



## Volatile Constituents of *Taxus baccata* L. Leaves from Western and Southern Turkey

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The fresh leaves of *Taxus baccata* L., growing in western (Aegean region) and southern (Mediterranean region) Turkey, on hydrodistillation, gave 0.03 and 0.04 % oil on dry basis, respectively. After GC and GC/MS analysis, 45 compounds (representing 97.4 % of the oil) and 56 components (representing 98 % of the oil) were identified for *T. baccata* L. leaves collected from western and southern Turkey. The predominant constituents were 1-octen-3-ol (32.4 %), (*E*)-2-hexen-1-ol (8.2 %), caryophyllene oxide (7.2 %) and hexahydrofarnesyl acetone (6.8 %) in the oil of *T. baccata* L. from western Turkey and 1-octen-3-ol (20.7 %), 1-hexanol (10.9 %) and (*E*)-2-hexen-1-ol (7.3 %) in the oil of *T. baccata* L. from southern Turkey. The most abundant components of *T. baccata* L. oil samples from both regions of Turkey were alcohols with their contents being 62.4 and 54.1 %, respectively.

**Key Words:** *Taxus baccata* L., *Taxaceae*, Essential oil, 1-Octen-3-ol, Western and southern Turkey.

### INTRODUCTION

The genus *Taxus* L. is classified in the family of *Taxaceae* and represented by eight species<sup>1,2</sup>. *Taxus* (yew) species range from North America into Central America and from Eurasia to Southeast Asia<sup>3</sup>. Only one species of *Taxus* is growing in Turkey, which is *Taxus baccata* L., a toxic plant and called European yew<sup>4</sup>.

Volatile compounds were extracted from *T. baccata* L. leaves collected from northern Turkey (Black sea region) have been studied by Erdemoglu *et al.*<sup>5</sup>. However, the geographical place of growth of the plant influences chemical composition of the volatile oil<sup>6</sup>. Therefore, the essential oils of *T. baccata* L. leaves collected from western (Aegean region) and southern (Mediterranean region) Turkey were analyzed by gas chromatographic method using flame ionization and mass selective detections in this study.

### EXPERIMENTAL

The leaves of *T. baccata* L. were collected from Bozdag-Acipayam/Denizli in Aegean region of Turkey at an altitude of 1450 m and Egirdir/Isparta in Mediterranean region of Turkey about 1100 m in July 2012. The fresh materials were carried in frozen bags to laboratory and then stored at -20 °C. Voucher specimen is deposited at Herbarium of the Forest Botany Department of Suleyman Demirel University as F4859 and F4865.

**Isolation of the essential oil:** For each sample, the essential oil of the 1500 g fresh leaves of *T. baccata* L. was obtained by hydrodistillation using a Clevenger-type apparatus for 3 h and then submitted to GC/MS and GC analysis.

**GC/MS and GC analysis:** The GC-MS analyses of the oils were carried out on a Hewlett-Packard 6890 gas chromatograph equipped with a capillary column HP-5MS (30 m × 0.25 mm i.d., 0.25 µm film thickness) and coupled with a 5973 mass selective detector from the same company in EI mode (70 eV). The injector and interface were operated at 250 and 300 °C, respectively. The oven temperature was raised from 70-290 °C at a rate of 5 °C/min and then isothermally held for 10 min. As a carrier gas, helium was used at 1 mL/min.

GC (FID) experimental was carried out under the same conditions with the same column and by same gas chromatograph type as described for the GC/MS. The relative percentages of the compounds were calculated from the chromatogram by computer.

**Identification of components:** Qualitative analysis of the volatile oil components was based on the comparison of their linear retention indices, relative to retention times of C<sub>7</sub>-C<sub>31</sub> *n*-alkanes on the HP-5MS column with those reported in the literature<sup>7</sup> and their mass spectra were also compared with those of authentic standards, as well as those from Wiley library with the spectra corresponding to pure compounds of known essential oils.

## RESULTS AND DISCUSSION

*T. baccata* L. leaves yielded 0.03 % (v/w, on dry basis) essential oil for Aegean sample and 0.04 % (v/w, on dry basis) essential oil for Mediterranean sample, respectively. The constituents in the essential oils of *T. baccata* L. leaves from Aegean and Mediterranean region in Turkey are presented in Table-1. Forty five components which were 97.4 % of the total oil of Aegean sample were identified, whereas 56 compounds were characterized as 98 % of the total oil of sample from Mediterranean region in Turkey. 1-Octen-3-ol (32.4 %), (E)-2-hexen-1-ol (8.2 %), caryophyllene oxide (7.2 %) and hexahydrofarnesyl acetone (6.8 %) were identified as major components for Aegean sample, while 1-octen-3-ol (20.7 %), 1-hexanol (10.9 %) and (E)-2-hexen-1-ol (7.3 %) were determined as main components for Mediterranean sample, respectively.

