Progress in Essential Oils

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Betel Leaf Oil

Jantan et al. (1994) analyzed an oil of *P. betle* leaves (betel leaf oil) that were grown in Masjid Tanah, Melaka (Malaysia). The components characterized in this oil were as follows:

methyl chavicol (0.1 percent)
chavicol (6.0 percent)
chavibetol (69.0 percent)
methyl eugenol (0.6 percent)
β-caryophyllene (2.4 percent)
α-bergamotene* (0.2 percent)
ε-muurolene (0.4 percent)
α-humulene (0.8 percent)
α-cadinene (0.6 percent)
γ-muurolene (5.2 percent)
eugenyl acetate (8.3 percent)
γ-cadinene (1.6 percent)
4-allyl-1,2-diacetoxybenzene (0.2 percent)
cedrol (0.7 percent)
phytol (0.5 percent)

*correct isomer not identified

Garg and Jain (1996) and (1996) produced oils from the Sagar Bangla cultivar of betel leaf grown in India and found that they contained the following constituents:

α-pinene (0.10-0.16 percent)
β-pinene (0.16-0.18 percent)
camphene (0.22-0.27 percent)
1,8-cineole (0.11-0.12 percent)
γ-terpinene (0.24-0.43 percent)
p-cymene (0.40-0.47 percent)
chavicol (47.81-48.78 percent)
α-terpineol (0.43-0.90 percent)
methyl chavicol (0.32-0.59 percent)
allyl-pyrocatechol (8.68-10.80 percent)
α-terpinyl acetate (2.28-2.44 percent)
chavibetol (4.15-7.21 percent)
chavibetyl acetate (14.65-20.69 percent)
allyl-pyrocatechyl diacetate (2.81-3.51 percent)
bisabolene* (0-0.89 percent)
isocaryophyllene (0.23-0.28 percent)
cadinene* (0.42-0.66 percent)
α-bergamotene* (0.46-0.59 percent)
aromadendrene (0.89-1.35 percent)
β-bergamotene* (0.71-1.28 percent)
(E)-anethole (0.16-0.53 percent)

*correct isomer not identified

Oils produced from five Indian cultivars of betel leaf (Bangla, Desawari, Kapoori, Sanchi and Meetha) were analyzed by Sharma et al. (1996). The main constituents of the Bangla cultivar were as follows:

eugenol (63.56 percent)
methyl eugenol (6.90 percent)
isoeugenol* (5.20 percent)
chavicol (1.07 percent)
eugenyl acetate (18.68 percent)

*correct isomer not identified

The composition of the oil of the other four cultivars can be seen in T-1.

A lab-distilled oil of *P. betle* leaves collected from a cultivated area in Kerala (India) was the subject of analysis by Jirovetz et al. (1999). The components identified in this oil are shown as follows:

safrole (39.9 percent)
eugenol (9.0 percent)
allyl-pyrocatechyl monoacetate (8.5 percent)
terpinen-4-ol (6.3 percent)
allyl-pyrocatechyl diacetate (3.6 percent)
sabinene (2.6 percent)
γ-cadinene (2.4 percent)
eugenyl acetate (2.2 percent)
allyl-pyrocatechol (2.1 percent)
chavibetol (2.0 percent)
γ-terpinene (1.9 percent)
linalool (1.8 percent)
β-pinene (1.7 percent)

