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THE COMPOSITION OF ESSENTIAL OILS FROM VARIOUS PARTS OF *Juniperus foetidissima*

Z. Tunalier, N. Kirimer, K. H. C. Baser

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Water-distilled oils from the leaf, cone berry, seedless cone berry, seed, and branch of Juniperus foetidissima were analyzed by GC/MS. The main components of the leaf oil were found as β-thujone and cedrol. Sabinene was the major component in the essential oil of cone berries. Sabinene, β-thujone, and abietal were the main components of the seed and seedless cone berry oils. In the branch oil α-pinene was the major component.

Key words: *Juniperus foetidissima* , Cupressaceae, essential oil, GC/MS.

The genus *Juniperus* (Cupressaceae) is widespread in the Northern hemisphere. It is represented by 60 species, 8 of which are found in Turkey. These species are dioecious or monoecious evergreen shrubs or trees.

One of the tree forms of *Juniperus* is *Juniperus foetidissima* Willd., whose height varies from 10 to 20 m. Plant material consists of sharply quadrangular twigs and adult triangular, acute, or acuminate leaves. Ripe cones are borne on erect pedicels and are reddish-brown to nearly black. The size of these cones, which contain 1-2 and rarely 3 seeds, is 7-12 mm. This plant grows in direct sunlight and can survive without water for a long time. It grows in Turkey, Greece, Albania, Yugoslavia, Syria, and Crimea. When the leaves are crushed by hand, they give an unpleasant odor. *J. foetidissima* usually resembles with *J. excelsa* (Boylu Ardic, Tall Juniper) and both grow in the same location. The distinguishing features are as follows: while cone-berries of *J. foetidissima* have 1 or 2 seeds (rarely 3) and those of *J. excelsa* always contain 4-6 seeds. Twigs of *J. foetidissima* are quadrangular but those of *J. excelsa* are terete [1].

Wood of *J. foetidissima* is used to make chests which are believed to be durable and resistant to attack by moths and other insects.

This paper reports on the essential oil composition of cone berries, seedless cone berries, seeds, leaves, and branches. The essential oil composition of *J. foetidissima* leaves was previously reported. Limonene (21% and 5%) and sabinene (17% and 5%) were reported as the main constituents in the monoterpene hydrocarbon fractions of oils of Russian and Turkish origin, respectively [2-4]. In another study, the major components of the hydrodistilled oil from Russia were found as limonene (20.0%) and α-pinene (12%) [5]. In 1990, a steam-distilled oil of Greek origin was reported to contain sabinene (20%), α-thujone (19%), and terpinen-4-ol (18%) as the main constituents [6, 7].

The composition of the essential oils of cone berries, seedless cone berries, seeds, and branches are reported here for the first time.

Crushed plant materials (leaves, cone berries, seedless cone berries, seeds, and branches) were separately subjected to hydrodistillation for 3 h using a Clevenger-type apparatus. The oils obtained were dried over anhydrous sodium sulfate and stored in sealed vials at low temperature before analysis. Essential oil yields are reported on a moisture-free basis. Hydrodistillation of the plant materials gave oils in 0.23-0.85% yield. The maximum oil yield was obtained from cone berries. The yields and compositions of the oils are given in Table 1. The results of GC/MS analyses show that β-thujone was the major component (26.5%) in the leaf essential oil. Cedrol (11.4%) was the second component in the leaf oil. Sabinene (15-24%) was the major component of seed, seedless cone berry, and cone berry oils. Limonene (13%), β-thujone (12%), and abietal (12%) were the second component of cone berry, seedless cone berry, and seed oils, respectively. Branches yielded an oil is rich in α-pinene (25%).

Medicinal and Aromatic Plant and Drug Research Center (TBAM), Anadolu University, 26470, Eskisehir, Turkey. Published in Khimiya Prirodnykh Soedinenii, No. 1, pp. 35-38, January-February, 2002. Original article submitted November 1, 2001.

