Essential oils composition of *Pinus peuce* Griseb. (Pinaceae) growing on Pelister Mtn., Republic of Macedonia

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Abstract

The composition of essential oils obtained by hydrodistillation from needles, from branches without needles and from branches with needles of *Pinus peuce* Griseb. (Pinaceae) from Pelister Mtn. (R. Macedonia) was analyzed by GC/FID/MS. One hundred and seven components (40 monoterpenes, 37 sesquiterpenes, 9 diterpenes and 21 other components - aliphatic and cyclic hydrocarbons; aliphatic alcohols, aldehydes, and acids; phenols and other oxygenated benzene derivates) were identified. The most abundant constituents were terpene hydrocarbons, encompassing the monoterpenes: α -pinene, β -pinene, limonene + β -phellandrene and bornyl acetate and the sesquiterpenes: *trans* (E)-caryophyllene and germacrene D.

Key words: *Pinus peuce*, Macedonian pine, essential oil composition, GC/FID/MS. Natural park Pelister, *locus classicus*, R. Macedonia.

Introduction

Pinus peuce Griseb. (Pinaceae), commonly called Macedonian pine or Balkan pine is an endemic conifer tree inhabiting the southern and western parts of the territory of R. Macedonia. This conifer is autothonus to the Baba Mountain (Pelister), Nidze and Shara Mountain. It can be also found in Bulgaria, Albania, Serbia and Greece, growing typically at 1000 - 2200 m altitude. It is a member of the white or soft pine group (subgenus *Strobus*, section *Strobus*, subsection *Strobi*), and thus differs from the other pine species (*P. mugo*, *P. nigra* and *P. sylvestris*) growing in R. Macedonia, that belong to the yellow or hard pine group (subgenus *Pinus*, section *Pinus*, subsection *Pinus*).

For the first time, *Pinus peuce* was described on Baba Mountain (Pelister) in 1839 by Grisebach, thus this location is *locus classicus* for this species.

In folk medicine, pine needle essential oils are mainly used for the treatment of respiratory infections accompanied by cough, bronchitis, bronchial asthma, emphysema, tracheitis, sinusitis, laryngitis, pharyngitis, tonsillitis

and influenza (Dervendzi, 1992). Data from recent scientific literature suggest an increased interest in studying the composition of the essential oil isolated from different pine species as well as biological activity. Generally, monoterpenes and sesquiterpenes are dominant components of pine needle essential oils (Dob, 2007; Menkovic, 1993; Nikolic, 2007; Dob, 2006; Pagula, 2006; Dormont, 1998; Roussis, 1994; Yong-Suk, 2005; Oluwadayo, 2008, Barnola, 2000). It is important to notice that these essential oils have antimicrobial (Oluwadayo, 2008; Yong-Suk, 2005; Sacchetti, 2005), antifungal and antioxidant activity (Guri, 2006; Limei, 2008; Pinelo, 2004; Jerez, 2005; Jerez, 2006; Guolcin, 2003; Sacchetti, 2005). Because of their characteristic odor, pine essential oils are also appreciated in the cosmetic and perfume manufacture. There are several registered pharmaceuticals such as Pinimenthol® ointment which contains pine needle essential oil and is particularly suitable for the treatment for upper respiratory tract infections both in adolescents and adults (Kamin, 2007).

Nowdays, there is uprising trend of consumption of value added natural products complying different standards as Sustainable, Organic/Biological, Fare Wild etc. The populations of *P. peuce* in the National Park (NP) Pelister have a great resource potential and sustainable use of these natu-

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ral resources can have a significant socio-economic impact on local community. In this direction, assessment of the essential oil of *P. peuce* would greatly contribute in its value added portfolio.

Up to present, there are no evident data about essential oil composition of *Pinus peuce* population growing on NP Pelister (*locus classicus*) neither from any locality of the territory of R. Macedonia. On a subject of all previously mentioned, the aim to this study was to obtain data for the yield and composition of the essential oils isolated from needles, from branches without needles and from branches with needles of *Pinus peuce* from NP Pelister.

