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Essential oils composition of *Juniperus drupacea* Lab. leaf from Turkey

Türkiye' de yetişen *Juniperus drupacea* Lab.' ın yapraklarından elde edilen uçucu yağların kimyasal yapıları

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Abstract

The fine chemical compositions of the essential oils of J. drupacea leaves growing in southern Anatolia have been investigated. In order to find out whether any chemical change happens in the leaves of *J.drupacea* due to seasons and different location materials have been collected four times a year in four different districts for two consecutive years. The compositions of volatile oils were analyzed by GC and GC/MS methods and 90.7 – 98.2 % of the compounds were characterized in the oils, corresponding to 118 – 122 substances. α-pinene (9.97 - 45.9%), limonene (22.7 - 52.5%), β-pinene (0.6 - 2.7%), β-phellandrene (0.9 - 7.4%), α-copaene (0.1 - 2.0%), β-caryophylene (0.1 - 1.4%), α-humulene (0.6 - 2.2%), δ-cadinene (0.1 - 2.3%) and γ-cadinene (0.8 - 3.9%) were found as major constituents.

Keywords: *Juniperus drupacea,* essential oil, GC, GC/MS.

Introduction

The genus *Juniperus* (in Turkish) is represented in Turkey by 8 species (Davis 1965). *Juniperus drupacea* Lab. [Syn. *Arceuthos drupacea* Ant. et Kotschy (Davis 1965, Adams 2004)] is called in Turkish "Andız" (Baytop 1994) Ardıç, and "Enek" (Semiz et al. 2007). Essential oil contents of the leaves of *J. drupacea* from Greece (Adams, 1997), Crimea (Adams 1997) and the Turkish materials from Gözne (Mersin) (Sakar 1985) and Kahramanmaraş (Dönmez 2005) have previously been investigated. Since the previous studies in Turkey were carried out only on single samples. In this work we investigate the effects of seasonal variations and geographical differences on the essential oil yield and content of *J. drupacea* leaves growing widely in Turkey.

Material and Methods

Plant Material and Hydro distillation

J. drupacea leaves were collected four times a year from four different locations for two consecutive years (Figure I). Collection data are given in Table I. Voucher specimens are kept at the Herbarium of the Faculty of Pharmacy of Gazi University (GUFP04-242).

Plant materials were subjected to hydro distillation for 3 h using a Clevenger type apparatus suitable for European Pharmacopoeia. The oils obtained were kept deep freeze until the GC-MS analysis.

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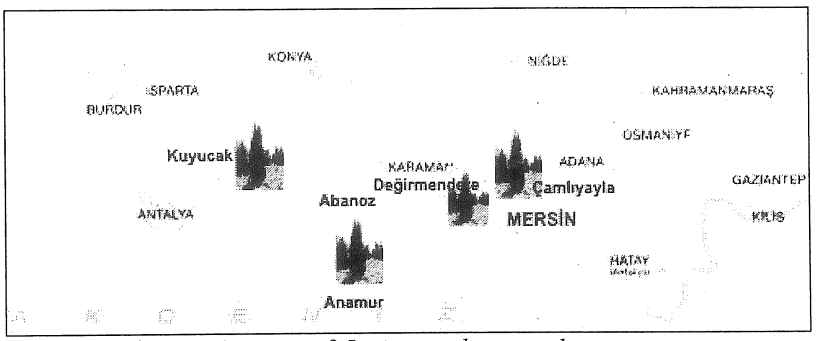

Figure 1. Collection area of *Juniperus drupacea* leaves

Table 1. Collection sites and dates of *Juniperus drupacea* leaves.

Kuyucak		Abanoz		Değirmendere		Çamlıyayla	
Code	**Date**	**Code**	**Date**	**Code**	**Date**	**Code**	**Date**
A1	13.04.2004	**B1**	14.04.2004	**C1**	14.04.2004	**D1**	15.04.2004
A2	14.07.2004	**B2**	14.07.2004	**C2**	15.07.2004	**D2**	15.07.2004
A3	13.10.2004	**B3**	13.10.2004	**C3**	14.10.2004	**D3**	14.10.2004
A4	12.01.2005	**B4**	12.01.2005	**C4**	13.01.2005	**D4**	13.01.2005
A5	26.04.2005	**B5**	26.04.2005	**C5**	27.04.2005	**D5**	27.04.2005
A6	24.07.2005	**B6**	20.07.2005	**C6**	20.07.2005	**D6**	20.07.2005
A7	25.10.2005	**B7**	14.10.2005	**C7**	13.10.2005	**D7**	13.10.2005

A: **Kuyucak** (Akseki-Konya road, 1300m, road edge) **B**: **Abanoz** (Anamur-Ermenek road, 1600m, road edge)
C: **Değirmendere** (Mersin-Gözne, 1100m, road edge) **D**: **Çamlıyayla** (Mersin, 1600m, road edge)

GC and GC-MS Analysis

All the oils were analyzed by GC using a Hewlett Packard HP6890 system with Innowax FSC column (60 m x 0.25 mm∅, 0.25 μm film thickness). Helium (0.9mL/min) was used as carrier gas. The GC oven temperature was kept at 60°C for 10 min and programmed to 220°C at the rate of 4°C/min and then kept constant at 220°C for 10 min and programmed to 240°C at a rate of 1°C/min. Split ratio was adjusted at 40:1. The injector and FID detector temperatures were at 250 °C. The relative percentage amounts of the separated compounds were calculated from FID chromatograms. The mass range was recorded from *m/z* 35 to 425. MS were recorded at 70 eV. Alkanes were used as reference points in the calculation of relative retention indices (RRI). The components of essential oils were identified by comparison of their mass spectra with those in the Başer Library of Essential Oil Constituents, Wiley GC/MS Library, Adams Library, Mass Finder 3 Library and confirmed by comparison of their retention indices.

Result and Discussion

The quantitative percentages of leaf oils were calculated on dry weight basis. The comparative results are shown in Table 2.

Table 2. Sites and the essential oil contents of *J. drupacea* leaves according to collection dates.

