Composition of the leaf volatile terpenoids of *Pinus eldarica* Medw. from Azerbaijan compared with *P. brutia* Ten. leaf essential oil

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ABSTRACT

The volatile leaf oil of *Pinus eldarica Medw.,* Azerbaijan, is dominated by β-pinene (20.7%), α-pinene (11.3%), (E)-caryophyllene (13.3%) and germacrene D (9.2%) with moderate amounts of δ-3-carene (2.5%), limonene (3.4), β-phellandrene (2.2), (E)-β-ocimene (3.2), α-terpinyl acetate (2.6), α-humulene (2.4), phenyl-ethyl-3-methyl-butanoate (2.6) and (E)-γ-bisabolene (2.1). Cultivated *P. eldarica* trees (USA, Utah) had a similar profile: germacrene D (27.4%), α-pinene (14.5%), β-pinene (13.4%) and (E)-caryophyllene (10.5%) and with moderate amounts of δ-3-carene (4.5%), limonene (0.9), β-phellandrene (1.3), (E)-β-ocimene (1.6), α-terpinyl acetate (2.3) and α-humulene (2.1). The concentrations of several compounds separate *P. eldarica* and *P. brutia* (α-pinene, camphene, β-pinene, myrcene, (Z)-β-ocimene, α-campholenal, trans-sabinol, camphor, α-terpinyl acetate, (E)-caryophyllene, germacrene D, germacrene D-4-ol, α-cadinene and sandaracopimarinal) and support the practice of recognizing *P. eldarica* (or *P. brutia* ssp. *brutia*) in Azerbaijan and Georgia, where these taxa a part of the native flora. Published on-line www.phytologia.org *Phytologia 101(3): 200-207 (Sept 21, 2019).* ISSN 030319430.
KEY WORDS: *Pinus eldarica,* Azerbaijan, *P. brutia* ssp. *brutia*, volatile leaf oil, terpenes, composition.

The *P. brutia* Ten. complex includes four subspecies: *brutia*, *eldarica*, *pithyusa* and *stankewiczii* (Nahal, 1983; Schiller, 1994; 2000). In the current edition of The Gymnosperm Database (https://www.conifers.org/) Frankis recognizes 5 infraspecific taxa: var. *brutia*, var. *eldarica* (Medw.) Silba, var. *pendulifolia* Frankis, var. *pithyusa* (Steven) Silba, and var. *stankewiczii* (Sukaczev) Frankis. But, in Azerbaijan, *P. brutia* ssp. *eldarica* is recognized at the specific level (*P. eldarica* Medw.). Analysis of cp SSRs in the *halepensis* complex (*P. halepensis* Ait., *P. brutia* and *P. eldarica*) revealed a phylogeny (based on cpSSRs) that placed *P. eldarica* in a significant clade, separate from *P. brutia* (Fig. 2, Bucci et al. 1998), thus, lending some support for the usage of *P. eldarica*. See The Gymnosperm Database (www.conifers.org) and Boydak (2004) for reviews of the taxonomy and nomenclature.

The natural ranges are: ssp. *brutia* - Aegean islands, Crete and Cyprus, and through Turkey to Lebanon and to northern Iraq; ssp. *eldarica* - Caucasus (Azerbaijan, Georgia), and perhaps into northernmost Iran and possibly Afghanistan; ssp. *pithyusa* - in relict stands on the Black Sea coast of the Caucasus mountains; and ssp. *stankewiczii* - Black Sea coast of the Crimea according to Schiller (1994, 2000).