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TABLE 1. The Composition of the Essential Oils from Various Parts of *Juniperus foetidissima*

Compound	RRI	Oil yield, %				
		I	II	III	IV	V
		0.3	0.3	0.9	0.4	0.2
α-Pinene	1032	25.3	4.8	7.0	8.7	7.8
α-Thujene	1035	-	0.5	0.6	0.6	0.4
α-Fenchene	1072	-	<0.1	<0.1	<0.1	<0.1
Camphene	1076	-	0.1	0.1	0.1	0.1
Hexanal	1093	-	<0.1	-	<0.1	0.2
β-Pinene	1118	0.4	0.1	0.2	0.2	0.2
Sabinene	1132	1.0	9.0	23.7	19.7	15.4
δ-3-Carene	1159	1.2	-	-	-	-
Myrcene	1174	3.0	2.2	4.7	2.7	1.6
α-Terpinene	1188	0.3	2.2	1.4	2.4	0.6
Limonene	1203	1.3	5.2	13.1	7.6	6.3
β-Pellandrene	1213	-	0.2	0.2	0.2	0.1
(*E*)-2-Hexenal	1232	-	0.1	<0.1	-	-
2-Pentyl furane	1244	-	-	-	<0.1	0.1
γ-Terpinene	1255	0.6	3.5	2.5	4.2	1.1
Butyl isovalerate	1259	-	0.2	-	-	-
p-Cymene	1280	0.3	0.6	0.2	0.3	0.2
Terpinolene	1290	2.6	1.1	1.8	1.6	0.8
Amyl isovalerate	1303	-	0.1	-	-	-
1-Hexanol	1360	-	0.1	<0.1	<0.1	-
3-Methyl-3-butenyl isovalerate	1379	-	0.4	-	<0.1	-
(*Z*)-3-Hexen-1-ol	1301	-	0.1	-	-	-
(*E*,*Z*)-1,3,5-Undecatriene	1402	-	-	0.1	<0.1	0.1
α-Thujone	1438	1.8	5.0	0.5	1.0	0.4
α-*p*-Dimethylstyrene	1452	0.1	-	<0.1	<0.1	-
β-Thujone	1457	13.3	26.5	7.7	12.0	5.0
cis-1,2-Limonene epoxide	1458	0.2	-	-	-	-
α-Cubebene	1466	0.1	-	0.4	0.4	0.6
trans-Sabinene hydrate	1474	0.2	0.6	0.6	0.5	0.1
4,8-Epoxy terpinolene	1476	-	<0.1	-	<0.1	-
α-Copaene	1497	-	-	0.2	0.2	0.3
α-Campholene aldehyde	1500	1.2	0.1	-	-	-
Camphor	1532	-	<0.1	-	<0.1	-
Pinocamphone	1535	0.5	-	-	-	-
Linalool	1553	-	0.1	-	-	-
cis-Sabinene hydrate	1556	0.1	0.4	0.3	0.5	<0.1
iso-Pinocamphone	1562	0.1	-	-	-	-
trans-*p*-Menth-2-en-1-ol	1571	0.1	0.6	0.3	0.6	0.1
α-Cedrene	1577	0.3	0.1	-	-	-
Pinocarvone	1586	0.6	-	-	-	-
β-Funebrene	1594	1.0	0.1	0.2	0.1	0.2
Bornyl acetate	1597	0.3	0.5	0.2	0.3	0.3
β-Elemene	1600	-	-	-	0.1	0.1
Terpinen-4-ol	1611	3.8	7.6	4.0	9.3	1.9
4-Terpinenyl acetate	1628	-	-	-	<0.1	-
cis-*p*-Menth-2-en-1-ol	1638	-	0.5	0.2	0.4	0.1
Thuj-3-en-10-al	1641	-	0.1	-	<0.1	<0.1
Thujopsene	1645	0.2	0.1	-	-	<0.1
Myrtenal	1648	0.5	-	-	0.2	<0.1
γ-Elemene	1650	-	-	0.2	0.1	0.3
Sabina ketone	1651	0.2	0.3	-	-	-