Kuyucak		Abanoz		Değirmendere		Çamlıyayla	
*	%	*	%	*	%	*	%
A1	0.13	B1	0.15	C1	0.15	D1	0.26
A2	0.10	B2	0.31	C2	0.26	D2	0.18
A3	0.13	B3	0.19	C3	0.20	D3	0.26
A4	0.16	B4	0.15	C4	0.17	D4	0.15
A5	0.16	B5	0.15	C5	0.21	D5	0.23
A6	0.15	B6	0.28	C6	0.22	D6	0.37
A7	0.18	B7	0.31	C7	0.14	D7	0.36
min-max	0.10-0.18	min-max	0.15-0.31	min-max	0.14-0.26	min-max	0.15-0.37

*Collection dates for each codes are given in Table 1.

Table 3 shows the main constituents of *J. drupacea* essential oils for samples collected in different sites and dates.

118-122 compounds were detected in the essential oils *of J. drupacea leaves*. α-pinene (9.97-45.9 %) and limonene (22.7 - 52.5 %) are the main constituents. In addition, β-pinene (0.6-2.7 %), β-phellandrene (0.9-7.4%), α-copaene (0.1-2.0 %), β-caryophyllene (0.1-1.4 %), α-humulene (0.6-2.2 %), δ-cadinene (0.1-2.3%) and γ-cadinene (0.8-3.9 %) are present in high amounts in the leaves oils (Table 3).

Table 3. Main constituents of *J. drupacea* the essential oils collected from different sites and dates.

	Kuyucak	Abanoz	Değirmendere	Çamlıyayla
α-pinene	11.5-37.6	9.97-27.2	23.7-41.6	20.9-45.9
Limonene	23.0-44.4	33.5-52.5	22.7-44.5	24.6-36.6
β-pinene	0.6-1.9	0.6-1.2	1.3-1.8	1.2-2.7
β-phellendrene	2.7-7.4	2.7-4.2	0.9-4.6	1.5-3.7
α-copaene	0.2-2.0	0.2-2.0	0.7-1.9	0.1-1.7
β-caryophylene	0.1-1.1	0.9-1.3	0.1-1.3	0.6-1.4
α-humulene	1.3-1.9	1.3-2.2	0.9-1.7	0.6-2.0
δ-cadinene	1.3-2.3	1.3-2.2	0.9-1.9	0.1-1.8
γ- cadinene	1.8-3.7	1.5-3.9	0.8-3.6	0.8-3.1

Furthermore, compounds like germacrene D (10.7%), γ-amorphene (10.3%), valensene (8.0%), α-muurolene (12.4%) and 13-epi-manoyloxide (3.3%) were found in high percentages for given period but they are generally present at lower concentrations.

The most prominent characteristic of the oils of *J. drupacea* appeared as monoterpene-rich (64.3-86.6%) while the ratios of sesquiterpenes and diterpenes varied as 10.1-27.9 % and 0.1-3.5 %, respectively. On the other hand, oxygenated monoterpenes occurred as 0.9-6.8 %, oxygenated essential oil as sesquiterpenes 0.8-4.5 % and oxygenated diterpenes as trace (3.3 %). Thus the leaf oils appeared to be rich in terms of hydrocarbons particularly, α-pinene and limonene.

No significant difference was observed among the oils obtained from leaves collected from different regions. Seasonal variations were not observed among the main constituents.

In previous studies, 97,4% of the oil had reportedly been belucidated corresponding to 18 compounds in the material collected from Gözne (Sakar 1985) (Table 4). A sesquiterpene with

a concentration of 1.9% having MW 204 had not been characterized. 55 substances representing to of 78% of the volatile oil obtained from the leaves collected at Kahramanmaraş had reportedly been characterized; however, 9 peaks having a total concentration of 4.3 % had not been attributed.

Table 4. Comparison of the chemical composition of *J. drupacea* essential oils from Gözne and Kahramanmaraş with Gözne (Değirmendere) samples.

Compounds	Tr2	Tr1	Tr3
α-pinene	12.2	14.3	23.4-41.6
β-pinene	0.7	0.7	1.3-1.8
β-myrcene	3.2	-	-
Myrcene	-	3.5	0-2.8
δ^3- careen	0.3	13.2	0.5-3.6
Limonene	49.4	55.6	22.7-44.5
β-phellandrene	-	-	0.9-4.6
1,8-cineol	-	4.3	-
Terpinolene	-	0.8	t-0.2
α –cubebene	1.0	0.3	0-1.2
α –copaene	1.3	0.1	0.8-1.9
β –caryophyllene	0.9	0.6	0.1-1.3
α-humulene	0.9	0.3	
γ-muurolene	0.4	-	0.8-8.6
Germacrene D	7.9	-	0.1-6.5
Ar-curcumene	-	-	0-0.3
α –muurolene	0.5	-	0-0.3
γ-cadinene	1.1	0.2	0.8-3.6
δ-cadinene	1.0	0.4	0.9-1.9
Cadinene	0.1	-	-
Trans-farnesol	0.7	-	0-0.1
Manoyl oxide	5.0	-	-
Manoyl oxide<13-epi->	-	-	0-3.3
Unknown	4.3	1.9	-
Total	**78.28**	**97.4**	**91.1-98.2**

Tr1: Gözne Tr2: Kahramanmaraş Tr3: Değirmendere (Gözne) t : < 0.1 %

In the present study, in all, 118-122 compounds corresponding to making up of 90.7-98.2 % of the oils were characterized. All the major compounds were characterized. Although the contents of α-pinene, β-pinene, limonene seem to be similar to previous reports, our results present a more complete study of the chemistry of *J. drupacea* oils of Turkey.

1,8-cineole (4.3%) reported previously from Gözne material (Sakar 1985) was not be detected either in the volatile oils of Kahramanmaraş material (Dönmez 2005) or in our materials. The occurrence of β-phellandrene (0.9-7.4%) was not previously reported from *J. drupacea* leaves.

As a result, our study is the most comprehensive one, for *J. drupacea* leaf essential oil study collected from Gözne (Sakar 1985) and Kahramanmaraş (Dönmez 2005) from the substances found point of view. α-pinene ratio is found to be 14.3 % maximum in the previous studies, in our study this ratio is increasing till 40 %. Common point between our results and the other two studies is that limonene is the main component of leaf essential oils. The results of our study is given above in Table 5 for an easy comparison with the studies done in Greece (Adams 1997) and Crimea (Adams 1997).