Pinus eldarica has a long history of cultivation dating back to least 500 B.C., when the Persian nobility used it to create forested gardens where few trees could survive. In Persia, the tree was reserved for only the royalty, and became known as the “Tree of Royalty” (Master Gardner Newsletter, July 2010, http://www.darrolshillingburg.com/GardenSite/NewsletterPDF/MG_Newsletters/MGNewsletter_Jul10.pdf). It is commonly grown in the arid southwestern US (s. California, Arizona, s. New Mexico, trans-Pecos Texas and sw Utah) and is sold by the trade names of: Mondell Pine, Mondale Pine, Afgan Pine, Eldarica Pine, Desert Pine, Goldwater Pine, Elder Pine, and Lone Star Christmas tree. Mondell pine was introduced into the US in 1961 when the USDA obtained five pounds of *P. eldarica* from Afghanistan and gave it to Universities to determine it test its adaptability and potential.

In Azerbaijan it may assume a gnarly shape (Fig. 1) and grows on rock slopes (Fig. 2). In the USA, it is grown as an ornamental tree along streets (Figs. 3, 4) and in gardens. It is said to be short lived in central Texas (10-15 yrs), but in the dry deserts of southwestern US, it is grown under drip irrigation in the arid lands that seem to favor long life, as in Azerbaijan.

Fig. 1. Habit of *Pinus eldarica* in Azerbaijan.

Fig. 2. *P. eldarica* on rock slope, Azerbaijan.

Fig. 3. *P. eldarica* (Mondell Pine) growing, drip irrigated, in Stone Cliff, Utah, USA.

Fig. 4 *P. eldarica* (Mondell Pine) growing as a street tree, drip irrigated, in Stone Cliff, St. George, Utah, USA.

The volatile leaf oils of *Pinus brutia* (usually including *P. eldarica*) have been the subject of several studies (Gohsn et al. 2006; Ioannou et al. 2014; Mitic, et al. 2017; Roussis et al. 1995; Sezik et al. 2008; Vidrich et al. 1999). But, no studies were found on the volatile leaf oil composition of *P. eldarica* from a natural population in Azerbaijan. However, Chubinidze et al. (1999) reported on the monoterpenes from Georgian *P. eldarica* in young vs. old needles and young vs. old cortex (Table 1).

They found the needle oils were dominated α-pinene, δ-3-carene and limonene, and the cortex (wood) oils reflected the same patterns in young and old needles (Table 1).

Table 1. Variation in monoterpene concentrations from leaves and wood cortex of *P. eldarica* from Georgia (former USSR). Adapted from Chubinidze et al. (1999).

cpd\ source	young needles	old needles	young cortex	old cortex
α-pinene	48.8%	78.3	35.8	73.4
camphene	2.1	8.8	2.1	3.2
β-pinene	2.3	5.0	5.4	6.7
δ-3-carene	22.4	3.1	10.9	4.8
limonene	10.2	1.0	20.8	5.6
β-phellandrene	5.0	0.0	25.0	6.0
myrcene	2.1	0.0	0.0	0.0
γ-terpinene	4.1	3.8	0.0	0.0
terpinolene	2.0	0.8	0.0	0.3

Although several other papers cited *P. eldarica* volatile analyses, their samples were obtained from cultivated materials of unknown source. The purpose of this paper is to report on the volatile leaf oil from *P. eldarica* from a natural population in Azerbaijan and compare that oil with other analyses was well as with that of *P. brutia* (ssp. *brutia*) oils.

MATERIALS AND METHODS

Leaf samples collected: *Pinus eldarica*, Azerbaijan, 41° 10' 42.76" N, 46° 13' 55.04" E., 241 m. Coll. *Vahid Farzaliyev 1-9*, 12 April 2019, Lab Acc. *Robert P. Adams 15607-15615(9)*. In addition, samples from cultivated *P. eldarica* (locally called Mondell Pine) were collected from Stone Cliff subdivision, St. George, UT, USA, 22 March 2019, 37° 04' 45" N, 113° 32' 16" W, 844 m, Washington Co., Utah, USA. Coll. *Robert P. Adams 15574-15579(6).* Voucher specimens are deposited in the herbarium, Baylor University.