Material and methods

Plant material

Only terminal, up to three years old branches were collected in July, 2008 and 2009, in the NP Pelister on 4 different altitudes (1208 m.a.s.l., 1723 m.a.s.l., 1943 m.a.s.l. and 2042 m.a.s.l.). Plant identity was verified as *Pinus peuce* Grisebach and voucher specimens (N°2008/Pp, N°2009/Pp) were deposited at the Herbarium at the Department of Pharmaceutical Botany, Institute of Pharmacognosy, Faculty of Pharmacy, Skopje. Plant material was dried at room temperature and on draft for two weeks. The needles were separated from the branches just before the hydrodistillation and were properly minced.

Essential oil isolation

Essential oil isolation from plant material was made by hydrodistillation in all-glass Clevenger apparatus (Ph. Eur 7). For that purpose, 20 g of plant material (needles, branches without needles and branches with needles) was distilled for 4 hours. After isolation, anhydrous sodium sulfate was added to remove residual water and to dry essential oil.

For GC/FID/MS analysis, the essential oil was dissolved in xylene (1: 1000 v/v).

Gas chromatography

Essential oil samples were analyzed on Agilent 7890A Gas Chromatography system equipped with FID detector and Agilent 5975C mass spectrometer as well as capillary flow technology which enables simultaneous analysis of the sample on both detectors. HP-5ms 5% phenyl 95 % dimethylpolysiloxane bonded phase capillary column (30 m x 0.25 mm, film thickness 0.25 µm) was used. Operating conditions were as follows: oven temperature at 60 °C for 5 min, then increased to 80 °C at rate of 1 °C/min and held 2 min and at the end increased to 280 °C at rate of 5 °C/min and held 5 min; helium as carrier gas at a flow rate of 1 ml/min; temperature of the injector 260 °C and that of the FID detector 270 °C; the GC split ratio 1:1. 1 µl of each sample

was injected per GC run.

The mass spectrometry conditions were: ionization voltage 70 eV, ion source temperature 230 °C, transfer line temperature 280 °C and mass range from 50 - 500 Da. The MS was operated in scan mode.

Identification of the components present in essential oils was made by comparing mass spectra of components in essential oils with those from Nist, Wiley and Adams mass spectra libraries, by AMDIS (Automated Mass Spectral Deconvolution and Identification System) and by comparing literature and estimated Kovat's (retention) indices that were determined using mixture of homologous series of normal alkanes from C₉ to C₂₅ in hexane, under the same above mentioned conditions.

The percentage ratio of essential oils components was computed by the normalization method of the GC/FID peak areas and average values were taken into further consideration (n=4).

Results and discussion

The yield of essential oils calculated on a dry mass and obtained by hydrodistillation from needles, from branches without needles and from branches with needles of *Pinus peuce*, is given in Table 1. The obtained essential oils were transparent, light yellowish liquids with specific and strong odor.

Table 1. The yield of *Pinus peuce* essential oils isolated from needles, from branches without needles and from branches with needles.

Sample	Yield* of essential oil (ml/kg) ± SD
<i>Pinus peuce</i> (needles)	4.65 ± 1.36%
<i>Pinus peuce</i> (branches without needles)	17.30 ± 0.2%
<i>Pinus peuce</i> (branches with needles)	7.50 ± 0.3%

*(n=3)

Table 2 shows components that were identified in the *Pinus peuce* essential oils isolated from needles, from branches without needles and from branches with needles with their percentage amount and Kovat's retention indices. The estimated percentage values are averages of components that are present in the essential oils obtained from plant material (needles, branches without needles and branches with needles) collected from four various altitudes.

One hundred and seven components were identified in the *Pinus peuce* essential oils. Among them, 40 monoterpenes, 37 sesquiterpenes, 9 diterpenes and 21 other com-

Table 2. Chemical composition of *Pinus peuce* essential oil from Pelister Mtn .