In the previous Grek study, four compounds had been claimed to be sesquiterpene alcohols

whereas in our study 12 sesquiterpene alcohols were fully determined.

In our study β-phellandrene (0.9-7.4 %) and γ-muurolene (0.7-8.6 %) appear as major compounds and were reported in trace amounts in Greek oil and γ-amorphene (1.6-10.3 %) and valencene (0.2-8.0 %) were not detected at all.

In the Crimean oil only 11 compounds had been determined. A comparison is given at Table 5. Similar compositions were observed in the oils of Greece, Crimea and our oils. However, the content of α-pinene seemed to be lower in the oils of Greek samples (3.5-5.1 %) and higher in the Turkish samples (9.97-45.9 %). However, the ratios of δ-3- carene was higher (13.5-22.3 %) in the Greek samples and lower in the Turkish samples (0.1-3.6 %). Another important difference is that α–muurolene happens to be seemingly higher (0.7-12.4 %) in the oils of Turkish samples.

Table 5. Comparison of the composition of *J.drupacea* essential oils from Greece and Crimea with Anatolian samples.

Compounds	**G1**	**G2**	**C**	**Tr**
α-pinene	5.1	3.5	22.1	10.0-45.9
β-pinene	0.6	0.3	0.2	0.6-2.7
Myrcene	3.0	2.7	6.7	1.7-3.3
δ^3-carene	22.3	13.5	7.0	0.1-3.6
Limonene	46.7	48.4	50.3	22.7-52.5
β-phellandrene	-	t	-	0.9-7.4
Terpinolene	0.8	0.8	1.1	t-0.4
α –cubebene	0.7	0.5	-	0.1-1.2
α –copaene	0.6	0.7	-	0.1-2.0
β -caryophyllene	0.1	0.5	-	0.1-1.4
α-humulene	0.1	0.6	-	0.6-2.2
γ-muurolene	e	-	-	0.7-8.6
Germacrene D	0.4	0.1	-	0.1-10.7
Ar-curcumene	1.9	3.6	-	t-0.8
β-alaskene	0.4	0.3	-	t-0.1
α -muurolene	e	0.2	-	0.7-12.4
γ-cadinene	0.2	1.6	-	0.8-3.9
δ-cadinene	0.1	0.4	-	0.1-2.3
Sesquiterpene alcohol	0.5	0.9	-	0.3-4.0
Sesquiterpene alcohol	0.6	1.0	-	-
Sesquiterpene alcohol	1.1	1.6	-	-
Sesquiterpene alcohol	0.6	1.1	-	-
Total	**98.0**	**94.2**	**90.10**	**90.7-98.2**

G1, G2: Greece
C: Crimea
Tr: Our research
t : < 0.1 %

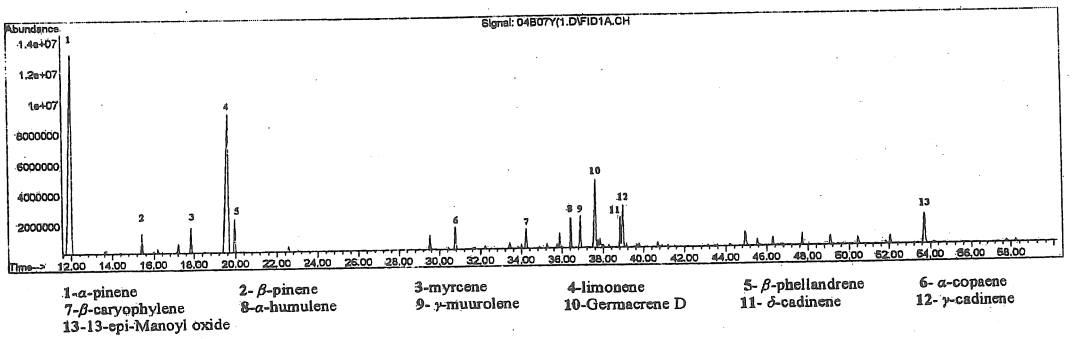

Figure 2. The chromatogram of *J. drupacea* collected from Değirmendere in April 2004

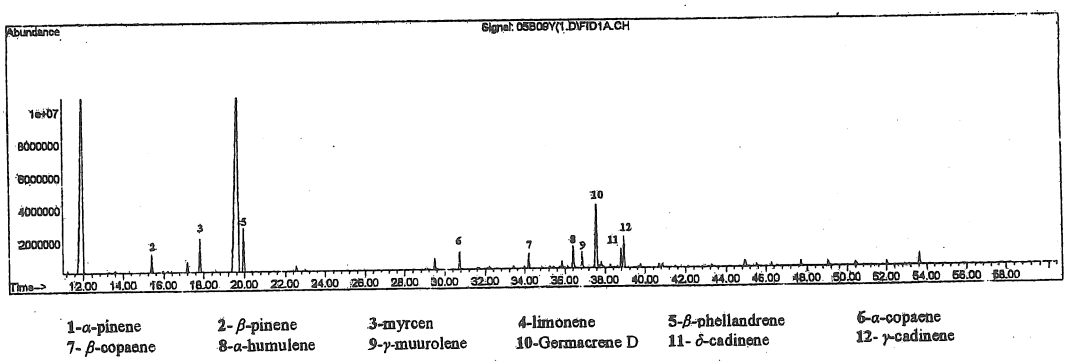

Figure 3. The chromatogram of *J. drupacea* collected from Değirmendere in April 2005

Table 6. Result of analysis of *J. drupacea* leaf oils from Kuyucak.