Gently dried leaves (100g, 40 - 45˚C) were steam distilled for 2 h using a circulatory Clevenger-type apparatus (Adams, 1991). The oil samples were concentrated (ether trap removed) with nitrogen and the samples stored at -20ºC until analyzed. The extracted leaves were oven dried (100ºC, 48 h) for determination of oil yields.

The oils were analyzed on a HP5971 MSD mass spectrometer, scan time 1/ sec., directly coupled to a HP 5890 gas chromatograph, using a J & W DB-5, 0.26 mm x 30 m, 0.25 micron coating thickness, fused silica capillary column (see Adams, 2007 for operating details). Identifications were made by library searches of the Adams volatile oil library (Adams, 2007), using the HP Chemstation library search routines, coupled with retention time data of authentic reference compounds. Note that limonene and β-phellandrene elute as a single peak on DB-5, but their amounts can be quantitated by the ratio of masses 68, 79 (limonene) and 77, 93 (β-phellandrene). Quantitation was by FID on an HP 5890 gas chromatograph using a J & W DB-5, 0.26 mm x 30 m, 0.25 micron coating thickness, fused silica capillary column using the HP Chemstation software.

RESULTS AND DISCUSSION

The volatile leaf oils of *Pinus eldarica (*and *P. brutia)* contain considerable amounts of β-pinene (20.7%), α-pinene (11.3%), (E)-caryophyllene (13.3%) and germacrene D (9.2%) with lesser concentrations of δ-3-carene (2.5%), limonene (3.4), β-phellandrene (2.2), (E)-β-ocimene (3.2), α-terpinyl acetate (2.6), α-humulene (2.4), phenyl-ethyl-3-methyl-butanoate (2.6), and (E)-γ-bisabolene (2.1). Cultivated *P. eldarica* trees (USA, Utah) had a similar profile dominated by germacrene D (27.4%), α-pinene (14.5%), β-pinene 13.4%) and (E)-caryophyllene (10.5%) and with moderate amounts of δ-3-carene (4.5%), limonene (0.9), β-phellandrene (1.3), (E)-β-ocimene (1.6), α-terpinyl acetate (2.3) and α-humulene (2.1).

The oil from samples from the natural stand in Azerbaijan differs quantitatively in some compounds from that of the cultivated *P. eldarica* in the USA (both were extracted and analyzed by identical methods). This is apparent (Table 2) in the concentrations of α-pinene (11.3%, 14.5%), β-pinene (20.7,13.4), δ-3-carene (2.5, 4.5), limonene (3.4, 0.9), β-phellandrene (2.2, 1.3), (E)-caryophyllene (13.3, 10.5), and germacrene D (9.2, 27.4).

The oil analysis from Iran (Sulriman and San'aty (2005) was generally quite similar to that from Azerbaijan and USA, but differed in having some unusual components (red, Table 2): citronellol, citronellyl formate, elemicin, and geranyl isovalerate. These compounds, usually minor, may have come from cross-contamination with an essential oil containing these compounds.

Analyses (from the literature) for plants from Italy (red, Table 2) differ considerably from Azerbaijan in some components (cf. β-pinene (1.4%, Italy), α-terpinyl acetate (54.3%, Italy), germacrene D (missing, Italy), along with several other components missing in the Italy analysis of Vidrich et al. 1999. The high amount of α-terpinyl acetate (54.3%) is inconsistent with other oils of *P. eldarica* (Table 2), and seems to be spurious.

The question of the distinctness of *P. eldarica* and *P. brutia* (ssp. *brutia*) is addressed in the oil analyses as we have included two analyses of *P. brutia* from a native, Lebanon stand, and cultivated in Greece in Table 2. Several compounds separate *P. eldarica* and *P. brutia* (green and yellow, Table 2) including α-pinene, camphene, β-pinene, myrcene, (Z)-β-ocimene, α-campholenal, trans-sabinol, camphor, α-terpinyl acetate, (E)-caryophyllene, germacrene D, germacrene D-4-ol, α-cadinene and sandaracopimarinal. Several of these are qualitative differences, but most of these are in low concentrations and may have been found (or reported) in other analysis in *P. brutia*. Still, the overall pattern is clear that the oils of *P. eldarica* and *P. brutia* do differ in several components, and this seems to support the practice of recognizing *P. eldarica* (or as P. *brutia* ssp. *brutia*) in Azerbaijan and Georgia, where these taxa are part of the native flora.