No.	KIL	KIE	Component	Pelister Mtn. 2008 (%) - n	Pelister Mtn. 2009 (%) - n	Pelister Mtn. 2008 (%) – n + b	Pelister Mtn. 2008 (%) – b
Monoterpene hydrocarbons							
2	931	980.5	α -Thujene	-	-	0.02	0.02
3	939	983.7	α -Pinene	12.89	19.72	23.77	23.34
4	953	988.5	Camphene	2.69	5.03	3.68	0.69
8	975	1000.3	Sabinene	0.05	0.08	0.02	0.02
9	980	1002.8	β -Pinene	6.16	7.95	11.85	13.00
10	991	1010.9	Myrcene	0.57	0.79	1.17	2.50
12	1003	1019.8	α -Phellandrene	0.14	0.34	0.16	0.05
13	1007	1024.0	Δ^3 -Carene	0.33	-	0.58	0.79
14	1018	1028.8	α -Terpinene	0.05	0.10	0.05	0.02
16	1025	1035.2	<i>p</i> -Cymene	0.22	0.80	0.05	0.05
17	1031	1039.0	Limonene + β -Phellandrene	3.08	3.97	13.94	8.77
19	1040	1064.3	β - <i>cis</i> -Ocymene	0.02	-	-	-
22	1062	1064.5	γ -Terpinene	0.13	0.37	0.04	0.05
25	1088	1092.2	Terpinolene	0.50	0.65	0.37	0.24
			14 components:	26.83	39.80	55.70	49.54
Oxygenated monoterpene							
18	1033	1040.8	1,8-Cineole	0.13	0.20	-	-
27	-	1131.2	<i>trans</i> - <i>p</i> -Menth-2-en-1-ol	0.30	0.07	0.08	0.02
28	1120	1136.4	α - Campholenal	0.13	0.02	0.08	0.10
29	1139	1144.8	<i>trans</i> -Pinocarveol	0.27	0.02	0.32	0.35
31	-	1148.0	Viridene	-	0.02	-	-
32	1143	1153.6	Camphor	0.06	-	0.02	-
33	1144	1155.5	<i>trans</i> -Verbenol	-	-	0.03	0.06
34	1160	1169.1	<i>trans</i> -Pinocamphone	-	-	0.03	0.05
35	1162	1170.1	Pinocarvone	0.20	0.02	0.27	0.10
36	1165	1172.5	Borneol	0.64	0.76	0.62	0.14
37	1177	1181.9	Terpinene-4-ol	0.08	0.02	0.34	0.11
38	1183	1189.4	<i>p</i> -Cymene-8-ol	0.08	0.02	0.09	0.10
39	1189	1191.6	α -Terpineol	0.30	0.29	0.51	0.45
40	1193	1195.2	Myrtenal	0.29	0.16	0.32	0.35
42	1205	1205.6	<i>trans</i> -Piperitol	0.19	0.20	0.02	-
43	-	1207.1	Verbenone	0.04	0.06	0.10	0.19
44	1212	1218.0	<i>trans</i> -Carveol	0.08	0.02	0.14	0.11
45	1220	1219.9	endo-Fenchyl acetate	0.03	0.02	0.02	-
46	1235	1237.1	Thymol methyl ether	-	-	-	0.02
47	1243	1246.2	Carvone	-	-	0.05	0.04
48	-	1254.6	Piperitone	0.02	-	0.02	-
49	1256	1257.6	Linalool acetate	0.12	0.02	0.03	0.05
51	1285	1285.6	Bornyl acetate	10.56	9.29	5.60	1.13
55	1350	1347.5	α -Terpenyl acetate	2.97	1.20	1.04	0.42
58	1383	1380.9	Geranyl acetate	0.04	-	-	-
61	1401	1400.7	Methyl eugenol	-	-	-	-
			26 components:	16.45	12.59	10.39	3.79