RRI	Compounds	A1	A2	A3	A4	A5	A6	A7
					%			
1032	α-Pinene	23.6	37.6	21.3	14.7	20.2	14.2	11.5
1072	α-Fenchene	0.2	0.1	0.1	0.1	0.1	0.1	0.2
1076	Camphene	0.2	0.2	0.1	0.1	0.1	0.1	0.1
1093	Hexanal	0.2	0.1	0.2	0.1	0.1	0.2	t
1118	β-Pinene	1.4	1.9	1.2	0.7	1.2	1.2	0.6
1132	Sabinene	0.1	0.1	t	0.1	0.1	0.1	0.1
1142	Thuja-2,4(10)-diene	0.3	0.2	0.2	0.1	0.1	0.1	t
1146	δ-2-Carene	0.2	0.1	0.2	0.1	0.2	1.6	-
1159	δ-3-Carene	1.9	0.8	1.7	-	1.5	3.1	2.7
1174	Myrcene	2.2	2.9	3.3	2.1	3.0	-	-
1176	α- phellandrene	0.1	0.1	0.2	0.1	0.2	-	-
1187	o-Cymene	0.4	0.1	0.1	0.1	0.1	-	-
1203	Limonene	32.8	23.0	38.7	44.4	35.3	40.2	41.2
1218	β-Phellandrene	4.0	4.1	7.4	2.7	6.5	6.7	6.2
1280	*p*-Cymene	0.7	0.4	0.5	0.3	0.4	0.3	0.6
1290	Terpinolene	0.1	0.2	0.3	0.3	0.2	0.4	0.1
1452	α,*p*-Dimethylstyrene	0.1	0.1	0.1	t	t	t	t
1466	α-Cubebene	0.7	0.5	1.1	0.1	-	0.6	0.1
1468	*trans*-1,2-Limonene epoxide	0.3	0.1	0.1	0.1	1.4	0.1	0.1
1493	α-Ylangene	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1497	α-Copaene	1.7	1.6	1.7	0.3	2.0	0.9	0.2
1536	Pinocamphone	0.1	0.1	0.1	-	-	0.1	0.1
1549	β-Cubebene	-	-	-	0.2	0.2	0.2	0.4
1553	Linalool	0.2	0.3	0.2	-	-	t	t
1586	Pinocarvone	0.3	0.3	0.1	-	-	-	-
1589	B-ylangene	-	-	-	0.1	0.1	0.1	0.1
1606	β-Copaene	0.2	0.2	0.2	0.2	t	0.1	1.5
1612	β-Caryophyllene	0.7	0.9	1.0	1.1	1.2	1.2	0.1
1634	Cadina-3,5-diene	-	-	-	-	-	0.3	0.1
1639	*trans-p*-Mentha-2,8-dien-1-ol	0.2	0.1	0.1	0.1	t	0.1	-
1642	Thuj-3-en-10-al	-	-	-	0.1	0.1	-	-
1648	Myrtenal	0.3	0.2	0.2	-	t	0.2	0.1
1663	*cis*-Verbenol	0.2	0.1	t	t	0.2	-	-
1670	*trans*-Pinocarveol	0.9	0.7	0.4	0.2	0.1	0.3	0.2
1687	α-Humulene	1.4	1.8	1.5	1.3	1.7	1.7	1.9
1704	γ-Muurolene	2.0	0.7	1.9	1.5	-	1.5	1.9
1706	α-Terpineol	T	1.2	-	0.4	t	-	-
1726	Germacrene D	2.6	5.3	5.7	10.5	2.2	-	0.1
1733	γ-Amorphene	-	-	-	-	-	10.3	-
1740	Valencene	0.4	0.3	0.2	-	8.0	0.2	-
1740	α-Muurolene	-	-	-	0.2	-	-	12.4
1741	α-Alaskene	0.2	0.1	0.2	-	1.7	-	-
1744	α-selinene	-	-	-	-	-	0.3	0.4
1751	Carvone	0.7	0.2	0.2	0.3	0.1	0.1	0.2
1773	δ-Cadinene	1.4	1.8	1.7	1.3	2.3	1.4	1.6
1776	γ-Cadinene	3.7	3.1	1.9	3.7	2.5	2.8	1.8
1786	*ar*-Curcumene	0.3	t	0.3	-	-	-	-
1799	Cadina-1,4-diene	-	-	-	-	0.4	-	0.1
1804	Myrtenol	0.3	0.1	0.1	-	-	0.3	-
1811	α-Cadinene		0.1	0.2	0.3	0.2	0.7	0.2
1845	*trans*-Carveol	0.6	0.1	0.1	0.2	0.1	-	0.2
1853	*cis*-Calamenene	0.2	0.3	0.2	0.3	0.3	0,5	0.3
1882	*cis*-Carveol	0.3	0.1	0.1	0.1	t	0.1	0.1
1941	α-Calacorene I	0.1	0.1	t	0.1	t	0.1	0.1
1950	Dendrolasin	0.1	0.1	t	0.3	0.1	-	-
1984	α-Calacorene II	-	0.1	0.1	0.1	0.1	t	0.1
2008	Caryophyllene oxide	-	0.4	0.2	0.4	0.4	0.3	1.1
2037	Salvial-4(14)-en-1-one	0.3	0.2	0.1	-	t	0.2	0.3
2071	Humulene epoxide-II	0.4	0.2	0.1	0.3	0.2	0.1	0.3
2080	Cubenol	0.1	0.1	0.1	-	-	-	0.1
2089	1,10-Diepicubenol	T	0.1	t	0.1	0.1	t	t
2132	Salviadienol	0.5	0.3	t	0.5	0.4	0.3	0.5
2187	T-Cadinol	0.7	0.5	0.2	0.9	0.4	0.6	0.3
2209	T-muurolol	0.1	0.1	t	-	t	-	0.1
2254	Torilenol	0.4	0.2	0.1	-	t	0.3	0.2
2255	α-Cadinol	0.1	0.2	0.1	0.4	t	0.3	0.4
2356	Isopimara-8,15-diene	-	-	-	-	-	t	0.3
2368	Eudesma 4(15),7-dien-1-β-ol	-	0.1	t	0.1	0.1	2.6	1.3
2369	(2*E*,6*E*)-Farnesol	-	-	-	0.2	0.1	-	-

2376	Manoyl oxide	-	-	-	1.7	-	-	-
2392	Caryophylla-2(12),6-dien-5-β-	0.2	0.1	t	0.1	0.1	0.1	t
2396	13-*epi*-Manoyl oxide	2.0	0.7	0.6	-	1.0	0.1	0.1
2503	Lauric asit (=Dodecanoic acid)	-	-	-	0.6	-	-	-
2524	Abietatriene	0.2	-	0.1	-	-	0.1	0.2
2931	Hexadecanoic acid	0.1	t	t	0.3	t	0.1	t
	Total	**94.5**	**96.2**	**97.1**	**95.3**	**97.4**	**98.1**	**93.1**

A1: April 2004 **A2**: July 2004
A3: October 2004 **A4**: January 2005
A5: April 2005 **A6**: July 2005
A7: October 2005
RRI: Relative retention indices calculated against n-alkanes
%: calculated TIC data
t: Trace (< 0.1 %)

Table 7. Result of analysis of *J. drupacea* leaf oils from Abanoz.