A comparison of the oils of individuals of *P. eldarica* cultivated in St. George, Utah, USA, revealed considerable variation with 3 to 5 fold differences between lowest and highest values (Table 3): α -pinene (6.2 - 19.7%); α -pinene (5.0 - 24.3%); δ-3-carene (1.1 - 7.6%); terpinolene (0.2 - 2.5%); α-terpinyl acetate (1.6 - 3.3%); (E)-caryophyllene (6.6 - 19.4%) and germacrene D (21.6 - 39.0%). This large amount of variation reflects the origin of all *P. eldarica* (Mondell pine, etc.) in the US that were obtained by growing seedlings from the USDA bulk lot of seeds from Afghanistan in 1961. It is very possible that the Afghanistan *P. eldarica* might have actually come from Persia originally, and the Persian *P. eldarica* pines were likely from Azerbaijan (or less likely, Georgia).

There is a suggestion that two chemotypes (or races) might exist in *P. eldarica* as one can see that several trees have a similar oil profile (15576, 15579, 15575, blue, Table 3) with higher α-pinene, α-pinene and δ-3-carene and trees 15578, 1577 and 1574)yellow, Table 3) are higher in germacrene D and (E)-caryophyllene. Additional sampling is needed to confirm if chemical races exist in nature.

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Table 2. The leaf oil constituents of *Pinus eldarica* from a natural, endemic population in Azerbaijan, compared with *P. eldarica* cultivated in the USA, Italy and Iran. Also included are analyses of the volatile leaf oils from the closely related (conspecific?) species, *P. brutia*. Compounds that differ in amounts between *P. eldarica* and *P. brutia* are highlighted in yellow.

