

Variation of Secondary Metabolites (Essential Oils) in Various Plant Organs of *Juniperus communis* L. Wild Growing in Lithuania

RITA BUTKIENĖ, JURGA BŪDIENĖ AND ASTA JUDŽENTIENĖ*

Center for Physical Sciences and Technology, Institute of Chemistry, A. Gostauto 9, LT-01108, Vilnius, Lithuania, e-mail: judzent@ktl.mii.lt

Butkienė, R., Būdienė, J. and Judžentienė, A. 2015. Variation of Secondary Metabolites (Essential Oils) in Various Plant Organs of *Juniperus communis* L. Wild Growing in Lithuania. *Baltic Forestry* 21(1): 59–64.

Abstract

Variation of some secondary metabolites of *Juniperus communis* among populations as well as at individual plant level was studied. Chemical composition and yield of the essential oils from branches, leaves (needles), sprouts, debarked wood and bark of common juniper collected in Eastern Lithuania was detailed. The oils of ten samples were obtained by hydrodistillation and analyzed by GC and GC-MS. A remarkable variation could be observed in the oil composition and yield depending on plant organs. The yield of the oils varied from 0.06% (v/w, on a dry weight basis) in wood to 0.46% – in the needles. α -Pinene was found to be the first major compound in the first-year sprout (43.5-57.1%), needle (31.0-44.7%) and shoot (25.4-46.3%) oils. Essential oil composition of bark and debarked wood differed drastically from oils of the other organs. Bark oil was characterized by predominance of longifolene (25.3-28.8%) and longiborneol (10.8-11.6%), while wood oil contained appreciable quantities of 1-epi-cubenol (up to 10.5%) and δ -cadinene ($\delta \leq 13.4\%$). Data of *J. communis* (of Lithuanian origin) essential oils obtained from debarked wood and bark was presented for the first time. Altogether there were identified 160 components (one of them tentatively, 25 ones in quantity more than 3%), which made up 74.3-98.0% of total oil content. The most of the investigated material was characterized by monoterpene hydrocarbon fraction (31.3-72.8%) in the essential oils, with exception for wood and bark, where the main fraction was oxygenated sesquiterpenes. Compounds with pinane and cadinane skeletons predominated in the *J. communis* essential oils. Additionally, a detailed survey of the previous published data on essential oils from *J. communis* of Lithuanian origin was presented in the paper.

Key words: *Juniperus communis* var. *communis*, secondary metabolites, essential oils, α -pinene, longifolene, longiborneol, 1-epi-cubenol, δ -cadinene.

Introduction

Juniperus (consisting of approximately 70 species and 40 varieties) is the second most diverse genus of the conifers. The genus is divided into three sections, and one of them is *Juniperus* (syn: sect. *Oxycedrus* Spach), containing 12 species. *Juniperus communis* (*Cupressaceae* Rich. Ex Bartl.), a highly variable taxon that is distributed around the Northern hemisphere (including and Baltic Sea region) has the largest distribution of any juniper species (Adams 2004). The clustering data of RAPD molecular markers showed that *communis* complex formed three groups: (I) *J. communis* var. *communis* and *J. communis* var. *saxatilis*, (II) *J. communis* var. *sibirica* (syn. *J. sibirica*) and (III) *J. communis* var. *oblonga* (syn. *J. oblonga*) (Adams 2004).

J. communis (known as common juniper) is a plant bearing volatile secondary metabolites, i.e. essential oils. Many constituents present in juniper essential oils

are bioactive. The oils are used widely for medicinal purposes, in aromatherapy, in cosmetics, chemistry and food industry as well. Juniper oils (mainly from berries) possess antiseptic, diuretic, antirheumatic, depurative, antispasmodic, stimulating, stomachic, astringent, carminative, vulnerary, antiinflammatory, tonic, antibacterial and antifungicidal properties (Angioni et al. 2003, Barnes et al. 2002, Cabral et al. 2012, Filipowicz et al. 2003, Martz et al. 2009, Ragažinskienė et al. 2005).

Chemical composition of the oils has a huge range of variability (both quantitative and qualitative) depending on plant origin and individual plant level as well. Detailed variation in juniper oils between different wild and cultivated populations from Lithuania and various plant organs was presented in Table 1.