No.	KIL	KIE	Component	Pelister Mtn. 2008 (%) - n	Pelister Mtn. 2009 (%) - n	Pelister Mtn. 2008 (%) - n + b	Pelister Mtn. 2008 (%) - b
Sesquiterpene hydrocarbons							
54	1339	1336.1	δ -Elemene	0.21	0.11	0.13	0.18
56	1373	1371.1	α -Ylangene	0.02	-	0.08	0.12
57	1376	1374.0	α -Copaene	0.10	0.02	0.15	0.32
59	1384	1383.3	β -Bourbonene	0.11	0.12	0.14	0.08
60	1391	1389.2	β -Elemene	0.47	0.36	0.44	0.36
62	1402	1403.4	Longifolene	0.02	-	0.19	0.22
63	1418	1418.0	<i>trans</i> (E)-Caryophyllene	7.13	4.88	4.13	7.30
64	-	1430.1	β -Copaene	0.76	0.40	0.45	0.57
65	1439	1444.3	Aromadendrene	0.04	-	0.03	0.02
66	-	1446.8	γ -Amorphene	0.19	0.15	0.16	-
67	1454	1453.6	α -Hummulene	1.59	0.79	1.00	1.68
68	-	1469.1	Epi-bicyclosesquiphellandrene	0.06	0.52	0.26	0.31
70	1477	1475.8	γ -Muurolene	0.15	0.22	1.34	2.17
71	1480	1481.7	Germacrene D	19.90	8.75	9.47	10.28
72	1485	1493.9	β -Selinene	0.03	-	0.28	0.34
73	1494	1496.3	Bicyclogermacrene	0.99	1.43	0.12	0.02
74	1495	1497.9	α -Muurolene	0.92	0.25	0.87	1.60
75	-	1507.5	<i>trans</i> -Cadina-1(6)4-diene	0.02	-	-	-
76	1513	1513.7	γ -Cadinene	0.45	0.39	1.00	1.88
77	1524	1525.3	δ -Cadinene	2.71	1.52	3.06	4.18
78	1532	1532.0	<i>trans</i> -Cadina-1,4-diene	0.06	0.39	0.12	0.16
79	1538	1540.6	α -Cadinene	0.13	0.31	0.22	0.27
80	1547	1546.4	α -Calacorene	0.02	0.14	0.10	0.09
83	-	1571.3	β -Calacorene	0.02	-	0.07	0.10
			24 components:	36.31	18.62	22.69	32.26
Oxygenated sesquiterpene							
81	1564	1561.4	Nerolidol-(E)	0.18	0.05	0.18	0.10
85	1574	1577.0	Germacrene-4-ol	0.10	-	-	-
86	1576	1583.0	Spathulenol	0.32	0.08	0.46	0.35
87	1581	1586.4	Caryophyllene oxide	0.57	0.07	0.70	1.18
88	1590	1598.0	Viridiflorol	0.03	-	-	-
89	1592	1609.0	Longiborneol	-	-	0.02	0.07
90	1606	1613.0	Humulene epoxide II	0.12	-	0.12	0.36
91	1627	1637.8	1-epi-Cubenol	0.07	0.02	0.16	0.31
92	1640 1641	1644.3 1647.4	τ -Cadinol (epi- α -Cadinol) + τ -Muurolol (epi- α -Muurolol)	1.58	0.52	0.64	0.72
93	1645	1650.1	α -Muurolol (Torreyol)	0.24	0.23	0.06	0.34
94	1653	1657.0	α -Cadinol	1.99	0.46	1.16	1.44
95	-	1693.1	Amorpha-4,9-dien-2-ol	0.17	0.03	0.37	0.44
96	1733	1746.3	Oplopanone	-	-	0.02	-
			13 components:	5.37	1.41	3.89	5.31

