Progress in Essential Oils

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Cinnamomum camphora Oils

Cinamomum camphora (L.) Nees et Eberm. (syn. *C. camphora* (L.) J. Presl.) is known to exist in a number of chemotypic forms, the most common being those whose oils are rich in linalool (ho oil), camphor and 1,8-cineole. As the first two of these oils have achieved economic importance, particularly ho oil, they will be treated separately within this section.

Linalool-rich oils

Bernreuther and Schreier (1991) determined that the enantiomeric ratio of linalool in ho oil was:

(3R)-(-)-linalool (96.2 percent): (3S)-(+)-linalool (3.8 percent)

Linalool-rich oils of *C. camphora* grown in Brazil were found by Frizzo et al. (2000) to possess the following composition:

α-pinene (0.01-0.08 percent)
sabinene (0-0.06 percent)
β-pinene (0.10-0.17 percent)
myrcene (0.08-0.09 percent)
limonene (0.08-0.30 percent)
1,8-cineole (0-0.15 percent)
(E)-β-ocimene (0.46-0.48 percent)
γ-terpinene (0-0.01 percent)
linalool (93.14-95.29 percent)
camphor (0.40-0.46 percent)
borneol (0.11-0.20 percent)
terpinen-4-ol (0-0.08 percent)
α-terpineol (0-0.37 percent)
p-cymen-8-ol (0-0.05 percent)
isobornyl acetate (0-0.11 percent)
γ-elemene (0-0.27 percent)
aromadendrene (0-0.09 percent)
β-caryophyllene (0.46-0.64 percent)
α-humulene (0.15-0.22 percent)
germacrene D (0.26-0.30 percent)
bicyclogermacrene (0.12-0.26 percent)
elemol (0.01-0.10 percent)
(E)-nerolidol (0.09-0.11 percent)
spathulenol (0-0.05 percent)
safrole (0-0.03 percent)

Liu et al. (2001) analyzed an oil produced from the seeds of *C. camphora* obtained in Nanjing (China) and found that it possessed the following composition:

methyl isobutyl ketone† (0.04 percent)
3-methylapopinene† (0.01 percent)
4-hydroxy-4-methyl-2-pentanone† (0.02 percent)
α-phellandrene (0.48 percent)
limonene (0.11 percent)
p-cymene (0.35 percent)
(E)-β-ocimene (0.12 percent)
linalool oxide* (0.09 percent)
linalool (82.70 percent)
hotrienol (0.07 percent)
camphor (0.30 percent)
4-carvomenthenol† (0.06 percent)
6-methyl-2-heptanone† (0.14 percent)
linalyl propionate (0.57 percent)
citronellol (0.15 percent)
nerol (0.24 percent)
β-caryophyllene (0.03 percent)
α-humulene (0.02 percent)
methyl isoeugenol* (1.63 percent)
eremophilene (0.26 percent)
methylisoeugenol* (0.18 percent)
(Z)-nerolidol (2.26 percent)
spathulenol (0.39 percent)
caryophyllene oxide (0.10 percent)
globulol (0.22 percent)
3α-(2-propenyl)-*cis*-pinane† (1.19 percent)
hexadecanoic acid (0.03 percent)

*correct isomer not identified; †incorrect identification as compounds are not naturally occurring constituents

Liang et al. (2001) analyzed some different samples of ho oil. They found that the content of these linalool-rich oils varied as follows:

α-pinene (t-0.01 percent)
camphene (t-0.03 percent)
β-pinene (0.02 percent)
sabinene (0-0.59 percent)
myrcene (0-0.22 percent)

α-phellandrene (0-0.08 percent)
α-terpinene (0-0.01 percent)
limonene (0.04-0.29 percent)
1,8-cineole (0.08-2.76 percent)
γ-terpinene (0.01-0.51 percent)
p-cymene (0.01-0.39 percent)
terpinolene (0-0.84 percent)
6-methyl-5-hepten-2-one (0.01-0.06 percent)
cis-linalool oxide† (0.11-4.52 percent)
trans-linalool oxide† (0.34-4.82 percent)
camphor (0.10-0.65 percent)
linalool (83.69-98.52 percent)
α-santalene (0-1.81 percent)
terpinen-4-ol (0-0.34 percent)
α-terpineol (0-0.78 percent)
citronellol (0-0.57 percent)
nerol (0-0.79 percent)
geraniol (0-0.02 percent)
safrole (0-0.01 percent)
methyl eugenol (0-0.03 percent)
(E)-nerolidol (0-1.95 percent)
isoeugenol* (0-0.37 percent)