The leaf (needle), unripe and ripe berry (cone) essential oils of *J. communis* from other countries are mostly of α -pinene chemotype (Adams 1998, 2000, 2004, Adams et al. 2010, Angioni et al. 2003, Lawrence

1989, 1990, 2003, 2006, 2008, Mastelic et al. 2000, Damjanovic et al. 2003, Filipowicz et al. 2006). Juniper berry oils of sabinene chemotype have been found only in high mountains (Shamir et al. 2003, Lawrence 2003). Some juniper needle essential oils from Scandinavian countries, Poland, Iran, Portugal and Italy were of sabinene chemotype beside mostly identified α -pinene profile (Angioni et al. 2003, Cabral et al. 2012, Filipowicz et al. 2006, Lawrence 2003, 2006, Shamir et al. 2003). Germacrene D-ol and germacrene D were the principal constituents in the oils of needles, collected at various latitudes and altitudes in Finland (Martz et al. 2009), while a wide variability for different monoterpene and sesquiterpenoids was observed in the berries of junipers grown in this country (Kallio and Junger-Mannermaa, 1998).

The essential oils of dried juniper needles investigated in Estonia were characterized by predominance of α -pinene, sabinene, β -caryophyllene, α -humulene and germacrene D, while fresh needles contained high amounts of (*E*)-2-hexenal and the berry oil was rich in α -pinene, β -myrcene and germacrene D (Orav et al. 2010). Raal et al. (2010) have determined that branch oils of Estonian origin are rich in α -pinene ($\leq 62.0\%$), limonene ($\leq 10.0\%$) and α -cadinol ($\leq 6.3\%$). Another monoterpene, limonene, was determined as a major constituent in needle and berry oils of juniper from Corsica (Gonny et al. 2006, Ottavioli et al. 2009). Monoterpenic hydrocarbons composition has been studied in needles, berries and wood oils of junipers from various locations in Poland (Ochocka et al. 1997). Major fraction in the *J. communis* wood oils from Sweden and South-Western France was of sesquiterpenoids with predominant constituent thujopsene (Adams 2004, Lawrence 2003), while the wood oils from Corsica and Sardinia islands were comprised mainly by monoterpenes (or oxygenated derivatives), such as limonene, α -terpinyl acetate, β -phellandrene, α -terpineol, α -pinene and *p*-cymene (Gonny et al. 2006, Marongiu et al. 2006).

The aim of the present study was to evaluate variation in volatile secondary metabolites (essential oils) among populations and in various plants organs (shoots, needles, sprouts, debarked wood and bark) of *Juniperus communis* var. *communis* growing in Lithuania.

Material and Methods

Plant material. The aerial parts (10-50 g): sprouts (one-year old), leaves (needles), branches, debarked wood and bark of *Juniperus communis* var. *communis* of two individual plants from two wild populations in Eastern Lithuania (Svėdasai, Anykščiai district (in

Table 1. Variability in essential oil composition of *Juniperus communis* L. growing wild in Lithuania (data published during the last decade)