Percentage composition of betel leaf oils produced from four cultivars **T-1**

Compound	Desawari oil	Kapoori oil	Sanchi oil	Meetha oil
α-thujene	-	1.90	-	-
camphene	-	0.35	3.68	0.50
sabinene	-	6.13	0.53	-
myrcene	-	2.16	0.53	-
β-ocimene*	0.36	0.40	-	-
bornylene	-	-	1.18	-
α-pinene	0.42	-	3.18	0.37
(E)-β-ocimene	-	0.70	-	-
allo-ocimene*	-	0.63	-	-
γ-terpinene	0.51	1.60	0.45	-
terpinolene	-	0.50	-	-
α-terpinene	-	-	0.23	0.94
β-phellandrene	0.37	-	1.28	-
limonene	0.37	-	-	-
p-cymene	0.35	-	0.31	-
γ-cadinene	1.10	-	-	9.44
δ-cadinene	-	1.18	-	-
α-cadinene	-	-	-	2.90
β-selinene	2.57	-	6.36	-
β-elemene	2.60	-	1.18	-
γ-elemene	0.86	0.89	1.78	0.56
β-caryophyllene	3.30	-	7.78	10.64
aromadendrene	-	-	-	1.16
α-cubebene	0.46	-	4.43	4.71
β-cubebene	0.53	-	-	1.12
linalool	0.23	1.46	1.29	0.32
α-terpineol	0.32	2.30	0.69	-
geraniol	-	2.46	-	-
terpinen-1-ol	1.45	-	-	-
α-muurolol	-	1.19	-	-
decanal	-	2.87	0.27	-
dodecanal	-	7.10	1.81	-
octadecanal	-	-	2.69	-
hexadecanoic acid	-	0.41	-	-
α-terpinyl acetate	6.80	11.00	8.70	-
1,8-cineole	2.28	2.75	-	2.33
caryophyllene oxide	1.63	0.66	-	-
eugenol	20.47	33.22	25.90	18.92
methyl eugenol	0.31	1.65	0.58	0.09
isoeugenol*	-	10.59	-	-
methyl chavicol	4.84	0.86	-	0.18
chavibetol	-	-	-	< 0.01
(E)-anethole	7.75	-	-	32.20
safrole	45.30	6.45	22.75	-

*correct isomer not identified

β-caryophyllene (1.2 percent)
methyl eugenol (0.8 percent)
chavicol (0.8 percent)
trans-piperitol (0.6 percent)
cis-piperitol (0.5 percent)
methyl chavicol (0.5 percent)
myrcene (0.4 percent)
α-terpinene (0.4 percent)
(Z)-β-ocimene (0.4 percent)
chavibetyl acetate (0.3 percent)
α-pinene (0.3 percent)
1,8-cineole (0.3 percent)
dodecanal (0.3 percent)
germacrene D (0.3 percent)
terpinolene (0.3 percent)
(E)-β-ocimene (0.3 percent)
α-copaene (0.3 percent)
β-bisabolene (0.2 percent)

cis-sabinene hydrate (0.2 percent)
α-fenchol (0.2 percent)
isocineole (0.2 percent)
α-humulene (0.2 percent)
α-bourbonene (0.2 percent)
limonene (0.2 percent)
β-elemene (0.2 percent)
β-selinene (0.2 percent)
α-terpineol (0.2 percent)

In addition, the other constituents that were found at levels at 0.1 percent were geranyl acetate, neryl acetate, α-fenchyl acetate, (Z)-3-hexenol, camphene, p-cymene, a β-farnesene isomer, β-phellandrene, (E)-3-hexenol, nonanal, α-muurolene, (Z)-3-hexenyl acetate, aromadendrene, an α-bergamotene isomer, (E)-3-hexenyl acetate, isocaryophyllene, (E)-anethole, *trans*-sabinene hydrate, a β-bergamotene isomer, α-terpinyl acetate, γ-muurolene, cedrol and phytol.

An oil produced from Thai betel leaves was determined by Liao (2000) to possess the following composition:

α-pinene (0.09 percent)
camphene (0.13 percent)
β-pinene (0.08 percent)
myrcene (0.06 percent)
limonene (0.08 percent)
1,8-cineole (0.98 percent)
(E)-β-ocimene (0.41 percent)
γ-terpinene (0.23 percent)
2,5,6-trimethylhepta-1,3,6-triene† (0.10 percent)
α-ylangene (0.05 percent)
α-copaene (0.44 percent)
β-bourbonene (0.11 percent)
linalool (0.88 percent)
β-maaliene (0.07 percent)
trans-α-bergamotene (0.08 percent)
β-caryophyllene (3.06 percent)
α-santalene (0.09 percent)
β-gurjunene (0.22 percent)
β-elemene (0.77 percent)
β-cubebene (0.10 percent)
aromadendrene (0.12 percent)
β-selinene (0.07 percent)
α-amorphene (2.52 percent)
γ-muurolene (0.11 percent)
isocaryophyllene (0.25 percent)
germacrene D (2.92 percent)
cadina-4,10-diene (0.28 percent)
methyl chavicol (0.30 percent)
α-humulene (1.04 percent)
ledene (0.96 percent)
δ-cadinene (1.84 percent)
α-selinene (0.68 percent)
bicyclogermacrene (0.96 percent)
cadina-1,4-diene (0.20 percent)
α-cadinene (0.20 percent)
geraniol (0.08 percent)
4-allyl phenylacetate (8.05 percent)
calamenene* (0.13 percent)
calacorene* (0.06 percent)
palustrol (0.19 percent)
α-calacorene (0.08 percent)

methyl eugenol (0.73 percent)
globulol (0.29 percent)
ledol (0.24 percent)
α-copaene† (0.34 percent)
viridiflorol (1.49 percent)
1-(1,1-dimethyl-2-butenyl)cyclohexene† (0.37 percent)
(E)-isoeugenol (28.32 percent)
7-methylhexahydronaphthalene-1(2H-one)† (0.14 percent)
spathulenol (0.11 percent)
α-elemene† (0.13 percent)
epi-bicyclosesquiphellandrene (0.48 percent)
α-cadinol (2.44 percent)
eugenyl acetate (31.77 percent)
(Z)-isoeugenol (0.62 percent)
p-menth-3-en-9-ol† (1.47 percent)
chavicol (1.99 percent)

†incorrect identification based on GC elution order

Chowdhury and Kumar (2002) repeated the results previously reported by Sharma et al. (1996) for the analyses of the leaf oils obtained from the Bangla, Desawari, Kapoori, Sanchi and Meetha betel vines grown in India.

Thanh et al. (2002) reported that the components found in an oil of *P. betle* were as follows:

camphene (0.2 percent)
methyl chavicol (0.3 percent)
decanol (0.1 percent)
chavicol (3.2 percent)
safrole (0.1 percent)
chavicyl acetate (1.4 percent)
eugenol (0.3 percent)
isoeugenol* (72.0 percent)
methyl eugenol (0.7 percent)
β-bourbonene (0.1 percent)
dodecanal (0.1 percent)
β-caryophyllene (1.2 percent)
α-humulene (0.4 percent)
γ-muurolene (1.1 percent)
germacrene D (1.1 percent)
isoeugenyl acetate* (12.2 percent)
δ-cadinene (0.2 percent)
cubenol (0.2 percent)
T-muurolol (0.1 percent)
α-cadinol (0.3 percent)

*correct isomer not identified

Trace amounts (< 0.1 percent) of α-pinene, β-pinene, myrcene, (E)-β-ocimene, linalool, (E,E)-α-farnesene and caryophyllene oxide were also found in this same oil.

I. bin Jantan, A.R. Ahmad, A.S. Ahmed and N.A.M. Ali, *A comparative study of the essential oils of five Piper species from Penninsula Malaysia*. Flav. Fragr. J., **9**, 339-342 (1994).

S.C. Garg and R. Jain, *Volatile constituents of the essential oil of Piper betle L. (cultivar Sagar Bangla)*. Indian J. Chem., **35B**, 874-875 (1996).

M.L. Sharma, A.K.S. Rawat, R.K. Khanna, A.R. Chowdhury and R.M. Raina, *Flavor characteristics of betel leaves*. Eurocosmetics, **(5)**, 23-26 (1996).

S.C. Garg and R. Jain, *Chavicol-rich essential oil of Piper betle L. cultivar Sagar Bangla*. Eurocosmetics, **(5)**, 27-28 (1996).