*correct isomer not identified; †furanoid form

Lorenzo et al. (2002) examined the enantiomeric distribution of a few constituents of two linalool-rich oil of *C. camphora*. The results are summarized as follows:

(1R,5R)-(+)-α-pinene (81.6-87.8 percent): (1S,5S)-(-)-α-pinene (12.2-18.4 percent)
(1R,5R)-(+)-sabinene (31.7-35.8 percent): (1S,5S)-(-)-sabinene (64.2-68.3 percent)
(1R,5R)-(+)-β-pinene (57.6-90.6 percent): (1S,5S)-(-)-β-pinene (9.4-42.4 percent)
(4R)-(+)-limonene (44.3-85.4 percent): (4S)-(-)-limonene (14.6-55.7 percent)
(+)-camphor (99.8-100.0 percent): (-)-camphor (0-0.2 percent)
(3S)-(+)-linalool (0.5-0.6 percent): (3R)-(-)-linalool (99.4-99.5 percent)
(4S)-(+)-terpinen-4-ol (45.1-48.1 percent): (4R)-(-)-terpinen-4-ol (51.9-54.9 percent)
(4R)-(+)-α-terpineol (77.6-88.2 percent): (4S)-(-)-terpineol (11.8-22.4 percent)

Shieh (2003) analyzed oil produced from the leaves of *C. camphora* ssp. *formosana* var. *oxidentalis* subvar. *linaloola* grown in Taiwan using GC and GC/MS. The composition of the oil produced after 2 h distillation (the time taken to produce the oil with the highest linalool content) was as follows:

α-pinene (0.05 percent)
β-pinene (0.06 percent)
p-cymene (0.03 percent)
limonene (0.02 percent)
linalool oxide* (0.04 percent)
linalool (94.47 percent)
polinol C† (0.07 percent)
citronellal (0.52 percent)

terpinen-4-ol (0.97 percent)
α-terpineol (0.99 percent)
β-caryophyllene (1.13 percent)
α-humulene (0.10 percent)
germacrene D (0.15 percent)
β-selinene (0.16 percent)
α-selinene (0.07 percent)
δ-cadiene (0.06 percent)
caryophyllene oxide (0.56 percent)
T-muurolol (0.15 percent)
farnesol* (0.06 percent)

*correct isomer not identified; †this compound is unknown to this reviewer

Shieh also analyzed an oil produced from the wood of the same tree. He found that the wood composition varied according to the length of distillation time. The most complex oil was produced after an 8 h distillation time. It was found to contain the following components:

α-pinene (0.08 percent)
β-pinene (0.30 percent)
1,8 cineole (3.83 percent)
β-ocimene* (1.35 percent)
linalool oxide* (0.65 percent)
linalool (45.90 percent)
camphor (31.60 percent)
isoborneol (1.08 percent)
terpinen-4-ol (2.12 percent)
α-terpineol (4.09 percent)
verbenone (0.17 percent)
geraniol (0.28 percent)
safrole (5.86 percent)
p-elemene (0.14 percent)
β-caryophyllene (0.46 percent)
α-muurolene (0.19 percent)
δ-cadinene (0.24 percent)
caryophyllene oxide (1.26 percent)

*correct isomer not identified

C.D. Frizzo, A.C. Santos, N. Paroul, L.A. Serafini, E. Dellacassa, D, Lorenzo and P. Moyna, *Essential oils of camphor tree (Cinnamomum camphora Nees & Eberm.) cultivated in southern Brazil*. Parana Inst. Technol. Public., 313-316 (2000).

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J-C. Shieh, *Yields and chemical components of essential oils from the leaves and wood of two linalool trees (Cinnamomum camphora subsp. formosara var. oxidentalis subvar. linaloola)*. Taiwan Forest. J., **18**, 329-333 (2003).