Plant organ	Time of hydro-distillation (h), essential oil yield *	Plants origin	Major components (or over 5.0%) in essential oils, %	Reference
Fresh ripe (black), unripe (green) berries	In unripe berries ~1.2; in ripe berries ~3.9	Vilnius district, four localities	α -Pinene (39.7-64.9), myrcene (4.8-19.6), α -cadinol (2.7-7.1), terpinen-4-ol (≤ 6.1)	Butkienė et al. 2004
Fresh needles	3 h; -0.37	Vilnius district, six localities	α -Pinene (38.5-59.9), β -phellandrene (4.1-11.4), α -cadinol (3.3-8.7), γ -cadinene (≤ 5.2)	Butkienė et al. 2005a
Fresh ripe berries (black)	3 h; 0.9	North-Eastern Lithuania, five habitats	α -Pinene (21.0-46.3), myrcene (7.6-17.4), terpinen-4-ol (9.6), α -terpineol (2.9-6.0)	Butkienė et al. 2005b
Needles	3 h; -0.37	North-Eastern Lithuania, five habitats	α -Pinene (40.3-66.5), δ -3-carene (≤ 5.2)	Butkienė et al. 2006a
Fresh twigs with unripe (green) and ripe (black) berries, fresh leaves	3 h; unripe berries -1.2, ripe berries -0.9, needles -0.37	Vilnius district, five habitats	α -Pinene (27.7-64.9), myrcene (≤ 19.6), β -phellandrene (≤ 9.1), terpinen-4-ol (6.1), α -cadinol (≤ 8.7)	Butkienė et al. 2006b
Wood, needles, unripe and ripe berries	3 h, in unripe berries -1.2, in ripe berries -0.9, in wood -0.22, in needles -0.37	Druskininkai district	Wood: α -pinene (15.9-31.0), nootkatone (18.4); leaf, unripe and ripe berries: α -pinene (42.4-67.4); ripe berries: myrcene (≤ 13.8), unripe berries: spathulenol (5.6)	Butkienė et al. 2007
Fresh needles, berries (unripe and ripe)	3 h; in needles -0.37%, in unripe -1.2 and ripe berries -0.9	Thirty-four habitats in Druskininkai, Kaunas, Vilnius, Šalčininkai, Molėtai, Trakai, Anykščiai, Ignalina and Varėna districts	Needles: sabinene (34.1-40.8), α -pinene (11.7-66.5), terpinen-4-ol (6.9-9.3), berries: α -pinene (21.0-67.4); unripe berries: sabinene (6.3-19.6), myrcene (4.3-12.8), terpinen-4-ol (13.1)	Butkienė et al. 2009
Unripe and ripe berries of two morphotypes (with light-green and bluish-green berries)	2 h	Plants cultivated in the field collection of the Institute of Botany (Vilnius)	ripe berries: myrcene (7.8-18.7), terpinen-4-ol (3.2-9.6)	Loziene et al. 2010
Leaves and unripe cones	2 h	Eleven natural habitats (samples 110)	α -Pinene (26.8-42.7), myrcene (9.2-24.9), caryophyllene ≤ 11.4 , caryophyllene oxide ≤ 17.9	Loziene and Labokas, 2011
Leaves and unripe cones	2 h, unripe cones: 1.3 \pm 0.63 (SD), leaves 0.4 \pm 0.14 (SD)	Eleven natural habitats (samples 110)	(1R)-(+)- α -Pinene in leaves 74 \pm 1 (SD); in unripe cones 69 \pm 2 (SD); (1S)-(-)- α -pinene: in leaves 26 \pm 1 (SD); in unripe cones 31 \pm 2 (SD)	Ložienė and Labokas, 2012
Leafy twigs with unripe cones	2 h, 0.3-4.2 in unripe cones; 0.1-0.9 in leaves	Eleven natural habitats (samples 110)	Leaves: α -pinene 54.1 \pm 13.9 (SD), unripe cones 58.0 \pm 14.6 (SD)	Labokas and Ložienė, 2013
First-year (unripe) cones; current-year shoots	2 h, in leaves 0.1-0.9; in cones 0.3-4.2	Eleven natural habitats	(1R)-(+)- α -Pinene: 74 \pm 13 (SD) in leaves; 69 \pm 17 (SD) in unripe cones; 26 \pm 13 (SD) in leaves; 31 \pm 17 (SD) in unripe cones	Vaičiulytė and Ložienė, 2013

*Essential oil yield was expressed in v/w% on dried weight basis

mixed forest) and Vievis, Elektrėnai (in marshy forest)) were gathered at full flowering stage, in June (2008). Plant material of separated organs was dried at room temperature (20-25°C). Voucher specimens with numbers 68931 (Vievis) and 68343 (Svėdasai) were deposited in the Herbarium of the Institute of Botany (BI-LAS), Vilnius, Lithuania. The essential oils from separated aerial parts were prepared by hydro-distillation (2h) in a Clevenger-type apparatus according to the European Pharmacopoeia and a mixture of hexane and diethyl ether (1:1) was used as a collecting solvent. Light yellow or colorless pure oils were obtained from 50 g of dry material. Yield ranged from 0.06 to 0.46% (v/w) on a dry weight basis.

Analyses of the essential oils were carried out by GC and GC/MS. The quantitative analysis was performed on a capillary column HP-FFAP (30m × 0.25mm × 0.25mm) using chromatograph HP 5890II equipped with FID. The GC oven temperature was programmed as follows: from 60°C (isothermal for 3 min) increased to 160°C at a rate of 5°C/min (isothermal for 1 min) and to 250°C at a rate of 10°C/min and the final temperature was kept for 3 min. The temperatures of the injector and the detector were 250°C. The flow rate of carrier gas (helium) was 1 ml/min. At least 2 repetitions (n≥2) per analysis were performed.