L. Jirovetz, C. Puschmann, G. Buchbauer, W. Fleischhacker, P.M. Shafi and M.M. Arif, *Analysis of the essential oil of Piper betle L. leaves from south India using GC/FID, GC/MS and olfactometry*. Sci. Pharm., **67**, 307-312 (1999).

C-L. Liao, *Chemical constituents of oil of betel vine from Thailand*. Xiangliao Xiangjing Huazhaungpin, **(2)**, 3-6 (2000).

A.R. Chowdhury and N. Kumar, *Volatile constituents of betel vine (Piper betle L.) leaves*. FAFAI, **4**(1), 53-59 (2002).

L. Thonh, N.X. Dung, H.V. Luu and P.A. Leclercq, *Chemical composition of the leaf oil from Piper betle L. cultivated in Vietnam*. J. Essent. Oil Bear. Plants, **5**, 38-42 (2002).

Effect of infection and treatment on the oils produced from parsley infected with *Cercospora petroselini*

T-2

	Percentage			
	Control plant oil		Infected plant oils	
Compound	**control**	**treated[a]**	**non-treated**	**treated**
α-pinene	6.94	2.39	3.05	2.39
camphene	0.11	-	0.02	-
β-pinene	4.57	3.62	2.02	3.62
myrcene	23.80	15.50	4.29	15.50
α-phellandrene	1.26	1.86	0.37	1.86
p-cymenene	0.86	1.60	1.64	1.60
p-mentha-1,3,8-triene	17.10	3.25	4.05	3.25
(Z,Z)-α-farnesene	1.94	1.64	0.59	1.64
myristicin	39.70	67.60	81.50	67.60
globulol	1.11	0.98	0.06	0.98
dillapiole	4.03	1.10	0.70	1.10
epi-α-bisabolol	0.71	0.51	0.07	0.51

[a]treatment with Cuprosan fungicide

Volatiles found in parsley leaves dried using different processes **T-3**

Compound	Fresh	Dried at ambient temp.	Oven dried at 45°C	Freeze dried
α-pinene	9[a]	18	13	7
myrcene	99	91	66	40
α-phellandrene	25	31	21	13
β-phellandrene	518	476	308	204
(Z)-β-ocimene	11	10	6	6
p-cymenene	18	37	12	11
terpinolene	117	83	57	32
p-mentha-1,3,8-triene	315	482	252	154
α-copaene	4	3	3	2
β-caryophyllene	52	32	29	23
β-farnesene*	3	2	2	1
β-selinene	3	3	2	2
γ-cadinene	39	22	22	16
myristicin	264	191	112	192
β-bisabolene	5	3	3	2
β-sesquiphellandrene	69	34	33	26
apiole	810	491	480	382

[a]µg/g (dry weight);*correct isomer not identified

Parsley Leaf Oil

Hashem et al. (1999) determined that infection of parsley with *Cercospora petroselini* and its treatment with Cuprosan fungicide had a pronounced effect on the leaf oil compositions of infected and uninfected (control) plants, as can be seen in T-2.

Shatar and Altantseteg (2000) analyzed an oil produced from parsley leaves obtained from plants grown in Mongolia. The oil composition was found to be as follows:

α-pinene (1.2 percent)
camphene (0.1 percent)
β-pinene (1.0 percent)
sabinene (0.2 percent)
myrcene (2.4 percent)
α-phellandrene (1.1 percent)
δ-3-carene (0.1 percent)
α-terpinene (0.1 percent)
limonene (5.1 percent)
β-phellandrene (17.2 percent)
(Z)-β-ocimene (0.1 percent)
(E)-β-ocimene (0.6 percent)
γ-terpinene (0.5 percent)
p-cymene (0.3 percent)
terpinolene (1.8 percent)
p-mentha-1,3,8-triene (19.8 percent)
p-cymenene (1.0 percent)
cis-linalool oxide[†] (0.1 percent)
α-fenchyl acetate (0.1 percent)
α-copaene (0.1 percent)
camphor (0.3 percent)