In the previous works, volatile components were reported for several *Taxus* species<sup>5,8-11</sup>. The chemical composition of essential oil collected from *T. chinensis* var. *mairei* were studied and 26 constituents were determined. Palmitic acid, 9-hexadecenoic acid/9-hexadecenyl ester, 3-octanol were identified as main components with their contents being 35.7, 11.3 and 4.5 %, respectively<sup>8</sup>. For Indian yew *T. wallichiana*, (E)-2-octen-1-ol (14.5 %), *n*-pentacosane (8.1 %), caryophyllene oxide (7.1 %), 1-octanol (6.5 %), hexanoic acid (5.5 %) and (Z)-3-hexenol (4.1 %) were identified as the main constituents out of 62<sup>9</sup>. Erdemoglu *et al.*<sup>5</sup> found 63 compounds in the volatile oil of *T. baccata* L. from northern Turkey (Black sea region). Hexadecanoic acid and decanoic acid were determined as the most abundant components with their contents being 19.6 and 19.5 %, respectively. The essential oil of *T. canadensis* was analyzed and 1-octen-3-ol (44.6 %) and (E)-2-hexenol (24.1 %) were the main constituents out of 18<sup>10</sup>. In another research, 62 components were determined in the volatile oil of *T. baccata* L. from Serbian. The major compounds were found as hexahydrofarnesyl acetone (18.3 %), myrtenol (18.3 %), (Z)-3-hexenol (6.0 %), 3-methyl-2-butenic acid (5.9 %) and tricosane (5.5 %)<sup>11</sup>.

The main groups of identified compounds of both essential oils from *T. baccata* L. are listed in Table-2. The most abundant components of *T. baccata* L. oil samples from Aegean region and Mediterranean region in Turkey were alcohols with their contents being 62.4 and 54.1 %, respectively. Terpenes and oxides constituted 16.3 and 14.2 % in the oil sample of *T. baccata* L. collected from Aegean region and Mediterranean region in Turkey. Other compound groups 18.7 and 29.7 % comprised aldehydes, esters, ketones, alkanes and acids in the oil of both *T. baccata* L. samples.

1-Octen-3-ol was the major component of *T. baccata* L. essential oil of Aegean and Mediterranean region in Turkey. 1-Octen-3-ol is an attractive chemical for biting insects such as mosquitos and contained in human breath and sweat. It is applied in combination with carbon dioxide to attract insects in order to kill them with definite electronic devices. Odor of 1-octen-3-ol is described as green and moldy or meaty. It is also utilized in certain perfumes<sup>12</sup>.

(E)-2-Hexen-1-ol was the second main constituent in the oil of Aegean sample and the third major compound in the oil of Mediterranean sample. It is categorized as flavor and