RRI	Compounds	B1	B2	B3	B4	B5	B6	B7
				%				
1014	Tricyclen	0.1	0.1	0.1	t	0.1	0.1	t
1032	α-Pinene	20.	22.	23.	15.	27.	22.	9.9
1072	α-Fenchene	0.1	0.1	0.1	0.1	0.1	t	0.1
1076	Camphene	0.1	0.1	0.1	0.1	0.2	0.1	0.1
1093	Hexanal	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1118	β-Pinene	1.1	1.2	1.1	0.7	1.2	1.0	0.6
1132	Sabinene	0.1	0.1	0.1	0.1	0.1	0.1	0.5
1142	Thuja-2,4(10)-diene	0.2	0.1	0.2	0.1	0.2	0.1	t
1146	δ-2-Carene	0.1	0.1	0.1	0.1	0.1	-	-
1159	δ-3-Carene	1.4	1.6	2.4	1.1	2.0	0.3	1.5
1174	Myrcene	1.9	2.4	2.5	2.2	2.1	2.5	-
1176	α-Phellandrene	0.1	0.1	0.1	0.1	0.1	-	-
1187	o-Cymene	0.2	0.1	0.1	0.1	0.1	-	-
1203	Limonene	33.	42.	38.	46.	34.	38.	52.
1218	β-Phellandrene	3.2	2.7	4.2	2.9	3.4	3.6	3.4
1225	(*Z*)-3-Hexenal	t	t	0.1	t	0.1	-	-
1280	*p*-Cymene	0.4	0.3	0.4	0.3	0.3	0.4	0.6
1290	Terpinolene	0.1	0.2	0.2	0.3	0.1	0.1	0.1
1452	α,p-Dimethylstyrene	0.1	t	0.1	t	t	t	t
1466	α-Cubebene	1.2	0.7	0.5	-	-	0.5	0.1
1468	*trans*-1,2-Limonene	0.1	0.1	0.1	0.1	0.5	t	0.1
1493	α-Ylangene	0.1	t	0.1	0.1	0.1	0.1	0.1
1497	α-Copaene	2.0	1.0	0.9	0.2	1.1	0.7	0.4
1549	β-Cubebene	-	-	-	0.2	0.1	0.3	0.2
1553	Linalool	0.1	0.3	0.4	-	-	-	t
1571	*trans-p*-menth-2-en-1-ol	0.2	t	t	t	-	-	-
1589	β-ylangene	-	-	-	0.1	0.2	0.1	0.2
1606	β-Copaene	0.2	0.6	0.2	0.2	0.2	0.2	0.2
1612	β-Caryophyllene	1.2	1.0	1.0	1.2	0.9	1.3	0.9
1634	Cadina-3,5-diene	-	-	-	-	-	0.2	0.1
1639	*trans-p*-Mentha-2,8-dien-1-	0.1	t	0.1	0.1	0.2	-	0.1
1642	Thuj-3-en-10-al	-	-	-	0.1	0.2	-	-
1648	Myrtenal	0.2	0.1	0.2	-	-	0.1	t
1670	*trans*-Pinocarveol	0.5	0.3	0.7	0.2	-	0.2	0.2
1687	α-Humulene	1.7	1.3	1.7	1.7	1.8	2.2	1.3
1704	γ-Muurolene	1.6	1.1	1.6	1.4	1.5	-	1.8
1706	α-Terpineol	0.3	0.1	-	0.2	0.1	-	5.9
1726	Germacrene D	7.5	6.5	6.2	10.	6.1	10.	-
1733	γ-Amorphene	-	-	-	-	-	1.6	0.1
1740	Valenchene	0.2	0.2	0.3	-	-	-	-
1740	α-Muurolene	-	-	-	0.2	0.2	0.2	0.5
1741	α-Alaskene	0.2	0.3	0.2	-	-	-	-
1751	Carvone	0.3	0.2	0.3	0.2	0.2	0.1	0.2
1773	δ-Cadinene	1.5	1.3	1.4	1.3	1.6	1.5	2.2
1776	γ-Cadinene	1.5	1.7	2.2	3.7	1.8	2.1	3.9
1786	*ar*-Curcumene	0.2	0.8	0.1	-	-	0.2	-
1804	Myrtenol	0.1	0.1	0.1	-	-	-	-
1811	α-Cadinene	-	1.2	0.2	0.3	0.2	0.2	0.3
1845	*trans*-Carveol	0.2	0.2	0.3	0.1	0.2	0.1	0.2
1853	*cis*-Calamenene	0.2	0.1	0.2	0.3	0.3	0.4	0.3
1882	*cis*-Carveol	0.2	t	0.1	0.1	0.1	0.1	0.1