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 on a capillary column DB-5 (50m × 0.32mm × 0.25 mm). The chromatographic conditions were the same as in GC (FID) analysis. 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 comparison of retention indexes on both columns, co-injection of some terpenes references and C₈-C₂₈ n-alkane series; and mass spectra with corresponding data in the literature (Adams, 2007) and computer mass spectra libraries (Wiley and NBS 54K).

Results

The yield of *J. communis* essential oils varied at individual plant level (Table 2). The lowest one was determined in wood (0.06%) and the highest was found in the needles (0.46%). It should be mentioned, that yield of the volatile oils is a very important factor during industrial production of juniper essential oils.

Table 2. Essential oil yields in different plant organs of *J. communis*, % (v/w, expressed on a dry weight)

Plant organ	Essential oil yield, %
One-year old sprouts	~0.2
Leaves (needles)	0.34-0.46
Branches (without needles)	~0.16
Bark from stem	~0.075
Debarked wood (of ~5 cm diameter, without bark)	~0.06

Main chemical composition (over 3.0%, at least in one sample) of *J. communis* essential oils of various plants organs (sprouts (one-year old), leaves (needles), shoots (branches), debarked wood and bark) was presented in Table 3. One hundred and sixty compounds were identified (one of them tentatively, 25 in quantity more than 3%) and they made up 74.3-98.0% of total oil content.

Compounds with pinane and cadinane skeletons predominated in the *J. communis* essential oils. Most of the investigated material was characterized by monoterpene hydrocarbons fraction (31.3-72.8%) in the essential oils, with exception for wood and bark, where the main fraction was sesquiterpenes or oxygenated sesquiterpenes (39.3-45.7%).

Content of a monoterpene, α -pinene, varied drastically according to the plant organs. It was found to be as a principal constituent in shoot, needles and sprout essential oils (25.4-46.3%, 31.0-44.7% and 43.5-57.1%, respectively), while quantity of this compound was only up to several percents in the wood oil. Quantities of another two monoterpenes, δ -3-carene and limonene differentiated not only in various plant organs, but also according to the collecting sites. The highest quantity of δ -3-carene was found in bark oils from Svėdasai (15.1%) and in branches from Vievis (9.1%), while the smallest amount of this compound was in wood and sprout oils from both juniper populations. α -Pinene, δ -3-carene and limonene are common and characteristic constituents for juniper oils of different geographical origins (see Introduction).

The major fraction was found to be sesquiterpenoids in wood and bark oils in the study. Oils of the bark was characterized by appreciable amounts of two sesquiterpenes, longifolene (25.3-28.8%) and longiborneol (10.8-11.6%), while these compounds even have not been detected in the other parts of the plants. To the best of our knowledge, there are no already published data on chemical composition of essential oils from bark of *J. communis*.

The juniper oils from debarked wood contained appreciable quantity of 1-*epi*-cubenol (up to 10.5%) and δ -cadinene (\leq 13.4%). It should be pointed out that debarked wood composition was found to be different from previously investigated juniper wood (together with bark) oils in our laboratory (Butkiene et al. 2007) and absolutely dissimilar from wood oils investigated in other countries (Adams 2004, Lawrence 2003, Gonny et al. 2006, Marongiu et al. 2006). Wood oils from juniper growing in Druskininkai district were characterized by major compounds nootkatone (18.5%) and α -pinene (\leq 31.0%), while contents nootkatone and α -pinene were significantly smaller (\leq 4.9 and 0.5%, respectively) in the debarked wood oils under this study.

Conclusions

A remarkable variability (both in chemical composition and yield, also depending on plant organs and collecting sites) of volatile secondary metabolites of juniper (*Juniperus communis* L.) of Lithuanian origin was evaluated. The lowest essential oil yield was de-

Table 3. Essential oil composition (≥ 3.0 %, at least in one oil sample) of *Juniperus communis* growing in Easter Lithuania

