A–C included only 43.9–45.5% compounds with the above skeleton, while unripe berry oils contained 51.0–61.1% of these constituents. The same regularity was found for essential oil of D^2 plant. The amount (mean) of compounds with a pinane skeleton decreased during ripening from 67.2% to 54.0%.

Six aliphatic (2,6-dimethyloctane skeleton) monoterpenoids (5.8–21.0% including esters) and 17 compounds with a menthane carbon skeleton (2.2–14.7%) comprised markedly smaller parts of oils than constituents with a pinane skeleton. Oils of ripe berries included larger amounts of compounds with aliphatic and menthane skeletons than those of unripe ones from the same juniper plant (Table 4). The juniper plants were separated into two parts according to the amounts of aliphatic monoterpenoids. Six essential oils produced by plants A–C contained 12.1–21.0% and four oils from D locality included only 5.8–7.3% of the above compounds. The quantities of constituents with a menthane skeleton divided the first part into two groups. Four essential oils of ripe and unripe berries collected from A and B (first group) plants included 8.6–14.7% (mean 11.1%) and two oils from juniper C (second group) contained only 2.2–4.2% (mean 3.2%) of these compounds. Plants from locality D produced four essential oils (third group) with 3.1–7.3% (mean 5.3%) of constituents with a menthane carbon skeleton besides a small amount of compounds with a 2,6-dimethyloctane skeleton. The amounts of compounds with a pinane skeleton were also different in three groups. The mean of the first group (AU, AR, BU, BR) was 50.1%, of the second (CU, CR) 53.1% and of the third (D^1U, D^1R, D^2U, D^2R) 61.3% of the above constituents.

Nineteen sesquiterpenoids with a cadinane carbon skeleton represented 7.5–16.7% of the essential oils. The mean of these compounds of three groups varied from 9.8 to 13.8%. The 59 compounds with four main carbon skeletons (2,6-dimethyloctane (including esters), menthane, pinane and cadinane) comprised 81.5–88.6% of the oils. One hundred nine of identified constituents made up 94.8–99.4% of investigated essential oils of α-pinene chemotype.

CONCLUSIONS

Essential oils of unripe and ripe berries of *Juniperus communis* L. growing wild in Vilnius district were of α-pinene chemotype. The amount of α-pinene during the ripening of berries decreased. Most of the essential oils consisted of monoterpene hydrocarbons (61.4–80.8%). The part of these hydrocarbons during ripening decreased markedly in berries of four from five plants. Terpenoids (59 compounds including esters) with four carbon skeletons (2,6-dimethyloctane, menthane, pinane and cadinane) comprised 81.5–88.6% of the oils. According to different content of the constitutent with the above skeletons, the essential oils were divided into three groups. Oils of unripe and ripe berries from plants A and B contained marked (mean ≥9.8%) amounts of constituents with each four carbon skeletons, those from plant C included a smaller (mean 3.2%) quantity of compounds with a menthane skeleton, and plants from locality D produced smaller amounts with two carbon skeletons, 2,6-dimethyloctane (mean 6.7%) and menthane (mean 5.3%).

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VILNIAUS RAJONE AUGANÈIØ KADAGIØ (*JUNIPERUS COMMUNIS* L.) NEPRINOKUSIØ IR PRINOKUSIØ UOGØ ETERINIØ ALIEJØ CHEMINË SUDËTIS

Santrauka

Keturiose Vilniaus rajono augavietëse nuo penkiø atskirø kadagio (*Juniperus communis* L.) krûmø 2003 metais buvo rinktos neprinokusios ir prinokusios uogos. Hidrodistiliacijos bûdu gauti eteriniai aliejai buvo analizuoti dujø chromatografijos ir dujø chromatografijos/masiø spektrometrijos metodais. Visi aliejai buvo α-pineno (39,7–64,9%) chemotipo. Antras svarbus komponentas buvo mircenas (4,8–19,6%). α-Kadinolis (2,7–7,1%) buvo treèias svarbus komponentas aðtuoniuose eteriniuose aliejuose ir ketvirtas dviejuose tirtuose mëginiuose. α-Pineno, sabineno, β-pineno ir bornilacetato kiekis uogose maþëja, joms nokstant. Prieðinga koreliacija buvo nustatyta mircenui, terpinen-4-oliui ir α-terpineoliui. Eteriniuose aliejuose vyravo monoterpeniniai angliavandeniliai (61,4–80,8%), kuriø dalis labai sumaþëjo nokimo metu keturiuose ið penkiø prinokusiø kadagio uogø aliejø. Didþiausià eteriniø aliejø dalá (81,5–88,6%) sudaro junginiai (áskaitant esterius) su keturiais anglies skeletais: 2,6-dimetiloktano, mentano, pinano ir kadinano. Identifikuoti junginiai sudaro 94,8–99,4% eteriniø aliejø.