1941	α-Calacorene I	0.1	t	t	t	0.1	0.3	0.1
1950	Dendrolasin	0.3	0.2	0.3	0.3	0.4	-	-
1984	α-Calacorene II	0.1	0.1	0.1	t	t	0.1	0.1
2008	Caryophyllene oxide	0.2	0.3	0.3	0.4	0.4	0.8	0.5
2037	Salvial-4(14)-en-1-on	0.4	0.2	0.2	-	-	0.2	0.3
2058	Germacrene D-1,10	0.2	t	t	t	t	t	t
2071	Humulene epoxide-II	0.5	0.2	0.2	0.2	0.3	0.3	0.3
2080	Cubenol	0.1	0.1	0.1	-	-	0.1	t
2132	Salviadienol	0.7	0.4	0.3	0.3	0.1	0.5	0.5
2187	T-Cadinol	0.3	0.3	0.2	0.6	0.4	0.6	1.0
2209	T-muurolol	0.1	t	t	-	-	0.1	0.1
2254	Torilenol	0.6	0.3	0.2	-	-	0.4	0.2
2255	α-Cadinol	0.2	0.1	0.1	t	0.1	t	0.4
2356	Isopimara-8,15-diene	-	-	-	-	-	0.3	0.1
2368	Eudesma 4(15),7-dien-1-β-	-	0.1	t	t	-	-	0.8
2369	Eudesma 4(15),7-dien-1-β-	-	-	-	-	t	1.4	-
2369	(2*E*,6*E*)-Farnesol	-	-	-	0.1	0.5	-	-
2376	Manoyl oxide	-	-	-	1.1	1.9	-	-
2392	Caryophylla-2(12),6-dien-	-	0.1	t	t	0.1	0.1	0.1
2396	13-*epi*-Manoyl oxide	2.2	1.4	1.0	-	-	0.1	t
2503	Lauric acid (=Dodecanoic	-	-	-	0.3	0.1	-	-
2524	Abietatriene	0.1	0.2	0.1	-	-	-	0.2
2931	Hexadecanoic acid	0.2	t	t	0.1	0.1	0.1	t
	Total	**91.**	**97.**	**96.**	**97.**	**94.**	**97.**	**94.**

B1:April 2004 **B2**: July 2004
B3: October 2004 **B4**: January 2005
B5: April 2005 **B6**: July 2005
B7: October 2005
RRI: Relative retention indices calculated against n-alkanes
%: calculated TIC data
t: Trace (< 0.1 %)

Table 8. Result of analysis of *J.drupacea* leaf oils from Değirmendere.

RRI	Compounds	C1	C2	C3	C4	C5	C6	C7
				%				
1014	Tricyclene	0.1	t	0.1	0.1	0.1	0.1	0.1
1032	α-Pinene	33.	23.	34.	23.	30.	41.	32.
1072	α-Fenchene	0.1	0.2	0.1	0.3	0.1	0.1	t
1076	Camphene	0.2	0.1	0.2	0.2	0.2	0.2	0.2
1093	Hexanal	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1118	β-Pinene	1.4	1.4	1.8	1.6	1.3	1.8	1.6
1132	Sabinene	0.1	0.2	0.2	0.2	0.1	0.1	0.1
1142	Thuja-2,4(10)-diene	0.3	0.1	0.1	0.1	0.1	0.2	0.1
1146	δ-2-Carene	0.1	t	0.1	0.1	-	-	-
1159	δ-3-Carene	0.6	3.6	1.1	3.5	0.7	1.1	0.5
1174	Myrcene	1.7	2.1	2.8	1.9	2.3	2.4	-
1176	α-Phellandrene	t	t	0.1	0.1	-	-	-
1187	o-Cymene	t	0.2	0.1	0.6	-	-	-
1203	Limonene	22.	44.	32.	36.	38.	33.	28.
1218	β-Phellandrene	2.3	0.9	4.6	2.4	3.0	1.4	2.4
1225	(Z)-3-Hexenal	0.1	0.1	t	t	-	-	-
1280	*p*-Cymene	0.3	0.2	0.5	t	0.3	0.2	0.2
1290	Terpinolene	0.1	0.2	t	0.1	0.1	0.1	0.2
1466	α-Cubebene	0.9	0.5	1.2	-	0.7	0.3	0.9
1468	*trans*-1,2-Limonene epoxide	0.1	0.1	0.1	0.6	0.1	0.1	t
1493	α-Ylangene	0.1	t	t	0.1	-	t	0.1
1497	α-Copaene	1.8	0.8	1.9	1.1	1.1	0.7	1.4
1536	Pinocamphone	0.1	0.1	0.1	-	0.1	0.1	0.1
1549	β-Cubebene	-	-	-	0.1	-	0.1	0.2
1553	Linalool	0.2	0.2	0.3	-	-	t	t
1586	Pinocarvone	0.3	0.1	t	-	-	0.2	-
1589	β-ylangene	-	-	-	0.2	0.1	-	0.2
1606	β-Copaene	0.3	0.1	0.1	0.1	1.0	0.2	1.4
1612	β-Caryophyllene	1.3	0.8	1.1	1.0	0.1	0.6	0.2
1634	Cadina-3,5-diene	-	-	-	-	0.1	0.1	0.1