TABLE-1  
VOLATILE COMPOUNDS OF *Taxus baccata* L. LEAVES  
FROM WESTERN AND SOUTHERN TURKEY

No	Constituent	RI	A (%)	M (%)
1	1-Penten-3-ol	683	2.2	2.4
2	(Z)-3-Penten-1-ol	725	0.9	0.5
3	(E)-2-Pentenal	744	1.4	1.6
4	1-Pentanol	762	0.2	–
5	Hexenal	801	1.3	1.2
6	2-Methylbutanoic acid	832	–	0.2
7	(E)-3-Hexen-1-ol	844	0.6	2.7
8	(E)-2-Hexen-1-ol	854	8.2	7.3
9	(Z)-3-Hexen-1-ol	858	1.4	0.8
10	1-Hexanol	867	2.7	10.9
11	2-Methylpentanoic acid	935	–	0.1
12	$\alpha$ -Pinene	946	1.4	1.7
13	(E)-2-Heptanal	956	–	0.3
14	Benzaldehyde	965	–	1.2
15	1-Heptanol	967	1.7	1.1
16	Hexanoic acid	971	0.5	–
17	Sabinene	974	3.2	2.5
18	1-Octen-3-ol	977	32.4	20.7
19	$\beta$ -Pinene	980	–	1.7
20	3-Octanone	982	–	0.1
21	3-Octanol	995	2.2	1.8
22	(Z)-3-Hexenyl acetate	1004	–	0.2
23	$\alpha$ -Phellandrene	1009	1.3	0.4
24	p-Cymene	1027	–	1.1
25	(Z)- $\beta$ -Ocimene	1044	–	0.4
26	(Z)-2-Octenal	1058	1.7	–
27	Heptanoic acid	1062	0.1	2.4
28	1-Octanol	1069	0.4	2.7
29	4-Methylbenzaldehyde	1072	–	0.1
30	3-Methylbenzaldehyde	1086	–	0.2
31	$\alpha$ -Terpinolene	1088	0.8	1.2
32	Nonanal	1106	0.6	0.3
33	2,6-Dimethylcyclohexanol	1114	–	0.1
34	3-Octyl acetate	1117	0.4	–
35	Camphor	1150	0.1	2.3
36	(E)-2-Nonenal	1161	0.7	0.3
37	Benzyl acetate	1167	0.9	–
38	Octanoic acid	1170	–	1.6
39	Ethyl benzoate	1175	–	0.7
40	Myrtenol	1202	7.8	–
41	Linalyl acetate	1248	0.2	0.3
42	Geraniol	1256	1.3	0.4
43	Nonanoic acid	1275	0.6	0.9
44	Menthyl acetate	1297	–	0.6
45	$\beta$ -Terpinylacetate	1349	0.7	1.1
46	$\alpha$ -Terpineol acetate	1353	–	0.3
47	Neryl acetate	1359	0.1	0.4
48	Eugenol	1361	0.3	1.8
49	Decanoic acid	1370	–	0.5
50	Geranyl acetate	1378	0.1	0.9
51	Dodecanal	1411	–	0.2
52	$\beta$ -Caryophyllene	1418	1.6	2.4
53	$\alpha$ -Humulene	1443	0.5	2.8
54	(E)- $\alpha$ -Farnesene	1462	0.3	–
55	(Z)-3-Hexenyl benzoate	1576	0.4	1.4
56	Caryophyllene oxide	1584	7.2	–
57	(E,E)-2,6-Farnesyl acetate	1844	–	0.7
58	Hexahydrofarnesyl acetone	1851	6.8	3.2
59	1-Eicosane	1994	0.4	0.4
60	Eicosane	2000	0.5	1.2
61	Nonadecanal	2116	0.2	1.6
62	1-Nonadecanol	2172	0.1	0.9
63	Docosane	2200	0.3	1.8
64	Tricosane	2300	0.7	1.4
Total			97.4	98

RI: Retention indices on HP-5MS column. A: Essential oil of *T. baccata* L. leaves from Aegean region in Turkey. M: Essential oil of *T. baccata* L. leaves from Mediterranean region in Turkey. %: Percentages calculated from FID data.

TABLE-2  
MAIN GROUPS OF DETERMINED COMPONENTS  
OF ESSENTIAL OILS OF *Taxus baccata* L.

Main groups	A (%)	M (%)
Alcohols	62.4	54.1
Aldehydes	5.9	7
Esters	2.8	6.6
Ketones	6.9	5.6
Monoterpenes	6.7	9
Sesquiterpenes	2.4	5.2
Terpene oxides	7.2	–
Alkanes	1.9	4.8
Acids	1.2	5.7
Total	97.4	98

A: Essential oil of *T. baccata* L. leaves from Aegean region in Turkey.  
M: Essential oil of *T. baccata* L. leaves from Mediterranean region in Turkey.

fragrance agents. Odor of (E)-2-hexen-1-ol is described as sharp, green, leafy, fruity and unripe banana. It is additive pleasant fruity notes to lavender, mint and geranium compositions and applied in apple, berry, orange and pear flavors and as an alcohol enhancer<sup>13</sup>.

1-Hexanol was the second major substance of *T. baccata* L. volatile oil from Mediterranean region in Turkey. The main usage of 1-hexanol is to produce other chemicals. These chemicals have much utilization. They can be applied in detergents, cleaners, to assist make plastics, adhesives or fragrances and to assist change the thickness of liquid products. 1-Hexanol is also used immediately as a fragrance, flavoring agent, solvent and to break down foam<sup>14</sup>.

Caryophyllene oxide was the third main component of *T. baccata* L. volatile oil from Aegean region in Turkey. It is categorized as flavoring agent, additive and used industrially in beverages, ice cream, candy, condiments, baked goods, frozen dairy desserts, meat products and also applied in cigarettes and smokeless tobacco<sup>15</sup>.

Hexahydrofarnesyl acetone was the fourth major compound of *T. baccata* L. volatile oil from Aegean region in Turkey. Hexahydrofarnesyl acetone is categorized as flavor and

fragrance agents<sup>16</sup>. Its odor is described as a long lasting fresh jasmine and celery odor and it is used in jasmine compositions<sup>17</sup>.

From the above it is evident that most of the predominant constituents of the essential oils of *T. baccata* L. leaves collected from western (Aegean region) and southern (Mediterranean region) Turkey provide a significant wide range of flavor and fragrance applications and may find utilization in the flavor and fragrance industry.

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