KI	compound	*P. eldarica* natural, Azerbaijan	*P. eldarica* cult. USA. U St. George	*P. eldarica* cult. Iran Isfahan[1]	*P. eldarica* cult. Italy[2]	*P. brutia* natural, Lebanon[3]	*P. brutia* cult. Greece[4]
921	tricyclene	t	t	-	-	t	-
924	α-thujene	t	0.1	-	-	t	t
932	**α-pinene**	**11.3**	**14.5**	**11.8**	**12.8**	**18.9**	**16.0**
946	**camphene**	**0.2**	**0.2**	**0.2**	**0.2**	**0.8**	**0.8**
948	benzaldehyde		-	-	2.1	-	-
969	sabinene	t	0.3	-	t	-	0.9
974	**β-pinene**	**20.7**	**13.4**	**7.9**	**1.4**	**31.2**	**45.7**
988	**myrcene**	**1.1**	**0.9**	**0.7**	**0.6**	**2.1**	**2.4**
1002	α-phellandrene	t	t	t	-	0.1	t
1008	δ-3-carene	2.5	4.5	1.7	-	2.4	0.5
1014	α-terpinene	t	0.1	t	t	0.1	0.1
1020	p-cymene	t	t	-	t	t	-
1024	limonene	3.4	0.9	3.2(w β-phell?	4.0	4.0	1.6
1025	β-phellandrene	2.2	1.3	-	0.2	2.5	1.1
1044	**(Z)-β-ocimene**	**0.1**	**0.4**	**0.3**	**-**	**-**	**-**
1044	(E)- β-ocimene	3.2	1.6	1.1	-	1.5	1.9
1054	γ-terpinene	0.1	0.1	0.1	0.1	0.2	0.3
1086	terpinolene	0.6	0.8	0.5	0.1	1.0	1.3
1095	linalool	0.1	0.4	0.1	0.3	0.2	0.7
1114	endo-fenchol	t	0.1	-	-	0.1	0.1
1122	α-campholenal	t	t	-	-	-	-
1136	trans-sabinol	t	t	-	-	-	-
1141	**camphor**	**0.1**	**0.1**	**-**	**-**	**-**	**-**
1165	borneol	t	0.1	-	-	-	0.1
1174	terpinen-4-ol	0.1	0.1	t	-	0.1	0.5
1179	p-cymen-8-ol	-	-	-	0.2	-	-
1186	α-terpineol	0.8	0.1	0.2	0.2	-	1.2
1195	myrtenol	t	t	t	0.1	-	-
1218	endo-fenchyl acetate	-	-	-	-	-	0.4
1227	citronellol	-	-	0.3	-	-	-
1247	linalool acetate	-	-	-	-	2.3	0.2
1273	citronellyl formate	-	-	0.3	-	-	-
1284	bornyl acetate	0.5	0.2	0.4	1.0	0.4	-
1342	trans-piperitol acetate	-	0.1	-	-	-	-
1345	**α-terpinyl acetate**	**2.6**	**2.3**	**3.8**	**54.3**	-	0.8
1374	α-copaene	0.1	0.1	0.3	0.2	0.4	-
1375	geranyl acetate	-	-	-	-	0.5	0.3
1387	β-bourbonene	0.1	0.6	3.3	0.8	0.5	-
1389	β-elemene	t	t	-	-	0.2	-
1398	methyl eugenol	t	t	-	-	0.3	-
1400	β-longipinene	0.4	0.1	0.3	-	0.2	-
1417	**(E)-caryophyllene**	**13.3**	**10.5**	**17.1**	**12.5**	**5.9**	**4.9**
1430	β-copaene	t	0.2	-	-	-	-
1454	α-humulene	2.4	2.1	4.2	2.2	1.5	0.9
1464	9-epi-(E)-caryophyllene	0.4	0.3	t	-	-	-
1478	γ-muurolene	t	t	-	1.3	-	-
1480	**germacrene D**	**9.2**	**27.4**	**26.6**	**-**	**14.5**	**7.6**
1480	phenyl-ethyl-3-me-butanoate	2.6	0.3	-	0.8	-	0.8
1495	γ-amorphene	0.3	0.2	-	-	-	-
1491	methyl isoeugenol	t	t	-	-	0.8	-
1500	α-muurolene	0.3	0.2	-	t	0.5	-
1500	(E,E)-α-farnesene	-	-	-	-	0.4	-
1511	δ-amorphene	0.3	0.2	0.5	-	-	-
1513	γ-cadinene	0.2	0.5	0.7	0.5	1.9	-
1522	δ-cadinene	0.5	1.3	1.7	1.9	-	0.4
1529	(E) γ -bisabolene	2.1	-	-	-	-	-

KI	compound	*P. eldarica* natural, Azerbaijan	*P. eldarica* cult. USA. U St. George	*P. eldarica* cult. Iran Isfahan[1]	*P. eldarica* cult. Italy[2]	*P. brutia* natural, Lebanon[3]	*P. brutia* cult. Greece[4]
1537	α-cadinene	-	-	0.2	-	-	-
1555	elemicin	-	-	4.3	-	-	-
1574	**germacrene-D-4-ol**	**0.2**	**0.6**	-	-	-	-
1583	caryophyllene oxide	1.3	0.4	1.4	-	0.3	-
1608	humulene epoxide II	0.3	t	-	-	-	-
1608	β-atlantol	0.3	t	-	-	-	-
1610	geranyl isovalerate	-	-	1.8	-	-	-
1638	epi-α-cadinol (= T-cadinol)	t	t	0.3	-	-	-
1640	phenyl ethyl hexanoate	-	0.2	-	-	-	-
1640	**epi-α-muurolol**	**t**	**0.1**	**-**	**0.9**	**-**	**-**
1652	**α-cadinol**	**0.5**	**0.5**	**0.9**	**-**	**-**	**-**
1710	pentadecanal	0.6	t	-	-	-	-
1890	sesquiterpene alcohol?, 43,79,6 192, FW 222?	0.9	-	-	-	-	-
1958	iso-pimara-8(14),15-diene	-	t	-	-	-	-
1987	manool oxide	0.6	t	-	-	-	-
2184	**sandaracopimarinal**	**0.3**	**0.3**	**-**	**-**	**-**	**-**
2200	docosane (C22)	t	t	-	-	-	-
2300	tricosane (C23)	t	0.2	-	-	-	-
2400	tetracosane (C24)	t	0.3	-	-	-	-
2443	methyl neoabietate	t	0.2	-	-	-	-