1639	*trans-p*-Mentha-2,8-dien-1-	0.1	0.1	t	0.1	-	-	-
1648	Myrtenal	0.3	0.1	0.1	-	0.1	0.2	-
1663	*cis*-Verbenol	0.2	0.1	0.1	0.1	0.1	0.1	0.1
1670	*trans*-Pinocarveol	0.9	0.3	0.4	0.4	0.4	0.6	0.4
1683	*trans*-Verbenol	-	-	t	0.2	t	t	0.4
1687	α-Humulene	1.7	1.0	1.1	0.9	1.5	1.2	1.2
1704	γ-Muurolene	2.2	0.9	0.8	1.0	1.1	1.2	8.6
1706	α-Terpineol	0.1	0.1	0.1	-	-	-	-
1726	Germacrene D	6.5	4.3	3.8	5.3	5.8	4.1	0.1
1733	γ-Amorphene	-	-	-	-	0.1	0.1	0.3
1740	Valenchene	0.3	0.1	0.1	-	-	-	-
1740	α-Muurolene	-	-	-	0.2	0.3	0.2	t
1741	α-Alaskene	t	0.1	0.1	-	-	-	-
1744	α-selinene	-	-	-	-	0.1	0.2	0.1
1751	Carvone	0.2	0.2	0.1	0.3	0.2	0.1	0.1
1773	δ-Cadinene	1.9	1.0	0.9	1.0	1.1	1.0	1.9
1776	γ-Cadinene	3.4	1.9	1.6	2.2	2.2	0.8	3.6
1786	*ar*-Curcumene	0.2	0.3	0.2	-	0.3	-	-
1804	Myrtenol	0.2	0.1	0.1	-	-	-	-
1811	α-Cadinene	0.2	0.2	0.1	0.2	0.2	0.1	0.2
1845	*trans*-Carveol	0.3	0.2	0.1	0.2	0.2	0.2	0.1
1853	*cis*-Calamenene	0.1	0.1	0.1	0.1	0.2	0.1	0.2
1882	*cis*-Carveol	0.1	0.1	t	0.1	0.1	t	t
1941	α-Calacorene I	0.1	t	t	t	t	t	0.1
1950	Dendrolasin	0.1	0.3	-	0.2	-	-	-
1984	α-Calacorene II	0.2	0.1	0.1	0.1	0.1	t	0.1
2008	Caryophyllene oxide	0.8	0.3	0.4	0.4	0.6	0.6	0.5
2037	Salvial-4(14)-en-1-on	0.4	0.2	0.2	-	0.2	0.2	0.2
2045	Humulene epoxide-I	-	-	-	-	t	0.1	0.1
2058	Germacrene D-1,10 epoxide	0.1	t	0.1	t	-	t	t
2071	Humulene epoxide-II	0.5	0.2	0.3	0.3	0.2	0.2	0.3
2080	Cubenol	0.1	t	t	-	0.1	0.1	t
2089	1,10-Diepicubenol	t	t	0.4	t	t	t	t
2132	Salviadienol	0.7	0.4	t	0.4	0.3	0.3	0.4
2144	Spathulenol	-	-	-	t	t	t	t
2187	T-Cadinol	0.7	0.3	0.2	0.4	0.2	0.2	0.7
2209	T-muurolol	0.1	t	t	-	t	t	0.1
2254	Torilenol	0.6	0.3	0.3	-	0.1	0.2	0.2
2255	α-Cadinol	t	0.1	-	0.1	0.2	t	0.3
2368	Eudesma 4(15),7-dien-1-β-	t	0.1	0.1	t	0.8	0.4	0.9
2392	Caryophylla-2(12),6-dien-5-	t	t	t	t	0.1	0.1	0.2
2396	13-*epi*-Manoyl oxide	3.3	2.9	1.8	1.8	-	t	0.1
2524	Abietatriene	0.2	0.1	0.1	-	-	-	-
2931	Hexadecanoic acid	0.2	t	T	t	t	t	0.1
	Total	**96.**	**96.**	**97.**	**90.**	**97.**	**98.**	**92.**

C1: April 2004 **C2**: July 2004

C1: April 2004 **C2:** July 2004
C3: October 2004 **C4**: January 2005
C5: April 2005 **C6**: July 2005
C7: October 2005
RRI: Relative retention indices calculated against n-alkanes
%: calculated TIC data
t: Trace (< 0.1 %)

Table 9. Result of analysis of *J.drupacea* leaf oils from Çamlıyayla.

RRI	Compounds	D1	D2	D3	D4	D5	D6	D7
					%			
1014	Tricyclene	0.1	0.1	0.1	0.1	0.1	0.1	t
1032	α-Pinene	23.	44.	39.	25.	45.	36.	20.
1072	α-Fenchene	0.4	0.1	0.2	0.4	0.1	0.1	0.6
1076	Camphene	0.1	0.3	0.2	0.2	0.3	0.2	0.1
1093	Hexanal	0.1	0.1	0.2	0.1	0.1	0.1	0.1
1118	β-Pinene	1.2	2.7	1.8	1.7	2.5	1.3	1.3
1132	Sabinene	0.2	0.1	0.1	0.1	0.1	0.1	0.2
1142	Thuja-2,4(10)-diene	0.2	0.2	0.3	0.2	0.3	0.1	0.1
1146	δ-2-Carene	0.1	0.1	0.1	0.1	-	-	-
1159	δ-3-Carene	6.2	0.1	3.3	6.3	0.9	2.6	10.
1174	Myrcene	2.0	2.5	2.5	2.0	2.8	2.2	-
1176	α-Phellandrene	t	0.1	0.1	0.1	-	-	-
1187	o-Cymene	0.5	0.1	0.3	-	-	-	-
1203	Limonene	33.	29.	24.	27.	28.	36.	36.
1218	β-Phellandrene	2.4	3.1	3.0	2.8	3.7	1.5	3.3
1224	*o*-Mentha-1(7),5,8-triene	0.1	t	0.1	-	0.1	t	t
1280	*p*-Cymene	0.4	0.3	0.3	0.4	0.3	0.2	0.3
1290	Terpinolene	0.1	0.1	0.1	0.2	0.1	0.2	0.1
1439	γ-Campholene aldehyde	t	0.1	0.1	t	-	t	t
1452	α,p-Dimethylstyrene	0.1	t	t	0.1	t	t	t
1458	cis-1,2-Limonene epoxide	-	-	-	-	0.1	t	0.1
1466	α-Cubebene	0.8	0.6	0.4	-	0.6	0.6	0.4
1468	*trans*-1,2-Limonene	0.1	0.1	0.1	1.1	t	t	0.1
1493	α-Ylangene	0.1	t	t	0.1	t	t	t
1497	α-Copaene	1.4	1.1	1.1	1.7	1.1	0.1	0.9
1536	Pinocamphone	t	0.1	0.1	-	t	0.1	0.1
1549	β-Cubebene	-	-	-	0.2	0.1	0.1	0.1
1553	Linalool	0.1	0.1	0.2	-	-	t	-
1586	Pinocarvone	0.3	0.2	t	-	-	-	-
1589	β-ylangene	-	-	-	0.2	0.2	0.1	0.2
1606	β-Copaene	0.2	0.1	0.1	0.2	0.1	0.1	0.1
1612	β-Caryophyllene	1.0	0.6	0.8	1.4	0.7	0.7	1.1
1634	Cadina-3,5-diene	-	-	-	-	-	0.1	0.1
1639	*trans*-*p*-Mentha-2,8-dien-	0.2	t	0.1	0.1	-	0.1	0.1
1642	Thuj-3-en-10-al	-	-	-	0.2	-	-	-
1648	Myrtenal	0.2	0.2	0.3	-	0.2	-	0.1
1663	*cis*-Verbenol	0.1	0.1	0.2	0.1	t	0.1	-
1670	*trans*-Pinocarveol	0.6	0.7	1.0	0.4	0.5	0.4	0.3
1683	*trans*-Verbenol	-	-	t	0.4	0.1	t	t
1687	α-Humulene	1.3	0.6	2.0	1.4	0.8	1.1	1.0
1704	γ-Muurolene	1.6	0.9	1.0	2.3	1.0	0.8	1.0
1726	Germacrene D	4.0	3.2	3.9	6.5	0.1	4.6	t
1733	γ-Amorphene	-	-	-	-	3.0	0.1	6.0
1740	Valencbene	0.4	0.2	0.3	-	-	-	-
1740	α-Muurolene	-	-	-	0.6	0.2	0.2	0.1
1741	α-Alaskene	0.1	0.1	0.2	-	-	-	-
1744	α-selinene	-	-	-	-	0.1	0.1	0.2
1751	Carvone	0.2	0.1	0.1	0.2	0.1	0.1	0.2
1773	δ-Cadinene	1.6	0.8	1.5	1.8	0.1	0.9	1.5
1776	γ-Cadinene	3.1	0.8	1.7	2.6	0.8	1.2	1.5
1786	*ar*-Curcumene	t	-	0.6	-	-	-	-
1804	Myrtenol	0.1	0.1	0.1	-	-	-	-
1811	α-Cadinene	0.2	0.1	0.1	0.2	0.1	0.1	0.1
1845	*trans*-Carveol	0.3	0.2	0.3	0.2	0.1	0.1	0.2
1853	*cis*-Calamenene	0.2	0.1	0.2	0.3	0.1	0.1	t
1882	*cis*-Carveol	0.1	0.1	0.1	0.1	t	t	t
1941	α -Calacorene I	0.1	t	0.1	0.1	t	t	0.1
1950	Dendrolasin	0.5	t	t	0.2	-	-	-
1984	α-Calacorene II	0.2	t	0.1	0.1	t	t	0.1
2008	Caryophyllene oxide	0.5	0.2	0.4	0.8	0.3	0.4	0.5
2037	Salvial-4(14)-en-1-one	0.3	0.1	0.2	-	0.1	0.1	0.2
2071	Humulene epoxide-II	0.4	0.2	0.2	0.4	0.1	0.2	0.3
2071	Humulene epoxide-II	0.4	0.2	0.2	0.4	0.1	0.2	0.3
2080	Cubenol	0.1	t	0.1	-	t	t	t
2089	1,10-Diepicubenol	0.1	t	t	0.1	-	t	t
2132	Salviadienol	0.5	0.2	0.3	0.5	0.2	0.2	0.4
2187	T-Cadinol	0.6	0.1	0.2	0.5	0.1	0.3	0.2
2209	T-muurolol	t	t	0.1	-	t	t	0.1
2254	Torilenol	t	t	0.2	-	t	0.3	0.4
2255	α-Cadinol	t	-	0.1	t	0.1	t	-