Camphor-rich oils

Pélissier et al. (1995) performed an analysis of the leaf oil of *C. camphora* that was found to be rich in camphor. The oil composition was determined to vary as follows:

α-thujene (0-0.1 percent)
α-pinene (0.1-1.7 percent)
camphene (0-1.2 percent)
sabinene (0-0.4 percent)
β-pinene (0-1.0 percent)
myrcene (0.1-1.5 percent)
α-phellandrene (0-0.3 percent)
1,8-cineole (1.0-1.7 percent)
limonene (0.6-2.1 percent)
trans-sabinene hydrate (0.1-0.2 percent)
camphor (63.6-84.1 percent)
borneol (0.8-1.0 percent)
terpinen-4-ol (0.9-1.2 percent)
α-terpineol (1.8-2.0 percent)
δ-elemene (0.1-0.6 percent)
β-elemene (0.1-0.7 percent)
β-caryophyllene (0.2-3.4 percent)
α-humulene (1.5-4.0 percent)
bicyclogermacrene (2.0-7.5 percent)
δ-cadinene (0.1-0.4 percent)
germacrene B (0.1-0.4 percent)
spathulenol (2.4-2.6 percent)
caryophyllene oxide (0-0.2 percent)
humulene epoxide * (0.1-0.3 percent)
T-cadinol (0.1-0.3 percent)
α-cadinol (0.1-0.3 percent)

*correct isomer not identified

The authors also found that the stem and bark oils were rich in camphor but the leaf oil was the richest.

Pandey et al. (1997) determined that the main constituents of the bark oil of *C. camphora* that was harvested from the Holongpara Reserve Forest, Jorhat (Assam, India) were as follows:

α-pinene (2.1 percent)
camphene (1.4 percent)
β-pinene (0.6 percent)
myrcene (0.9 percent)
p-cymene (0.2 percent)
1,8-cineole (8.2 percent)
camphor (78.7 percent)
borneol (0.2 percent)
α-terpineol (2.0 percent)
safrole (1.6 percent)

An oil produced from the leaves of *C. camphora* cultivated in Cuba was the subject of analysis by Pino and Fuentes (1998). The composition of this oil was found to be as follows:

α-pinene (0.2 percent)
α-fenchene (4.6 percent)
camphene (3.7 percent)
sabinene (0.1 percent)
β-pinene (1.7 percent)
myrcene (1.9 percent)
α-phellandrene (0.3 percent)

p-cymene (0.7 percent)
limonene (5.0 percent)
1,8-cineole (0.4 percent)
β-phellandrene (0.1 percent)
trans-sabinene hydrate (0.1 percent)
terpinolene (0.2 percent)
camphor (71.2 percent)
borneol (0.9 percent)
terpinen-4-ol (0.9 percent)
α-terpineol (1.2 percent)
neral (0.1 percent)
α-terpinyl acetate (0.1 percent)
α-copaene (0.1 percent)
β-elemene (0.1 percent)
β-caryophyllene (1.7 percent)
α-humulene (0.2 percent)
germacrene D (1.5 percent)
bicyclogermacrene (1.5 percent)
δ-cadinene (0.1 percent)
elemol (0.1 percent)
germacrene B (0.2 percent)
spathulenol (1.1 percent)
caryophyllene oxide (0.4 percent)
14-hydroxy-9-epi-β-caryophyllene (0.1 percent)

Trace amounts (< 0.1 percent) of tricyclene, δ-3-carene, α-terpinene, *cis*-piperitol, 2-undecanone, β-bourbonene, γ-elemene and (Z)-nerolidol were also found in this oil.

Khiên et al. (1998) examined a leaf oil of *C. camphora* growing in Vietnam for its major constituents. They were found to be as follows:

α-thujene (0.1 percent)
α-pinene (0.4 percent)
β-pinene (0.2 percent)
α-phelladrene (0.9 percent)
1,8-cineole (4.9 percent)
camphor (81.5 percent)
terpinen-4-ol (0.9 percent)
α-terpineol (1.3 percent)
safrole (0.2 percent)

The leaf oils of Hon-Sho (*C. camphora*) were analyzed by Frizzo (2000) and they were found to be as follows:

α-thujene (0.20-0.98 percent)
α-pinene (2.29-3.15 percent)
camphene (1.83-1.95 percent)
sabinene (0.19-1.35 percent)
β-pinene (1.16 percent)
myrcene (1.90-2.90 percent)
α-phellandrene (0-0.56 percent)
limonene (3.59-5.11 percent)
(E)-β-ocimene (0.19-0.27 percent)
γ-terpinene (0-0.21 percent)
terpinolene (0.61-0.87 percent)
linalool (8.92-18.84 percent)
camphor (54.47-68.03 percent)

borneol (0-0.54 percent)
terpinen-4-ol (0.67-1.29 percent)
α-terpineol (0.96-1.35 percent)
citronellol (0.08-0.15 percent)
neral (0.07-0.35 percent)
isobornyl acetate (0-0.98 percent)
γ-elemene (0-1.79 percent)
β-caryophyllene (0.66-1.26 percent)
α-humulene (0.27-0.55 percent)
germacrene D (0.14-0.45 percent)
bicyclogermacrene (0.11-0.56 percent)
elemol (0.07-0.25 percent)
(E)-nerolidol (0.08-0.19 percent)
spathulenol (0.14-0.25 percent)
nerol (0-0.12 percent)
safrole (0-0.69 percent)
globulol (0.12-0.16 percent)
α-cadinol (0-0.11 percent)

Stubbs and Brushett (2001) analyzed oils produced from leaves of *C. camphora* growing in northeastern New South Wales (Australia). The oils of 20 of these accessions were found to vary in the following way:

α-pinene (4.1-4.8 percent)
camphene (2.2-2.8 percent)
sabinene (< 1.0-1.1 percent)
myrcene (1.4-1.7 percent)
β-pinene (1.7-2.1 percent)
limonene (3.2-3.8 percent)
1,8-cineole (< 1.0-2.7 percent)
camphor (61.6-74.1 percent)
terpinen-4-ol (< 1.0 percent)
citronellol (< 1.0 percent)
β-caryophyllene (1.2-8.3 percent)
germacrene D (< 1.0-5.7 percent)
β-selinene (1.0-5.4 percent)
allo-aromadendrene (< 1.0-3.1 percent)

Baruah et al. (2002) reported that a leaf oil of *C. camphora* produced from plants harvested in India was found to contain:

α-pinene (2.1 percent)
camphene (1.4 percent)
β-pinene (0.6 percent)
myrcene (0.9 percent)
p-cymene (0.2 percent)
1,8-cineole (8.2 percent)
camphor (78.7 percent)
borneol (0.2 percent)
α-terpineol (2.0 percent)
safrole (1.6 percent)

The leaf oil of *C. camphora* ssp. *formosana* var. *oxidentalis* subvar. *eucamphor* that was rich in camphor was determined by Shieh (2003) to possess the following composition:

α-pinene (6.25 percent)
camphene (2.42 percent)

β-pinene (2.68 percent)
myrcene (2.83 percent)
α-phellandrene (1.19 percent)
p-cymene (7.88 percent)
1,8-cineole (3.28 percent)
β-ocimene* (0.42 percent)
terpinolene (0.72 percent)
linalool (1.66 percent)
camphor (54.01 percent)
borneol (0.57 percent)
terpinen-4-ol (2.14 percent)
p-cymen-8-ol (3.09 percent)
bornyl acetate (1.48 percent)
β-caryophyllene (1.77 percent)
γ-elemene (0.26 percent)
α-humulene (1.16 percent)
elemol (0.37 percent)
caryophyllene oxide (0.30 percent)
aromadendrene† (0.53 percent)
β-eudesmol (2.24 percent)

*correct isomer not identified; † incorrect identification based on GC elution order

Shieh also found that the wood oil of this same camphor rich strain of *C. camphora* possessed the following composition:

α-pinene (0.16 percent)
camphene (0.08 percent)
β-pinene (0.48 percent)
myrcene (0.24 percent)
α-phellandrene (0.09 percent)
1,8-cineole (5.10 percent)
β-ocimene* (0.21 percent)
terpinolene (0.08 percent)
linalool (3.11 percent)
camphor (57.72 percent)
δ-terpineol (1.04 percent)
terpinen-4-ol (1.90 percent)
α-terpineol (5.04 percent)
verbenone (0.21 percent)
citronellol (0.14 percent)
piperitone (0.08 percent)
safrole (14.43 percent)
δ-elemene (0.15 percent)
α-cubebene (0.42 percent)
eugenol (0.43 percent)
α-copaene (0.13 percent)
β-caryophyllene (0.29 percent)
β-selinene (0.09 percent)
farnesene* (1.28 percent)
β-cubebene† (0.38 percent)
curcumene* (0.17 percent)
β-bizabolene (0.20 percent)
δ-cadinene (0.55 percent)
germacrene B (0.09 percent)
caryophyllene oxide (0.16 percent)
tetradecanal (0.38 percent)
cadina-1,4-diene† (0.19 percent)
α-cadinol (0.30 percent)
β-eudesmol (1.11 percent)