Percentage composition of an oil of nutmeg produced by steam distillation and an oil produced from a nutmeg extract **T-4**

Compound	Oil	Extract oil	Compound	Oil	Extract oil
α-thujene	1.2	0.8	γ-terpinene	1.8	1.2
α-pinene	10.4	7.3	p-cymene	1.0	0.8
β-pinene	8.0	5.6	terpinolene	0.3	0.2
sabinene	56.5	40.0	*trans*-sabinene hydrate	2.4	8.1
myrcene	2.4	1.7	*cis*-sabinene hydrate	0.8	3.0
α-terpinene	0.9	0.6	terpinen-4-ol	6.4	22.0
limonene	2.9	2.0	elemicin	0.7	2.5
1,8-cineole	0.8	1.0	myristicin	0.9	2.9

linalool (0.1 percent)
β-elemene (1.1 percent)
β-caryophyllene (0.2 percent)
terpinen-4-ol (0.1 percent)
β-farnesene* (0.1 percent)
α-terpineol (0.2 percent)
germacrene D (0.7 percent)
carvone (0.3 percent)
δ-cadinene (0.1 percent)
naphthalene (0.3 percent)
cis-carveol (0.3 percent)
tridecanal (0.1 percent)
(E)-anethole (0.2 percent)
methyl eugenol (0.1 percent)
pentadecanal (0.7 percent)
T-muurolol (0.1 percent)
carvacrol (0.1 percent)
myristicin (26.6 percent)
apiole (0.4 percent)
dillapiole (0.1 percent)

†furanoid form; °correct isomer not identified

Broda et al. (2001) examined the headspace of a number of parsley cultivars using GC/MS. The components characterized in the headspace were acetaldehyde, dimethyl sulphide, propanal, methanol, α-pinene, α-thujene, camphene, hexanal, β-pinene, sabinene, δ-3-carene, α-phellandrene, (E)-2-hexenal, (Z)-β-ocimene, γ-terpinene, (E)-β-ocimene, p-cymene, terpinolene, p-mentha-1,3,8-triene and p-cymenene. No quantitative data was presented.

Díaz-Maroto et al. (2002) studied the effect of different drying methods on the volatiles of parsley. Using simultaneous distillation/extraction with ethylene dichloride as the solvent the 17 major volatile constituents of parsley were determined using GC/MS. The results of this study can be seen in T-3.

As can be seen, drying parsley at ambient temperatures was the procedure that produced the lowest loss of volatiles of the drying methods examined.

F.A. El-Megeed Hashem and A.F. Sahab, *Chemical response of parsley and Mentha herbs to certain stress agents*. Food Chem., **65**, 29-33 (1999).

S. Shatar and S. Altantseteg, *Essential oil composition of some plants cultivated in Mongolian climate*. J. Essent. Oil Res., **12**, 745-750 (2000).

S. Broda, R. Habegger, A. Hanke and W.H. Snitzler, *Characterization of parsley by chemosensory and other analytical methods*. J. Appl. Bot., **75**, 201-206 (2001).

M.C. Díaz-Maroto, M.S. Pérez-Coello and M.D. Cabezudo, *Effect of different drying methods on the volatile components of parsley (Petroselinum crispum L.)*. Eur. Food Res. Technol., **215**, 227-230 (2002).

Nutmeg Oil

Borges and Pino (1993) compared the volatile composition of a oil produced by steam distillation and an oil produced from an ethanolic extract of the same batch of nutmeg. The results of this study can be seen in T-4.