Compound	RI	Anykščiai d., Svėdasai, %					Elektrėnai d., Vievis, %				
		sprout	needle	shoot	bark	debarked wood	sprout	needle	shoot	bark	debarked wood
α -Pinene	939	43.5	31.0	46.3	10.1	0.6	57.1	44.7	25.4	4.2	3.1
β -Pinene	979	4.0	2.0	1.1	0.4	tr.	3.7	2.3	1.1	0.4	0.2
Myrcene	990	4.1	2.3	-	0.3	-	3.7	3.4	0.9	0.2	-
δ -3-Carene	1011	1.8	6.9	3.5	15.1	0.2	1.0	2.0	9.1	4.8	1.1
Limonene	1029	1.4	1.9	5.5	1.8	0.2	5.5	9.8	1.0	1.0	0.4
Longifolene (Junipene)	1407	-	-	-	25.3	-	-	-	-	28.8	0.1
β -Caryophyllene	1419	2.2	tr.	0.6	0.8	3.9	0.4	0.6	5.7	0.5	1.5
α -Humulene	1454	0.5	3.2	0.9	0.9	4.1	0.7	0.6	3.9	0.8	1.9
<i>cis</i> -Cadin-1(6),4-diene	1463	0.2	0.2	tr.	0.1	3.0	-	-	0.3	-	0.2
γ -Muuroleone	1479	1.5	0.5	2.3	-	-	1.9	0.2	3.0	-	-
<i>epi</i> -Cubebol	1494	1.6	0.4	0.2	-	6.4	0.2	0.7	tr.	-	3.0
Cubebol	1515	-	-	-	-	3.4	-	-	-	-	3.9
δ -Cadinene	1523	4.4	5.6	1.9	2.2	13.4	2.8	1.8	5.4	1.6	7.2
Germacrene D-4-ol	1575	2.0	4.1	0.6	-	-	1.4	0.8	2.1	-	0.6
Spathulenol	1578	-	0.9	3.3	1.0	-	-	1.8	1.9	0.7	-
Unknown (M ⁺ 284)	1589	-	-	-	-	-	-	-	-	-	7.0
Longiborneol	1599	-	-	-	11.6	-	-	-	-	10.8	-
1- <i>epi</i> -Cubebol	1628	0.5	0.5	0.5	-	10.0	0.2	0.1	4.4	tr.	10.5
<i>epi</i> - α -Cadinol	1640	1.6	1.9	1.3	1.4	3.0	0.5	0.6	-	-	3.0
<i>epi</i> - α -Muuroleone	1642	3.7	2.3	-	1.4	-	1.7	0.9	-	3.0	-
Cubebol	1647	-	-	-	-	7.0	-	-	-	-	5.6
α -Cadinol	1654	6.0	6.8	3.3	-	2.5	4.0	2.6	3.8	-	4.1
Longiborneol acetate	1685	-	-	-	1.1	-	-	-	-	4.4	-
14-hydroxy- α -Muuroleone	1780	-	-	-	-	3.1	-	-	-	-	2.9
Nootkatone	1806	-	-	-	-	4.9	-	-	0.3	0.5	3.2
Total (including compounds <3.0%)*		95.4	93.7	93.5	95.2	77.7	98.0	92.3	93.0	86.4	74.3
Monoterpene hydrocarbons*		58.4	47.2	59.7	31.3	1.3	72.8	64.5	42.1	12.9	5.0
Oxygenated monoterpenes*		4.2	5.2	10.7	2.2	4.9	4.9	7.7	4.8	5.4	5.4
Sesquiterpene hydrocarbons*		13.5	19.5	10.6	39.3	35.8	9.8	8.8	27.2	45.7	25.6
Oxygenated sesquiterpenes*		19.4	21.2	12.2	22.3	43.5	10.5	9.9	19.0	22.9	44.1
Pinane skeleton*		47.5	33.3	48.7	10.8	1.1	61.5	48.2	26.5	5.6	3.3
Cadinane skeleton*		21.3	22.3	11.7	10.9	49.3	13.0	7.0	23.4	7.1	41.1
Menthane skeleton*		5.0	4.3	10.3	4.7	3.1	7.6	13.0	5.0	3.8	1.4
2,6-Dimethyl octane skeleton*		4.3	3.7	0.7	0.3	0.2	4.0	4.4	1.4	0.2	-

MS (RI 1589) of unknown: M⁺284 (84), 213 (45), 202 (100), 199 (47), 91 (5), 81(5). tr.- in amounts $\leq 0.05\%$