*correct isomer not identified; †incorrect identification based on GC elution order

Stubbs et al. (2004) determined that two main constituents of the leaf oil of *C. camphora* from eastern Australia varied as follows:

α-pinene (3.2-5.0 percent)
camphene (1.8-2.8 percent)
limonene (2.2-4.5 percent)
camphor (57.0-72.5 percent)
allo-aromadendrene (0.8-4.4 percent)

The authors also found that the wood oil varied as follows:

α-pinene (0.5-3.4 percent)
limonene (0.5-3.8 percent)
1,8-cineole (4.2-23.9 percent)
camphor (20.0-71.1 percent)
citronellol (1.5-5.2 percent)
safrole (1.0-55.4 percent)

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Jasmin Oil and its Extracts

Using a 25 m CPSil-5 fused silica capillary column which was programmed from 70°-250°C (26-28 min) at 5°C, a heart cut of the area around the methyl jasmonate peak of an authentic sample of jasmin concrete was further subjected to chiral GC using an octakis-(2-O-methyl-3,6-di-O-pentyl)-γ-cyclodextrin column isothermal at 125°C (König et al. 1992). The authors showed that the enantiomerics found for the methyl jasmonate and the epi-methyl jasmonate were (1R,2R)- and (1R,2S)-, respectively.

Ellena (1993) reported that the main constituents of the headspace of live and pitched jasmin flowers were as shown in T-1.

Basset (1994) summarized the data presented at the 25th Symposium of Essential Oils (Digne). She noted that production of jasmin concrete in 1993 was France (70 kg), Italy (20-30 kg), Morocco (600 kg), India (4-4.5 tonnes).

Basset noted that Flament reported that 259 components have been characterized in jasmin absolute. Since 1990, 62 hydrocarbons, 66 esters and lactones and 52 miscellaneous compounds including acids, phenols and heterocyclic compounds have been found. She further reported the main components found in the absolute of jasmin of different geographical origins, as shown in T-2.

Srivastava et al. (1997) reported that a new high oil yielding cultivars of *Jasminum grandiflorum* (Arka Surabhi) contained the following major components:

linalool (5.02 percent)
benzyl acetate (13.62 percent)
benzyl alcohol (1.87 percent)
(Z)-jasmone (8.97 percent)
methyl anthranilate (1.43 percent)

Comparative percentage composition of the main odorous components in the headspace of live and picked jasmin flowers **T-1**

Compound	Live flowers headspace	Picked flowers headspace
benzyl acetate	60	40
linalool	3	30
indole	11	2
(Z)-jasmine	3	-

isophytol (9.33 percent)
indole (3.67 percent)
eugenol (3.19 percent)
phytol (4.53 percent)
benzyl benzoate (10.19 percent)

Cum et al. (1998) determined that the main components of a supercritical fluid CO_2 extract of jasmin flowers were:

Principal constituents of jasmin absolute of different geographic origin **T-2**

Compound	Egyptian	Indian	French	Italian	Moroccan
methyl benzoate	0.25-0.60	0.30-1.00	0.25	0.20	0.45
linalool	3.00-5.00	3.50-6.50	4.00	4.35	4.40
benzyl acetate	18.00-24.50	20.00-24.50	15.00	19.20	18.30
indole	2.50-3.50	0.70-2.00	0.75	2.30	1.10
eugenol	1.50-2.50	1.70-3.00	1.10	1.65	1.35
(Z)-jasmone	2.00-3.00	1.50-2.20	2.10	3.30	2.65
jasmolactone	0.55-1.10	0.30-0.65	0.80	1.20	1.10
cis-methyl jasmonate	0.50-0.75	0.15-0.60	1.20	0.75	1.30
benzyl benzoate	8.00-10.50	13.00-20.00	8.65	14.00	11.00
isophytol	6.00-7.50	5.00-8.00	8.00	6.35	6.90
geranyl linalool	2.50-3.50	2.50-3.50	5.00	3.15	3.80
phytol	7.00-12.00	7.00-10.00	12.50	8.85	9.90
phytyl acetate	3.50-6.50	4.00-5.50	5.30	3.70	7.00
squalene	3.50-6.00	2.50-4.50	5.10	5.40	4.75
squalene 2,3-oxide	8.00-12.00	7.00-11.00	5.80	6.30	6.65

benzyl acetate (17.84 percent)
benzyl benzoate (26.97 percent)
phytol (6.04 percent)
(Z)-jasmone (1.28 percent)
linalool (5.25 percent)