Zhu et al. (1995) reported that nutmeg oil produced from plant material cultivated in Guangdong contained the following constituents:

α-thujene (1.16 percent)
α-pinene (27.63 percent)
sabinene (26.84 percent)
β-pinene (15.52 percent)
myrcene (2.05 percent)
α-phellandrene (0.72 percent)
δ-3-carene (1.01 percent)
α-terpinene (1.95 percent)
β-phellandrene (4.45 percent)
γ-terpinene (2.75 percent)
δ-2-carene[†] (1.33 percent)
α-terpineol (0.15 percent)
safrole (1.54 percent)
(E)-isoeugenol (0.37 percent)
myristicin (7.39 percent)

[†]incorrect identification based on GC elution order

Alta-ur-Rahman et al. (1999) analyzed a series of spice oils among which was nutmeg oil that was produced by hydrodistillation from nutmegs purchased from the local market in Karachi. The components characterized in this oil can be seen as follows:

α-pinene (4.9 percent)
α-thujene (1.3 percent)
camphene (0.1 percent)
β-pinene (4.6 percent)
sabinene (1.9 percent)
δ-3-carene (0.6 percent)
myrcene (1.6 percent)
α-phellandrene (0.6 percent)
α-terpinene (3.5 percent)
limonene (3.2 percent)
1,8-cineole (0.1 percent)
β-phellandrene (2.7 percent)
γ-terpinene (7.8 percent)
p-cymene (6.5 percent)
terpinolene (2.4 percent)
p-cymenene (0.1 percent)
α-copaene (0.1 percent)
linalool (0.4 percent)
trans-p-menth-2-en-1-ol (0.2 percent)
terpinen-4-ol (31.3 percent)
cis-p-menth-2-en-1-ol (0.1 percent)
trans-piperitol (0.1 percent)
α-terpineol (5.2 percent)
α-terpinyl acetate (0.1 percent)
borneol (0.1 percent)
cis-1,2,epoxy-terpinen-4-ol (1.1 percent)
cis-piperitol (0.1 percent)
geranyl acetate (0.2 percent)
p-cymen-8-ol (0.3 percent)
safrole (2.0 percent)
methyl eugenol (0.8 percent)
cis-p-menth-3-ene-1,2-diol (0.2 percent)
eugenol (0.2 percent)
(E)-methyl isoeugenol (0.1 percent)

Comparative percentage composition of nutmeg oils of different origins **T-5**

Compound	Jamaican oil	Indonesian oils	Grenada oils
α-pinene	22.2	18.0-21.2	1.6-12.6
α-thujene	t	0.9-2.7	1.2
camphene	0.2	0.1-0.6	t-0.2
β-pinene	16.4	8.7-17.7	7.8-12.1
(Z)-α-ocimene	t	-	-
sabinene	37.0	14.0-44.1	42.0-57.0
δ-3-carene	t	0.5-1.5	0.3
α-phellandrene	0.3	0.4-5.8	0.3-0.7
myrcene	2.6	0.3-4.0	2.2-3.4
α-terpinene	1.4	t-5.2	0.8-4.2
limonene	3.6	2.0-7.0	2.9-4.4
β-phellandrene	t	t-2.4	-
(Z)-β-ocimene	t	-	-
(E)-β-ocimene	t	-	-
γ-terpinene	2.4	1.3-7.7	1.7-4.7
p-cymene	0.2	0.3-2.7	0.7-3.2
terpinolene	0.7	0.6-2.6	0.4-1.7
trans-sabinene hydrate	0.4	t-0.6	0.2-2.4
α-cubebene	t	t-0.2	t
α-copaene	0.1	t-0.5	t-0.8
cis-sabinene hydrate	0.3	t-0.6	0.2-0.8
linalool	0.4	0.2-7.4	0.2-0.9
cis-p-menth-2-en-1-ol	t	0.1-1.2	0.1-0.4
bornyl acetate	t	0.1	t
β-caryophyllene	t	0.4-0.6	t
trans-β-bergamotene	t	-	-
terpinen-4-ol	4.0	1.0-10.9	3.0-6.4
α-terpineol	-	0.1-1.4	0.3
cis-sabinene hydrate acetate	t	-	-
trans-p-menth-2-en-1-ol	t	0.2-0.3	-
β-cedrene	t	-	-
α-farnesene*	t	-	-
citronellyl acetate	t	t	t
β-farnesene*	t	t	-
cis-piperitol	t	0.1-0.6	0.4-1.2
trans-sabinene hydrate acetate	t	-	-
cis-α-bergamotene	t	-	-
γ-muurolene	t	-	-
trans-piperitol	t	t	-
germacrene D	t	t	-
β-bisabolene	t	t	t
δ-cadinene	t	t-0.3	t
geranyl acetate	t	t-0.3	0.2
citronellol	t	0.2	t
safrole	t	0.3-3.3	0.1-0.5
geraniol	t	t	t
methyl eugenol	t	0.5-1.2	0.1-0.2
eugenol	t	0.3-0.7	t-0.2
myristicin	t	3.3-13.5	0.5-0.8