2368	Eudesma 4(15),7-dien-1-β-	0.1	t	t	0.1	0.4	-	1.5
2369	(2*E*,6*E*)-Farnesol	-	-	-	0.1	-	1.6	-
2376	Manoyl oxide	-	-	-	1.4	-	-	-
2392	Caryophylla-2(12),6-dien-	t	0.1	0.1	0.1	t	0.1	0.1
2396	13-*epi*-Manoyl oxide	1.4	0.5	1.3	-	t	0.1	0.1
2524	Abietatriene	0.1	0.1	0.2	-	-	-	-
	Total	**94.**	**95.**	**97.**	**95.**	**97.**	**97.**	**93.**

D1: April 2004 **D2**: July 2004
D3: October 2004 **D4**: January 2005
D5: April 2005 **D6**: July 2005
D7: October 2005
RRI: Relative retention indices calculated against n-alkanes
%: calculated TIC data
t: Trace (< 0.1 %)

Özet

Güney Anadolu'da yetişen *J. drupacea* yaprak uçucu yağlarının yapısı araştırılmıştır. *J. drupacea* yapraklarının yapısında mevsime ve bölgeye bağlı değişiklik olup olmadığını tespit amacı ile bitkinin yaprakları yılda dört kez, dört farklı bölgeden iki yıl boyunca toplanmıştır. Uçucu yağların yapısı GC ve GC-MS metotları ile analiz edilmiş ve % 90.7-98.2 oranında tayin edilmiş, 118-122 madde bulunmuştur. Bulunan ana maddeler α-pinen (% 9.97-45.9), limonen (% 22.7-52.5), β-pinen (% 0.6-2.7), β-fellandren (% 0.9-7.4), α-kopaen (% 0.1-2.0), β-karyofilen (% 0.1-1.4), α-humulen (% 0.6-2.2), δ-kadinen (% 0.1-2.3) ve γ-kadinen (% 0.8-3.9) dir.

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References

Adams, R.P. (1997). Comparisons of the leaf oils of *Juniperus drupacea* Lab. from Greece, Turkey and Crimea. *J. Essent. Oil Res.* 9: 541-544.

Adams, R.P. (2004). Juniperus of the world. The Genus Juniperus, Trafford Publishing Co, Canada, pp. 105.

Baytop, T. (1994). Türkçe Bitki Adları Sözlüğü, Türk Dil Kurumu Yayınları, Ankara, pp.578.

Davis, P.H. (1965). Flora of Turkey and the East Aegean Islands 1, The University Press, Edinburgh, pp. 76-84.

Dönmez, İ.E. (2005). Andız (*Arceuthos drupacea* Ant.et. Kotschy) Ağacının kimyasal bileşimi üzerine araştırmalar, Yüksek Lisans Tezi, Zonguldak Karaelmas Üniversitesi, Bartın.

Sakar, M.K. (1985). Zusammensetzung des Nadelblattöls von *J. drupacea*, *Fitoterapia,* 56: 360-361.

Semiz, G., Isık, K., Unal, O. (2007). Enek Pekmez Production from Juniper "Fruits" by Native People on the Taurus Mountains in Southern Turkey, *Economic Botany,* 61: 299-301.

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