*Including corresponding compounds with quantity less than 3.0 %:

hexanal, (2E)-hexenal, n-hexanol, tricyclene, α -thujene, (2E)-heptanal, thuja-2,4(10)-diene, α -fenchene, camphene, sabinene, verbenene, hexanoic acid, 1-octen-3-ol, 2-pentyl furan, n-octanal, 1,3,5-trimethyl benzene, α -, β -phellandrene, (2E,4E)-heptadienal, α -terpinene, *o*-, *p*-cymene, 1,8-cineol, (2E)-octen-1-ol, pentyl-isobutanoate, γ -terpinene, *p*-mentha-2,4(8)-diene, α -terpinolene, linalool, n-nonanal, isopentyl-2-methyl butanoate, isopentyl-isovalerate, 3-methyl-3-butenyl-3-methyl butanoate, α -campholenal, *trans*-pinocarveol, 3-methyl-2-butenyl-2-methyl butanoate, *cis*-, *trans*-verbenol, *p*-mentha-1(7),2-dien-8-ol, camphor, pinocarvone, borneol, 1,3-dimethoxybenzene, *p*-mentha-1,5-dien-8-ol, terpinen-4-ol, α -terpineol, *m*-, *p*-cymen-8-ol, myrtenol, verbenone, (2E,4E)-nonadienal, *trans*-carveol, 4-methylen-isophorone, citronellol, methyl thymol, (E)-ocimenone, isobornyl formiate, methyl citronellate, (2E,4Z)-decadienal, borneol acetate, carvacrol, (Z)-methyl cinnamate, α -terpinen-4-ol acetate, α -terpineol acetate, (2E,4E)-decadienal, myrtenol acetate, δ -elemene, α -, β -longipinene, dihydro *iso*-jasmone, α -cubebene, α -ylangene, α -copaene, β -elemene, sativene, *trans*-myrtenol acetate, β -bourbonene, 2,5-dimethoxy *p*-cymene, β -copaene, β -gurjunene, γ -elemene, aromadendrene, *allo*-aromadendrene, (Z)- β -farnesene, 6,9-guaidiene, *cis*-, *trans*-muuroleone-3,5-diene, 9-*epi*-(E)-caryophyllene, γ -curcumene, β -selinene, *cis*-, *trans*-muuroleone-4(14),5-diene, citronellol butanoate, *trans*-cadin-1(6),4-diene, *trans*-cadin-1,4-diene, γ -gurjunene, amorph-4,7(11)-diene, germacrene D, α -muuroleone, δ -amorphene, γ -cadinene, 10-*epi*-cubebol, α -cadinene, zonarene, elemol, selina-3,7(11)-diene, germacrene B, (E)-nerolidol, α -, β -calacorene, globulol, viridiflorol, caryophyllene oxide, salvia-4(14)-en-1-one, humulene epoxide II, gleenol, β -oplopenone, 1,10-di-*epi*-cubebol, *cis*-dihydro muuroleone, *cis*-cadinen-10-ol, *trans*-calamen-10-ol, α -muuroleone, cadalene, 14-hydroxy-(Z)-caryophyllene, guaia-3,10(14)-dien-11-ol, selin-11-en-4- α -ol, khusinol, germacrene-4(15),5,10(14)-trien-1- α -ol, 14-oxy- α -muuroleone, eudesma-4(15),7-dien-1 β -ol, *cis*-14-nor-muuroleone-5-en-4-one, eudesm-7(11)-en-4-ol, amorph-4,9-dien-14-al and abietatriene.

terminated in wood (0.06%) and the highest one was found in the needles (0.46%). The most predominant fraction was of monoterpene hydrocarbons (31.3-72.8%, containing compounds characteristic for juniper oils), with exception for wood and bark essential oils, where the main fraction was sesquiterpenes or oxygenated sesquiterpenes (39.3-45.7%). Composition of essential oils of debarked wood drastically differed from the oils

of juniper of other world origins. To the best of our knowledge, the composition of juniper bark essential oils was evaluated for the first time under this study.

To know chemical composition it is very important for industrial production of juniper essential oils. Also, utilization of all plant parts of juniper during production process, avoiding the waste, is of huge commercial significance.