No.	KIL	KIE	Component	Pelister Mtn. 2008 (%) - n	Pelister Mtn. 2009 (%) - n	Pelister Mtn. 2008 (%) - n + b	Pelister Mtn. 2008 (%) - b
Diterpene							
99	1929	1946.7	Cembrene	0.04	-	0.09	0.14
100	-	2009.4	Manool oxide	0.09	-	0.16	0.18
101	1967	2013.0	Sclarene	0.02	0.06	0.02	0.06
102	2054	2073.7	Abietatriene	0.02	0.02	0.03	0.06
103	2080	2101.4	Abietadiene	0.02	-	0.03	0.06
104	-	2166.4	Abienol	-	-	0.14	0.29
105	2220	2253.2	Sclareol	-	-	0.03	0.14
106	2263	2296.5	Dehydroabietal	0.02	-	0.06	0.22
107	2302	2332.1	Abietal	-	0.08	0.03	0.14
			9 components:	0.21	0.18	0.59	1.23
Other components							
1	926	959.9	Tricyclene	0.02	0.02	0.21	0.02
5	-	990.1	Benzene acetaldehyde ^t	0.16	0.58	-	-
6	-	993.6	p-Ethyl methyl benzene ^t	0.04	2.64	-	-
7	-	998.1	1,2,5-Trimethyl benzene ^t	0.15	2.23	-	-
11	1000	1016.7	n-Decane	0.34	3.02	-	-
15	1023	1033.3	1,2,4- Trimethyl benzene ^t	0.02	0.42	-	-
20	-	1057.2	2-Phenilpropanol ^t	0.12	0.02	-	-
21	1057	1058.2	<i>trans</i> -Decahydronaphtalene ^t	0.06	0.39	-	-
23	1067	1084.0	m-Tolualdehyde	0.14	2.30	-	-
24	1079	1084.4	p-Tolualdehyde	0.50	1.37	-	-
26	1099	1106.8	n-Undecane	1.10	1.75	-	-
30	1261	1145.0	2,6-Dimethylphenol ^t	0.76	1.50	-	-
41	1198	1199.2	Dodecane ^t	0.25	0.23	-	-
50	1261	1263.1	2-Decenal ^t	0.02	0.12	-	0.02
52	1294	1296.2	Tridecane ^t	0.02	-	-	-
53	1314	1312.5	2E,4E-Decadienal ^t	0.02	0.02	-	-
69	1473	1474.5	Dodecanol	0.15	0.07	-	-
82	1568	1564.8	Dodecanoic acid ^t	0.50	0.06	-	-
84	1570	1575.2	Hexenyl bezoate (3-Z-)	0.05	0.02	0.04	-
97	1762	1769.9	Benzyl benzoate	0.05	0.02	0.02	0.02
98	-	1884.5	Hexenyl cinnamate (3-Z-)	0.15	1.23	0.03	0.02
			21 components:	4.55	16.01	0.30	0.08
TOTAL				89.72	88.61	93.56	92.21

n=4; KIL - Kovat's index literature, KIE – Kovat's index estimated, *n* – needles, *b* – branches without needles, *n+b* – branches with needles, (-) - not found, t – tentative identification, No. - ordinal number of the component according to its retention time.

ponents (aliphatic and cyclic hydrocarbons; aliphatic alcohols, aldehydes, and acids; phenols and other oxygenated benzene derivatives) were identified. Analysis of the essential oils composition shows variations in the content of components that are present, probably due to the impact of weather conditions throughout the year. Seasonal variability is mostly seen in the presence of monoterpenes cam-

phene and α -terpenil acetate and sesquiterpenes δ -cadinene and α -cadinol (Table 2).

The most abundant components in the needle essential oil were monoterpenes α -pinene (12.89/19.72 %), β -pinene (6.16/7.95 %), limonene + β -phellandrene (3.08/3.97 %) and bornyl acetate (9.29/10.56 %) and sesquiterpenes *trans* (E)-caryophyllene (4.88/7.13 %) and germac-

rene D (8.75/19.90 %). These components represent 54.56 %/59.72 % of the whole needle essential oil and are likely to determine the physico-chemical characteristics as well as chemical profile of the oils.