TABLE 1. (Continued)

Compound	RRI	Oil yield, %				
		I	II	III	IV	V
		0.3	0.3	0.9	0.4	0.2
Umbellulone	1658	-	0.1	-	<0.1	-
Sabinyl acetate	1658	-	0.1	0.2	0.4	0.4
cis-Verbenol	1663	0.4	<0.1	-	0.1	-
3-Thujanol (neoisothujanol)*	1665	-	-	-	-	1.2
iso-Thujanol*	1666	-	2.2	-	2.7	-
(*Z*)-*β*-Farnesene	1668	-	-	<0.1	-	<0.1
trans-Pinocarveol	1671	2.4	-	-	-	-
p-Mentha-1,5-dien-8-ol	1674	0.4	0.1	-	0.1	-
cis-*p*-Mentha-2,8-dien-1-ol	1678	-	0.1	-	<0.1	-
trans-Verbenol	1684	2.4	-	-	-	-
α-Humulene	1687	0.9	-	0.1	0.1	0.1
trans-Piperitol	1689	-	0.3	0.1	0.3	0.1
Carvotan acetone	1697	-	0.1	-	<0.1	<0.1
p-Mentha-1,8-dien-4-ol	1700	-	<0.1	<0.1	-	-
γ-Muurolene	1704	0.4	-	0.1	0.1	0.1
α-Terpineol	1707	0.3	0.5	0.2	0.5	0.1
trans-Sabinol	1719	-	0.3	0.1	0.4	0.2
Germacrene-D	1726	1.6	-	4.7	2.7	5.4
α-Muurolene	1737	0.6	0.1	0.4	0.5	0.5
α-Selinene	1744	0.4	-	-	-	-
Carvone	1751	0.1	0.1	-	0.1	0.1
cis-Piperitol	1758	-	0.3	0.1	0.3	0.1
δ-Cadinene	1772	0.4	0.1	0.3	0.3	0.3
γ-Cadinene	1776	0.1	<0.1	0.1	0.1	<0.1
Cuminaldehyde	1802	-	<0.1	-	<0.1	<0.1
Myrtenol	1797	0.4	0.1	<0.1	<0.1	<0.1
p-Mentha-1,5-dien-7-ol	1815	0.2	0.3	-	0.1	-
(*E*,*E*)-2,4-Decadienal	1827	-	<0.1	-	<0.1	0.1
trans-Carveol	1845	0.6	0.3	<0.1	0.1	<0.1
Germacrene-B	1853	-	-	1.0	0.6	1.1
p-Cymen-8-ol	1864	0.1	0.1	-	0.1	-
cis-Carveol	1882	-	0.1	-	<0.1	-
epi-Cubebol	1900	-	-	-	<0.1	<0.1
Cubebol	1957	-	-	<0.1	<0.1	0.1
Caryophyllene oxide	2008	0.6	<0.1	-	<0.1	<0.1
Salvial-4(14)-en-1-one	2037	-	-	-	<0.1	<0.1
Pentadecanal	2041	-	-	-	<0.1	<0.1
(E)-Nerolidol	2053	-	<0.1	-	<0.1	-
p-Mentha-1,4-dien-7-ol	2065	-	0.3	-	-	-
Germacrene D-4-ol	2069	-	-	0.5	0.3	1.0
Humulene epoxide-II	2069	0.5	-	-	-	-
Cubenol	2080	-	<0.1	-	<0.1	-
1-*epi*-Cubenol	2088	-	-	-	<0.1	<0.1
β-Plopenone	2092	-	0.2	-	-	-
Elemol	2096	-	-	<0.1	<0.1	0.1
Cumin alcohol	2113	<0.1	0.1	-	<0.1	-
Cedrol	2148	16.6	11.4	1.6	1.6	2.4
T-Cadinol	2187	0.4	0.2	0.1	-	<0.1
T-Muurolol	2209	0.5	0.1	0.1	0.1	0.2
δ-Cadinol	2219	0.2	<0.1	<0.1	0.1	-
Carvacrol	2246	0.2	0.2	<0.1	0.1	0.1