In addition, the authors reported that jasmin absolute contained the following components:

benzyl benzoate (22.00 percent)
phytol isomers (14.30 percent)
linalool (7.90 percent)
benzyl acetate (7.73 percent)
(Z)-jasmone (4.71 percent)
(Z)-3-hexenyl benzoate (4.14 percent)
α-farnesene* (3.32 percent)
benzyl alcohol (3.28 percent)
methyl palmitate (3.26 percent)
6,10,14-trimethyl-2-pentadecanone (3.23 percent)
methyl oleate (0.80 percent)
(E)-3-hexenyl benzoate (0.60 percent)
(E)-anethole (0.59 percent)
methyl chavicol (0.59 percent)
nerolidol* (0.54 percent)
linalyl acetate (0.42 percent)
hexyl benzoate (0.40 percent)
methyl linoleate (0.31 percent)
geranyl acetone (0.15 percent)
geranyl acetate (0.10 percent)
α-terpineol (0.09 percent)
geraniol (0.06 percent)
6-methyl-5-hepten-2-one (0.06 percent)
130 minor components (21.42 percent)

*correct isomer not identified

Wright (1999) reported that the main constituents of jasmin oil which is ca. 16 percent of the concrete are:

benzyl acetate (11.0 percent)
linalool (3.0 percent)
(Z)-jasmone (1.4 percent)
methyl jasmonate (0.9 percent)
indole (0.5 percent)

Tamogami et al. (2001) determined the enantiomeric ratios of some specific components of jasmin absolute of Egyptian, French and Indian origins. The results of this study are shown in T-3. As can be seen, the ratios of some of the components varied according to the country of production (presumably the country in which the jasmin was grown). Tamogami et al. further postulated that it might be possible to distinguish between samples of jasmin absolute using enantiomeric ratios.

W.A. König, B. Gehrcke, D. Icheln, P. Evers, J. Donnecke and W-C. Wang, *New selectively substituted cyclodextrins as stationary phases for the analysis of chiral constituents of essential oils*. J. High Resol. Chromatogs., **15**, 367-372 (1992).

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Enantiomeric distribution of some chiral constituents of jasmin absolute of different origin **T-3**

Compound	Egyptian	Indian	French
(3R)-(-)-linalool	8.68	17.18	22.91
(3S)-(+)-linalool	91.32	82.82	77.09
(2R,5R)-*trans*-linalool oxide†	14.99	14.08	27.60
(2S,5S)-*trans*-linalool oxide†	85.01	85.94	72.40
(2R,5S)-*cis*-linalool oxide†	13.19	15.74	19.83
(2S,5R)-*cis*-linalool oxide†	86.81	84.26	80.16
(E)-(+)-nerolidol	98.95	99.53	96.53
(E)-(-)-nerolidol	1.05	0.47	3.47
(R)-(-)-δ-jasmin lactone	> 99.90	> 99.90	99.50
(S)-(+)-δ-jasmin lactone	< 0.10	< 0.10	0.50
(1R,2R)-methyl jasmonate	98.50	84.57	95.95
(1S,2S)-methyl jasmonate	1.50	15.49	4.05
(1R,2S)-methyl epi-jasmonate	> 99.90	> 99.90	> 99.90
(1S,2R)-methyl epi-jasmonate	< 0.10	< 0.10	< 0.10

†furanoid form

H.C. Srivastava, J.V.R. Bhupal Rao, P.G. Karmarkar, S.P. Angadi, T.V. Tumar and G.Venkateshwarlu, *A new variety of Jasminum grandiflorum Linn. for high yield of essential oil*. PAFAI J., (Oct/Nov), 16-18 (1997).

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S. Tamogami, K. Awano and T. Kitahara, *Analysis of the enantiomeric ratios of chiral components in absolute jasmin*. Flav. Fragr. J., **16**, 161-163 (2001).