Dominant components in the essential oil obtained from branches with needles were the same 6 components that were found in the needle essential oils, representing 68.76 % of the total amount of the oil. Among

them, α -pinene (23.77 %), β -pinene (11.85 %), limonene + β -phellandrene (13.94 %) were the most abundant, while germacrene D (9.47 %) and bornyl acetate (5.60 %) were present in smaller amounts.

The essential oil isolated from branches without needles contains large amount of α -pinene (23.34 %), β -pinene (13.00 %), limonene + β -phellandrene (8.77 %), *trans* (E)-caryophyllene (7.30 %) and germacrene D (10.28 %), but

Fig. 1. Different classes of components that are present in *Pinus peuce* essential oils isolated from needles, from branches without needles and from branches with needles (THC – terpene hydrocarbons, OT – oxygenated terpenes, DT – diterpenes, OC – other components)

Fig. 2. Monoterpene and sesquiterpene fractions that are present in *Pinus peuce* essential oils isolated from needles, from branches without and from branches with needles (MT – monoterpenes, ST – sesquiterpenes, DT – diterpenes, OC – other components)

smaller amount of bornyl acetate (only 1.13 %). These components represent 63.82 % of the total essential oil. It is important to notice that this essential oil contains 4.18 % of δ -cadinene.

Among different classes of components that are present in the needle essential oil, the major constituents were terpene hydrocarbons (58.42 %/ 63.14 %). Oxygenated terpenes were present from 14.00 %/21.80 %, other components 4.55 %/16.01 % and diterpenes only 0.18 %/0.21 % (Fig. 1).

The most abundant fraction among the total amount of monoterpenes and sesquiterpenes, diterpenes and other components that are present in needle essential oil were monoterpenes (43.28 %/52.39 %) (Fig. 2).

The major constituents in the essential oil obtained from branches with needles from *Pinus peuce* were also components that belong to terpene hydrocarbons fraction (78.39 %) and fraction of oxygenated terpenes (14.28 %) (Fig. 1). The same situation was with the essential oil isolated from branches without needles which contains 81.8 % of terpene hydrocarbons fraction and 9.1 % of oxygenated terpenes (Fig. 1). Diterpenes and other components were present in smaller amount (0.59 % diterpenes and 0.30 % other components in the essential oil from branches with needles and 1.23 % diterpenes and 0.08 % other components in the essential oil isolated from branches without needles).

The most abundant fraction among the total amount of monoterpenes and sesquiterpenes, diterpenes and other components that are present in essential oil obtained from branches with needles were monoterpenes (66.09 %) (Fig. 2), while essential oil isolated from branches without needles contains 53.33 % and 37.57 % of monoterpenes and sesquiterpenes, respectively (Fig. 2).

Compared with the chemical composition of needle essential oil isolated from *Pinus sylvestris* (*Pini sylvestris aetheroleum*) and from *Pinus mugo* (*Pini pumillonis*

aetheroleum) for which the European Pharmacopoeia prescribes certain limits for same components (Table 3), it is evident that the composition of needle essential oil from *P. peuce* is closer to the chemical composition of *Pini pumillonis aetheroleum*. There is no big difference in presence of α -pinene and β -pinene between these two oils. Camphene and bornyl acetate are present in larger amount in needle essential oil from *Pinus peuce* while Δ^3 -carene, β -myrcene, limonene + β -phellandrene and terpinolene are present in smaller amount.