[1]Suleiman and San'aty (2005), [2]Vidrich et al. (1999), [3]Ghosn and Saliba (2006), Roussis et al. (1995). KI = Kovat's Index (linear), t = trace, < 0.05%.

Table 3. Variation in composition among six *P. eldarica* trees oil., cultivated, using drip irrigation, in St. George, Utah, USA. Components never larger than a trace (t) are omitted.

KI	compound	*P. eldarica 15576*	*P. eldarica 15579*	*P. eldarica 15575*	*P. eldarica 15578*	*P. eldarica 15577*	P. eldarica cult. USA *15574*	P. eldarica cult. USA. Range
921	tricyclene	t	0.1	t	t	t	t	t - 0.1
924	α-thujene	t	t	t	t	t	0.1	t - 0.1
932	**α-pinene**	**19.7**	**13.2**	**19.1**	**12.6**	**15.6**	**6.2**	**6.2 - 19.7**
946	camphene	0.3	0.2	0.3	0.2	0.2	0.1	0.1 - 0.3
969	sabinene	0.2	0.1	0.1	0.7	t	t	t -0.7
974	**β-pinene**	**24.3**	**22.2**	**15.0**	**5.0**	**10.8**	**5.0**	**5.0 - 24.3**
988	myrcene	1.0	1.0	1.0	0.9	0.7	0.6	0.6 - 1.0
1002	α-phellandrene	t	t	t	t	t	0.1	t - 0.1
1008	**δ-3-carene**	**7.5**	**7.3**	**2.9**	**6.3**	**1.1**	**0.6**	**1.1 - 7.5**
1014	α-terpinene	0.1	t	t	0.1	0.1	t	t - 0.1
1020	p-cymene	0.1	t	t	t	t	t	t - 0.1
1024	limonene	0.7	1.2	1.0	0.7	0.5	1.3	0.5 - 1.3
1025	β-phellandrene	1.1	1.7	1.4	1.0	0.8	2.0	0.8 - 2.0
1044	(Z)-β-ocimene	0.3	0.4	0.5	0.6	0.2	0.4	0.2 - 0.6
1044	(E)- β-ocimene	1.0	1.0	4.0	1.4	0.9	1.1	1.0 - 4.0
1054	γ-terpinene	0.1	0.1	0.1	0.1	0.1	0.1	0.1 - 0.1
1086	**terpinolene**	1.1	1.1	**0.6**	**1.5**	**0.3**	**0.2**	**0.2 - 1.5**
1095	linalool	0.7	0.4	0.3	0.7	t	0.1	t - 0.7
1114	endo-fenchol	t	0.1	t	t	t	t	t - 0.1
1136	trans-sabinol	t	0.3	t	t	t	t	t - 0.3
1141	camphor	t	0.2	t	t	t	t	t - 0.3
1165	borneol	t	0.2	t	t	t	t	t - 0.2
1174	terpinen-4-ol	t	0.2	t	0.1	t	t	t - 0.2
1186	α-terpineol	0.2	0.1	0.1	t	0.1	0.1	t - 0.2
1195	myrtenol	t	0.1	t	t	t	t	t - 0.1
1284	bornyl acetate	0.2	0.4	0.3	0.2	t	0.4	t - 0.4
1342	trans-piperitol acetate	0.1	0.2	0.1	0.1	t	0.1	t - 0.2