References

- Adams, R. P. 1998. The leaf essential oils and chemotaxonomy of *Juniperus* sect. *Juniperus*. *Biochemical Systematics and Ecology* 26: 637-645.
- Adams, R. P. 2000. Systematics of *Juniperus* section, *Juniperus* based on leaf essential oils and RAPD (DNA) fingerprinting. *Biochemical Systematics and Ecology* 28: 515-528.
- Adams, R. P. 2004. *Junipers of the World: The Genus Juniperus*. Trafford Publishing Co., Vancouver.
- Adams, R. P. 2007. Identification of Essential Oil Components by Gas Chromatography/Mass Spectroscopy. 4th Ed., Allured Publ. Corp., Carol Stream, IL.
- Adams, R. P., Beauchamp, P. S., Dev, V. and Bathala, R. M. 2010. The leaf essential oils of *Juniperus communis* L. varieties in North America and the NMR and MS data for isoabienol. *Journal of Essential Oil Research* 22(1): 23-28.
- Angioni, A., Barra, M., Russo, T., Coroneo, V., Dessi, S. and Cabras, P. 2003. Chemical composition of the essential oils of *Juniperus* from ripe and unripe berries and leaves and their antimicrobial activity. *Journal of Agriculture and Food Chemistry* 51(10): 3073-3078.
- Barnes, J., Anderson L. A. and Phillipson, J. D. 2002. *Herbal Medicines*. 2nd Ed., Pharmaceutical Press, London.
- Butkienė, R., Nivinskienė, O. and Mockutė, D. 2004. Chemical composition of unripe and ripe berry essential oils of *Juniperus communis* L. growing wild in Vilnius district. *Chemija* 15(4): 57-63.
- Butkienė, R., Nivinskienė O. and Mockutė, D. 2005a. a-Pinene chemotype of leaf (needle) essential oils of *Juniperus communis* L. growing wild in Vilnius district. *Chemija* 16(1): 53-60.
- Butkienė, R., Nivinskienė, O. and Mockutė, D. 2005b. Volatile compounds of ripe berries (black) of *Juniperus communis* L. growing wild in North-East Lithuania. *Journal of Essential Oil Bearing Plants* 8(2): 140-147.
- Butkienė, R., Nivinskienė, O. and Mockutė, D. 2006a. Leaf (needle) essential oils of *Juniperus communis* L. growing wild in Eastern Lithuania. *Journal of Essential Oil Bearing Plants* 9(2): 144-151.
- Butkienė, R., Nivinskienė, O. and Mockutė, D. 2006b. Differences in the essential oils of the leaves (needles), unripe and ripe berries of *Juniperus communis* L. growing wild in Vilnius district (Lithuania). *Journal of Essential Oil Research* 18(5): 489-494.
- Butkienė, R., Nivinskienė, O., Mockutė, D. and Miliūtė, A. 2007. Variety of the essential oils composition of wood, needles (leaves), unripe and ripe berries of *Juniperus communis* var. *communis* growing wild in Druskininkai district. *Chemija* 18(3): 35-40.
- Butkienė, R., Nivinskienė, O. and Mockutė, D. 2009. Two chemotypes of essential oils produced by the same *Juniperus communis* L. growing wild in Lithuania. *Chemija* 20(3): 196-202.
- Cabral, C., Francisco, V., Cavaleiro, C., Gonçaves, M. J., Cruz, M. T., Sales, F., Batista, M. T. and Salgueiro, L. 2012. Essential oil of *Juniperus communis* subsp. *alpina* (Suter) Čelak needles: chemical composition, antifungal activity and cytotoxicity. *Phytotherapy Research* 26(9):1352-1357.
- Damjanovic, B. M., Skala, D., Petrovic-Djakov D. and Baras, J. 2003. Comparison between the oil, hexane extract and supercritical carbon dioxide extract of *Juniperus communis* L. *Journal of Essential Oil Research* 15(2): 90-92.
- Filipowicz, N., Kamiński, M., Kurlenda, J., Asztemborska, M. and Ochocka, J. R. 2003. Antibacterial and antifungal activity of juniper berry oil and its selected components. *Phytotherapy Research* 17(3):227-231.
- Filipowicz, N., Piotrowski, A., Ochocka, J. R. and Asztemborska, M. 2006. The phytochemical and genetic survey of common and dwarf Juniper (*Juniperus communis* and *Juniperus nana*) identifies chemical races and close taxonomic identity of the species. *Planta Medica* 72 (9): 850-853.
- Gonny, M., Cavaleiro, C., Salgueiro, L. and Casanova, J. 2006. Analysis of *Juniperus communis* subsp. *alpina* needle, berry, wood and root oils by combination of GC, GC/MS and ¹³C-NMR. *Flavour and Fragrance Journal* 21: 99-106.
- Kallio, H. and Junger-Mannermaa, K. 1989. Maritime influence on the volatile terpenes in the berries of different ecotypes of juniper (*Juniperus communis* L.) in Finland. *Journal of Agricultural Food Chemistry* 37:1013-1016.
- Labokas, J. and Ložienė, K. 2013. Variation of essential oil yield and relative amounts of enantiomers of a-pinene in leaves and unripe cones of *Juniperus communis* L. growing wild in Lithuania. *Journal of Essential Oil Research* 25(4): 244-250.
- Lawrence, B. M. 1989. Progress in Essential Oils 1981-1987. In: Allured Publ. Corp., Carol Stream, IL, p. 110-111, 140-141, 240-241 (and therein cited).
- Lawrence, B. M. 1990. Progress in Essential oils. *Perfumer & Flavorist* 15: 59-67 (and therein cited).
- Lawrence, B. M. 2003. Progress in Essential Oils 1995-2000. In: Allured Publ. Corp., Carol Stream, IL, p. 53 (and therein cited).
- Lawrence, B. M. 2006. Essential oils 2001-2004. In: Allured Publ. Corp., Carol Stream, IL, p. 36-38 (and therein cited).
- Lawrence, B. M. 2008. Essential Oils 2005-2007. In: Allured Publ. Corp., Carol Stream, IL, p. 60 (and therein cited).
- Loziene, K., Labokas, J., Venskutonis, P. R. and Mazdzieriene, R. 2010. Chromatographic evaluation of the composition of essential oil and a-pinene enantiomers in *Juniperus communis* L. berries during ripening. *Journal of Essential Oil Research* 22: 453-458.
- Loziene, K. and Labokas, J. 2011. Enantiomeric composition of a-pinene in essential oils of leaves and unripe cones of *Juniperus communis* L. *Planta Medica* 77-PE8.
- Ložienė, K. and Labokas, J. 2012. Effects of abiotic environmental conditions on amount and enantiomeric composition of a-pinene in *Juniperus communis* L. *Biochemical Systematics and Ecology* 44: 36-43.
- Marongiu, B., Porcedda, S., Piras, A., Sanna, G., Murreddu, M. and Loddo, R. 2006. Extraction of *Juniperus communis* L. ssp. *nana* Willd. essential oil by supercritical carbon dioxide. *Flavour and Fragrance Journal* 21:148-154.
- Martz, F., Peltola, R., Fontanay, S., Duval, R. E., Julkunen-Tiitto, R. and Stark, S. 2009. Effect of latitude and altitude on the terpenoid and soluble phenolic composition of juniper (*Juniperus communis*) needles and evaluation of their antibacterial activity in the boreal zone. *Journal of Agricultural Food Chemistry* 57(20): 9575-9584.
- Mastelic, J., Millos, M., Kustrak D. and Radonic, A. 2000. Essential oil and glycosidically bound volatile compounds from the needles of common juniper (*Juniperus communis* L.). *Croatica Chemica Acta* 73: 585-593.