Dwarf Pine Oil

An oil produced from the needles of dwarf pine (*Pinus mugo* Turra; syn. *P. montana* Mill., *P. pumilio* Haenke) that were collected from the Royal Botanic Gardens in Edinburgh was analyzed by Tsitsimpikou et al. (2001). Using a combination of both GC and GC/MS, the oil was found to possess the following components:

tricyclene (1.2 percent)
α-pinene (33.3 percent)
α-fenchene (6.4 percent)
β-pinene (2.8 percent)
myrcene (1.2 percent)
limonene (0.9 percent)
α-pinene oxide (1.5 percent)
α-thujone (1.2 percent)
cis-chrysanthenol (1.0 percent)
isobornyl acetate (2.0 percent)
2-undecanone (0.8 percent)
carvacrol (1.6 percent)
α-terpinyl acetate (3.6 percent)
β-caryophyllene (2.7 percent)
γ-muurolene (3.5 percent)
β-selinene (2.1 percent)
α-muurolene (2.4 percent)
epi-cubebol (1.8 percent)
γ-cadinene (9.0 percent)
caryophyllene oxide (6.1 percent)
spathulenol (3.5 percent)
β-oplopenone (0.8 percent)
T-muurolol (4.6 percent)
α-muurolol (0.2 percent)
α-cadinol (4.4 percent)
benzyl benzoate (1.5 percent)

An analysis of dwarf pine oil of Austrian origin was reported by Kubeczba and Formacek (2002). The constituents identified in this oil were:

tricyclene (1.72 percent)
α-thujene & α-pinene (27.57 percent)
camphene (8.14 percent)
β-pinene (3.40 percent)
sabinene (0.99 percent)
δ-3-carene (16.20 percent)
myrcene (3.94 percent)
α-terpinene (0.30 percent)
limonene (0.92 percent)
β-phellandrene (1.46 percent)
(Z)-β-ocimene (0.07 percent)
γ-terpinene (0.41 percent)
(E)-β-ocimene (1.58 percent)
p-cymene (0.18 percent)
terpinolene (3.22 percent)
α-cubebene (0.18 percent)
α-copaene (0.06 percent)
bornyl acetate (8.19 percent)
β-elemene (0.33 percent)
β-caryophyllene (2.76 percent)
α-humulene (0.41 percent)
α-terpineol (0.40 percent)
borneol (0.63 percent)
germacrene D (3.88 percent)

bicyclogermacrene (1.88 percent)
δ-cadinene (2.89 percent)
γ-cadinene (0.65 percent)
germacrene D-4-ol (0.37 percent)
T-cadinol (0.41 percent)
T-muurolol (0.49 percent)
α-muurolol (0.12 percent)
α-cadinol (1.13 percent)

Stevanovic et al. (2005) used GC and GC/MS to analyze an oil produced from the needles and twigs of *P. mugo* collected in a national park in Ostrovica region (Serbia and Montenegro) The composition of the oil was found to be as follows:

tricyclene (0.4 percent)
α-thujene (0.8 percent)
α-pinene (17.9 percent)
camphene (1.7 percent)
sabinene (1.3 percent)
β-pinene (7.8 percent)
myrcene (2.7 percent)
α-phellandrene (0.2 percent)
δ-3-carene (23.9 percent)
p-cymene (1.1 percent)
limonene (3.9 percent)
β-phelladrene (7.2 percent)
(E)-β-ocimene (0.1 percent)
terpinolene (0.4 percent)
linalool (0.3 percent)
terpinen-4-ol (1.2 percent)
cryptone (1.3 percent)
p-cymen-8-ol (0.9 percent)
α-terpineol (0.5 percent)
methyl thymol (0.2 percent)
cuminaldehyde (0.6 percent)
bornyl acetate (3.2 percent)
piperitenone (1.2 percent)
α-terpinyl acetate (2.5 percent)
β-caryophyllene (2.4 percent)
α-humulene (0.4 percent)
germacrene D (0.7 percent)
γ-cadinene (0.8 percent)
δ-cadinene (1.1 percent)
spathulenol (1.2 percent)
caryophyllene oxide (1.6 percent)
T-cadinol (0.7 percent)
T-muurolol (1.1 percent)
α-cadinol (1.0 percent)

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