1345	**α-terpinyl acetate**	**2.2**	**2.6**	**2.7**	**3.3**	**1.6**	**2.4**	1.6 - 3.3
1374	α-copaene	t	0.1	0.1	0.1	0.2	0.1	t - 0.2
1387	β-bourbonene	0.6	1.1	0.3	0.8	0.4	0.8	0.3 - 1.1
1389	β-elemene	t	t	t	t	t	0.1	t - 0.1
1400	β-longipinene	0.4	0.2	0.3	0.3	0.1	0.2	0.1 - 0.4
1417	**(E)-caryophyllene**	**6.6**	**8.8**	**8.2**	**12.0**	**16.0**	**19.4**	**6.6 - 19.4**
1430	β-copaene	0.1	0.2	0.1	0.2	0.2	0.3	0.1 - 0.3
1454	α-humulene	1.3	1.7	1.6	2.4	3.1	3.9	1.3 - 3.9
1464	9-epi-(E)-caryophyllene	0.1	0.1	t	0.3	0.1	1.1	t - 1.1
1478	γ-muurolene	t	t	0.1	t	t	t	t - 0.1
1480	**germacrene D**	**21.7**	**21.6**	**28.5**	**37.1**	**35.2**	**39.0**	**21.6 - 39.0**
1480	**phenyl-ethyl-3-me-butanoate**	**1.9**	**0.9**	**1.0**	**0.9**	**0.6**	**0.6**	**0.6 -1.9**
1495	γ-amorphene	0.2	0.3	0.3	0.4	0.4	0.9	0.2 - 0.9
1500	α-muurolene	0.2	0.2	0.2	0.3	0.3	0.5	0.2 - 0.5
1511	δ-amorphene	0.1	0.1	0.3	0.1	0.3	0.5	0.1 - 0.5
1513	γ-cadinene	0.2	0.4	0.5	0.5	0.6	1.1	0.2 - 1.1
1522	δ-cadinene	0.3	1.0	1.4	1.2	1.6	2.8	0.3 - 2.8
1574	germacrene-D-4-ol	0.6	0.6	0.6	1.0	0.7	0.9	0.6 - 1.0
1583	caryophyllene oxide	0.4	0.4	0.3	0.5	0.3	0.5	0.3 - 0.5
1608	humulene epoxide II	t	0.1	t	t	t	t	t - 0.1
1608	β-atlantol	t	0.1	t	t	t	0.1	t - 0.1
1638	epi-α-cadinol (= T-cadinol)	t	t	t	0.1	t	t	t - 0.1
1640	phenyl ethyl hexanoate	0.2	t	t	0.1	0.2	0.2	t - 0.2
1640	epi-α-muurolol	0.1	t	t	t	0.1	t	t - 0.1
1652	α-cadinol	0.3	0.5	0.5	0.5	0.5	0.7	0.3 - 0.7
1958	**iso-pimara-8(14),15-diene**	**t**	**0.5**	**0.6**	**0.2**	**0.4**	**0.2**	**t - 0.6**
1987	manool oxide	t	t	t	t	t	0.1	t - 0.1
2184	**sandaracopimarinal**	**t**	**0.7**	**0.9**	**0.1**	**0.1**	**t**	**t - 0.9**
2200	docosane (C22)	t	t	t	t	t	0.5	t - 0.5
2300	**tricosane (C23)**	**t**	**t**	**t**	**t**	**0.2**	**0.6**	**t - 0.6**
2400	tetracosane (C24)	0.3	0.3	0.2	0.5	0.3	0.2	0.2 - 0.5
2443	methyl neoabietate	t	0.2	0.2	0.2	0.3	0.1	t - 0.3