*correct isomer not identified

elemicin (4.8 percent)
myristicin (7.1 percent)
tetradecanoic acid (2.9 percent)

Nutmeg oil produced in the laboratory from nutmegs purchased in the United Kingdom by Damian Dorman et al. (2000) and Damien Dorman and Deans (2004) was determined to possess the following composition:

α-thujene (1.18 percent)
α-pinene (22.00 percent)
camphene (0.37 percent)
sabinene (15.40 percent)
β-pinene (21.50 percent)
myrcene (1.89 percent)
α-phellandrene (0.67 percent)
δ-3-carene (0.89 percent)
α-terpinene (1.24 percent)
p-cymene (1.87 percent)
limonene (3.87 percent)
γ-terpinene (1.80 percent)
terpinolene (0.93 percent)
linalool (0.47 percent)
borneol (0.25 percent)
terpinen-4-ol (5.72 percent)
α-terpineol (0.73 percent)
geraniol (0.13 percent)
bornyl acetate (0.11 percent)
eugenol (0.35 percent)
α-terpinyl acetate (0.14 percent)
neryl acetate (0.15 percent)
methyl eugenol (0.58 percent)
myristicin (9.43 percent)
methyl myristate (0.28 percent)

It is surprising that elemicin was not found as a component of the lab-distilled nutmeg oil analyzed by Damien Dorman et al. (2000).

Simpson and Jackson (2002) compared the composition of nutmeg oil produced in Jamaica, Indonesia and Grenada. The results of their study are presented in T-5. As can be seen, the oils can be readily differentiated by their α-pinene, β-pinene, safrole and myristicin contents. It was surprising that elemicin was not identified particularly in the East Indian oil. The safrole content of East Indian nutmeg oil was determined to be 2.3 percent (Anon 2002).

A lab-distilled oil of nutmeg that was produced from nutmegs grown in Oyo State (Nigeria) was analyzed by Ogunwande et al. (2003). The composition of this oil was as follows:

α-pinene (13.19 percent)
camphene (0.21 percent)
sabinene (49.09 percent)
β-pinene (2.42 percent)
myrcene (3.09 percent)

α-phellandrene (6.72 percent)
p-cymene (3.30 percent)
limonene (0.56 percent)
trans-sabinene hydrate (1.62 percent)
terpinolene (0.49 percent)
linalool (0.47 percent)
cis-p-menth-2-en-1-ol (0.43 percent)
trans-p-menth-2-en-1-ol (0.33 percent)
terpinen-4-ol (6.43 percent)
α-terpineol (0.54 percent)
cis-piperitol (0.11 percent)
trans-piperitol (0.14 percent)
safrole (1.34 percent)
bornyl acetate (1.10 percent)
eugenol (0.81 percent)
α-terpinyl acetate (0.19 percent)
α-cubebene (0.18 percent)
geranyl acetate (0.29 percent)
methyl eugenol (0.23 percent)
β-caryophyllene (0.83 percent)
trans-α-bergamotene (0.17 percent)
germacrene D (0.33 percent)
bicyclogermacrene (0.13 percent)
α-asarone[†] (1.10 percent)
myristicin (1.85 percent)

[†]incorrect identification, should be elemicin

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