- Ochocka, J. R., Asztemborska M., Zook, D. R., Sybilska, D., Perez G. and Ossicini, L. 1997. Enantiomers of monoterpenic hydrocarbons in essential oils from *Juniperus communis*. *Phytochemistry* 44 (5): 869-873.
- Orav, A., Kailas, T. and Muurisepp, M. 2010. Chemical investigation of the essential oil from berries and needles of common juniper (*Juniperus communis* L.) growing wild in Estonia. *Natural Product Research* 24(19):1789-1799.
- Ottavioli, J., Gonny, M., Casanova, J. and Bighelli, A. 2009. Chemical variability of the needle oil of *Juniperus communis* ssp. *alpina* from Corsica. *Chemistry and Biodiversity* 6(12): 2192-2199.
- Raal, A., Kanut, M. and Orav, A. 2010. Annual variation of yield and composition of the essential oil of common juniper (*Juniperus communis* L.) branches from Estonia. *Baltic Forestry* 16(1): 50-56.
- Ragažinskienė, O., Rimkienė, S. and Sasnauskas, V. 2005. Encyclopaedia of Medical Plants. Lututė, Kaunas, p. 154-456 (in Lithuanian).
- Shamir, F., Ahmadi, L., Mirza, M. and Korori, S. A. A. 2003. Secretory elements of needles and berries of *Juniperus communis* L. ssp. *communis* and its volatile constituents. *Flavour and Fragrance Journal* 18: 425-428.
- Vaičiulytė, V. and Ložienė, K. 2013. Variation of chemical and morphological characters of leaves and unripe cones in *Juniperus communis*. *Botanica Lithuanica* 19(1): 37-47.

Received 02 June 2014
Accepted 29 January 2015