TABLE 1. (Continued)

Compound	RRI	Oil yield, %				
		I	II	III	IV	V
		0.3	0.3	0.9	0.4	0.2
α-Cadinol	2255	0.9	0.3	0.4	0.3	0.5
Sandaracopimaradiene	2287	-	0.1	0.1	0.1	0.2
Juniper camphor	2320	-	-	-	<0.1	<0.1
Cinnamyl isovalerate	2329	-	-	-	<0.1	<0.1
Selina-11-en-4α-ol	2273	0.6	-	-	-	-
Manoyl oxide	2376	0.2	0.1	-	<0.1	0.1
8α-13-Oxy-14-en-epilabdane	2391	0.3	0.1	-	-	-
8,13-Abietadiene	2489	-	0.4	4.2	4.1	9.3
Abietatriene	2524	2.1	0.1	-	0.1	0.1
Hexadecanoic acid	2931	-	0.1	-	<0.1	0.2
Abietal*	2994	-	-	7.5	3.5	11.5
4-*epi*-Abietal*	3018	-	-	0.1	-	0.3
Dehydroneo-abietol*	3100	-	-	0.7	-	1.7
Abietol*	3278	-	-	0.5	0.2	-

RRI - Relative retention indices.
I: Branch, II: Leaf, III: Cone berry, IV: Seedless cone berry, V: Seed.
*Tentative identification.

TABLE 2. The Comparisons of Essential Oils of *Juniperus foetidissima* Leaves of Turkish, Greek, and Russian Origin

Compound	Greece [6, 7]	Turkey* [3, 4]	Russia* [2]	Russia [5]	Turkey**
Sabinene	19.6	4.5	16.6	6.3	9.0
α-Thujone	18.6	-	13.4	-	5.0
Terpinen-4-ol	17.6	-	-	-	7.6
γ-Terpinene	6.5	3.2	5.3	6.9	3.5
α-Terpinene	4.3	1.4	-	3.1	2.2
β-Thujone	3.5	-	-	-	26.5
Cedrol	3.2	-	-	-	11.4
Myrcene	2.7	1.8	0.7	3.0	2.2
α-Pinene	2.6	2.8	4.6	11.5	4.8
Limonene	0.8	5.2	21.2	19.5	5.2

*Only the monoterpene hydrocarbons were characterized.
**Present study.

The main components of the oils found in the present and previous studies are shown in Table 2. Comparison of the results from leaf oils of Turkish, Russian, and Greek origin revealed that the Russian oils were rich in limonene/α-pinene/sabinene/α-thujone, the Greek oil was rich in sabinene/α-thujone/terpinen-4-ol, and the Turkish oils were reported is rich in limonene/sabinene. In this study, β-thujone/cedrol/sabinene were found as the main components of the leaf oil. The differences in composition may be due to age of the tree, edaptic factors, or to the occurrence of chemotypes.

EXPERIMENTAL

The oils were analyzed by GC/MS using a Hewlett-Packard GCD system. Innowax FSC column (60 m × 0.25 mm i.d. with 0.25 μm film thickness) was used with helium as carrier gas. Oven temperature was kept at 60°C for 10 min and programmed to 220°C at a rate of 4°C/min and then kept constant at 220°C for 10 min, to 240°C at a rate of 1°C/min. The split ratio was adjusted at 50:1. The injector temperature was at 250°C. MS were taken at 70 eV. MS range was from *m/z* 35 to 425. Library search was carried out using Wiley GC/MS Library and TBAM Library of Essential Oil Constituents. Relative percentage amounts were calculated from TIC by computer.

Plant materials (leaves, cone berries, and branches) were collected on 16 August 1998, from Bozdag (8 km from Muttalip village), Turkey. Cone berries were used either with seeds or without ones. Voucher specimens were deposited at the Herbarium of the Faculty of Pharmacy, Anadolu University, Turkey (ESSE 11730).

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