Nowdays, there are a lack of data that are relate to chemical composition of *Pinus peuce* essential oil. Up to now, there are only five references that are concern to the composition of the essential oils isolated from needles and branches from *Pinus peuce* that grows on the territory of Greece, Serbia and Montenegro (Henning, 1994; Papadopoulou, 1996; Koukos, 2000; Petrakis, 2001; Nikolic, 2008). Seventy eight components were detected, but only fifty six components were identified in the needle essential oil. α -Pinene, camphene, β -pinene, β -phellandrene, bornyl acetate, β -caryophyllene, germacrene D and citronellol are declared as main components in the needle essential oil while α -pinene, β -pinene, β -phellandrene, β -caryophyllene and citronellol are concerned as main components in the essential oil isolated from branches from *P. peuce*. Compared with essential oils isolated from *P. peuce* from Macedonia, the needle essential oil isolated from *P. peuce* from Greece contains larger amount of α -pinene (23.07 %) and β -pinene (22.00 %) and large amount of citronellol (13.42 %), but it doesn't contain germacrene D, while essential oil isolated from branches contains larger amount of β -phellandrene (26.93 %) and large amount of citronellol (12.48 %), smaller amount of α -pinene (7.38 %), but it doesn't contain germacrene D and bornyl acetate. The needle essential oils isolated from *P. peuce* from Montenegro and Serbia contain larger amount of α -pinene (36.5 %) and camphene (8.5 %), but smaller amount of bornyl acetate (6.8 %).

Table 3. Chemical composition of *Pini sylvestris aetheroleum* and *Pini pumillonis aetheroleum* (Ph. Eur 7).

Component	<i>Pini sylvestris aetheroleum</i> (%)	<i>Pini pumillonis aetheroleum</i> (%)
α -Pinene	32.0-60.0	10.0-30.0
Camphene	0.5-2.0	0.0-2.0
β -Pinene	5.0-22.0	3.0-14.0
Δ^3 -Carene	6.0-18.0	10.0-20.0
β -Myrcene	1.5-10.0	3.0-12.0
Limonene	7.0-12.0	8.0-14.0
β -Phellandrene	0.0-2.5	10.0-19.0
<i>p</i> -Cymene	0.0-2.0	0.0-2.5
Terpinolene	0.0-4.0	0.0-8.0
Bornyl acetate	1.0-4.0	0.5-5.0
β -Caryophyllene	1.0-6.0	0.5-5.0

Conclusion

The yield of needle essential oil obtained by hydro-distillation of *Pinus peuce* from Pelister Mtn. (Republic of Macedonia) ranged from 3.00/6.75 ml/kg. The branches without needles contain significantly larger amounts of essential oil (17.30 ml/kg) in terms of needles, while the values for content of essential oil in the branches with needles (7.50 ml/kg) were found between those obtained from needles and from the branches without needles. The obtained essential oils were transparent, light yellowish liquids with specific and strong odor.

Dominant components in the *Pinus peuce* essential oils obtained from needles, from branches without needles and from branches with needles were monoterpenes: α -pinene, β -pinene, limonene + β -phellandrene and bornyl acetate and sesquiterpenes: *trans* (E)-caryophyllene and germacrene D. Among different classes of components in the essential oils, the major constituents were terpene hydrocarbons, both monoterpenes and sesquiterpenes, representing almost 80% of the oils.

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Резиме

Хемиски состав на етерично масло од молика (*Pinus peuce* Griseb., Pinaceae) од Пелистер, Р. Македонија

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Клучни зборови: *Pinus peuce*, македонски бор, хемиски состав на етерично масло, GC/FID/MS, Национален парк Пелистер, *locus classicus*, Р. Македонија.

Анализата на хемиски состав на етерични масла добиени со дестилација со водена пареа од иглички, од гранки без иглички и од гранки со иглички од молика (*Pinus peuce* Griseb., Pinaceae) собрана на Пелистер (Р. Македонија) е направена со GC/FID/MS. Вкупно се идентификувани сто седум компоненти (40 монотерпени, 37 сесквитерпени, 9 дитерпени и 21 други соединенија - алифатични и циклични јаглеводороди; алифатични алкохоли, алдехиди и киселини; феноли и други оксидирани деривати на бензенот). Најзастапени компоненти се компонентите од класата на терпенските јаглеводороди, вклучувајќи ги монотерпените α -пинен, β -пинен, лимонен + β -феландрен и борнил ацетат и сесквитерпените *trans* (E)-кариофилен и гермакрен D.