Progress in Essential Oils

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Tarragon Oil

Tarragon (*Artemisia dracunculus* L.) is a perennial member of the Asteraceae (Compositae) family that can be found in North America, Europe, Northern Asia and Russia. There are three varieties known, e.g. *A. dracunculus* L. var. *glauca*, *A. dracunculus* L. var. *dracunculus* and *A. dracunculus* L. var. *sativa*. The latter of these varieties is sterile and is the source of French tarragon, which can only be reproduced by vegetative means.

Arabhossein et al. (2006) compared the composition of French tarragon and Russian tarragon oils using GC-FID and GC/MS. As French tarragon oil is the one of commerce, the composition of Russian tarragon (which was found to be rich in sabinene, methyl chavicol and elemicin) will not be included in this review. They found the composition of French tarragon oil was as follows:

α-pinene (0.7%)
camphene (0.4%)
sabinene (4.9%)
β-pinene (0.1%)
myrcene (0.5%)
α-terpinene (0.1%)
limonene (2.4%)
(Z)-β-ocimene (6.0%)
(E)-β-ocimene (6.0%)
γ-terpinene (0.1%)
terpinen-4-ol (0.2%)
methyl chavicol (68.6%)
citronellyl acetate (0.1%)
geranyl acetate (1.0%)
methyl eugenol (8.5%)
germacrene D (0.1%)
bicyclogermacrene (0.1%)

Guerrini et al. (2006) examined the compositions of some oils that were rich either in anethole and methyl chavicol. The authors used GC-FID, GC/MS, ^{1}H-NMR and ^{13}C-NMR to characterize a commercial oil of tarragon presumed to be of French origin. The components characterized in this oil were as follows:

α-pinene (1.3%)
camphene (0.1%)
β-pinene (0.3%)
myrcene (0.1%)
p-cymene (0.1%)
limonene (4.6%)
(Z)-β-ocimene (8.6%)
(E)-β-ocimene (9.4%)
allo-ocimene* (0.7%)
isomenthol (0.3%)
methyl chavicol (70.1%)
(E)-anethole (0.1%)
isobornyl acetate (0.4%)
eugenol (0.2%)
methyl eugenol (1.2%)
β-caryophyllene (0.2%)
p-methoxycinnamaldehyde (0.1%)
spathulenol (0.3%)

*correct isomer not identified

Dried tarragon leaves (2.5 g; purchased commercially in Germany) were ground in liquid N_2 and extracted (1 h) by stirring with freshly distilled methylene chloride (100 mL). After extraction, the extract was dried over anhydrous sodium sulfate and the volatiles were removed from the non-volatiles by solvent-assisted flavor evaporation (SAFE) at 40°C. The tarragon volatiles were concentrated at 47°C using a Vigreux column to 200 µL. Analysis of the volatile concentrate by Zellerand Rychlik (2007) using GC-FID and GC/MS revealed that it possessed the following composition:

1-octen-3-one (0.0042)*
(Z)-octa-1,3-dien-3-one (0.007)
2-isopropyl-3-methylpyrazine (0.013)
linalool (1.8)
methyl chavicol (2900)
guaiacol (0.021)
β-ionone** (5.1)
eugenol (26.0)
sotolone (0.011)
vanillin (0.64)
7-methoxycoumarin (220)

*concentration in leaves (µg/g)
**correct isomer not identified

Kamarainen-Karppinen et al. (2008) examined three lines of French tarragon for their capacity to overwinter in Finland, essential oil content, biomass yield and oil composition. They found that the three lines were genetically and biochemically different. They postulated that these differences resulted from spontaneous mutations over centuries (tarragon has been vegetatively reproduced since the 14th century). Furthermore, they reported that this is an example of the necessity to preserve important selected herbs possessing the required traits for cultivation by future generations.

The main components of tarragon oils produced from plants grown in Italy, the United States, France and Hungary were determined by Dohi et al. (2009) to be:

α-pinene (0.0–1.4%)
camphene (0.0–0.1%)
β-pinene (0.0–1.8%)
limonene (0.3–4.9%)
1,8-cineole (0.0–0.1%)
methyl chavicol (77.0–89.0%)
eugenol (0.0–0.1%)
methyl eugenol (0.0–0.7%)

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β-caryophyllene (0.1–0.5%)
4-methoxycinnamaldehyde (0.0–0.6%)

Haghi et al. (2010) used GC-FID and GC/MS to analyze an oil produced from the fresh aerial parts of *A. dracunculus* harvested from Khorasgan (Isfahan province, central Iran). The components characterized in this oil were as follows:

α-pinene (0.7%)
β-pinene (0.1%)
p-cymene (0.2%)
limonene (2.5%)
(Z)-β-ocimene (6.9%)
(E)-β-ocimene (11.0%)
cis-limonene oxide (0.1%)
methyl chavicol (76.6%)
4-methoxyphenol (0.2%)
carveol* (0.3%)
p-propyl anisole (0.3%)
methyl eugenol (0.5%)
3-methoxycinnamaldehyde (0.1%)

*correct isomer not identified

Trace amounts (< 0.1%) of benzaldehyde, 6-methyl-5-hepten-2-one and linalool were also found in this oil.

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S. Dohi, M. Terasaki and M. Makino, *Acetylcholinasterase inhibitory activity and chemical composition of commercial essential oils.* J. Agric. Food Chem., **57**, 4313–4318 (2009).

G. Haghi, F. Ghasian and J. Safaei-Ghomi, *Determination of the essential oil from root and aerial parts of* Artemisia dracunculus *L. cultivated in central Iran.* J. Essent. Oil Res., **22**, 294–296 (2010).

Lemon Verbena Oil

Lamparsky (1985) reported that although he characterized isoneral and isogeranial and their corresponding alcohols in oils produced from fresh leaves of lemon verbena [*Aloysia citriodora* Palau syn. *Aloysia triphylla* (L'Herit.) Britt., *Lippia citriodora* (Ort.) H.B.K.], he believed that they were artifacts produced during oil isolation by steam distillation.

Gil et al. (2007) analyzed a wide range of oils produced from *A. citriodora* obtained from six different regions of Argentina. The oils, which were analyzed by GC-FID and GC/MS, were determined to possess the following constituent range:

α-pinene (0.0–1.1%)
sabinene (0.1–5.9%)
6-methyl-5-hepten-2-one (0.3–1.0%)
p-cymene (0.0–1.1%)
limonene (12.1–21.9%)
1,8-cineole (0.0–7.6%)
cis-sabinene hydrate (0.2–1.3%)
α-thujone (0.0–0.5%)
citronellal (0.0–0.6%)
neral (17.7–23.9%)

piperitone (0.5–0.7%)
geranial (18.3–32.2%)
geranyl acetate (0.5–2.3%)
β-caryophyllene (0.2–3.0%)
ar-curcumene (1.6–4.0%)
epi-cubebol (0.0–0.7%)
spathulenol (2.7–5.9%)
caryophyllene oxide (2.7–5.4%)
T-cadinol (0.1–1.8%)

The fresh leaves that were collected from lemon verbena plants cultivated in an experimental garden in Athens (Greece) in May (full vegetative growth) and September (full bloom) were subjected to oil isolation using a Likens-Nickerson apparatus. The oils produced were analyzed by a combination of GC-FID and GC/MS by Argyropoulou et al. (2007). The results of this comparative study are shown in **T-1**. Trace amounts (< 0.05%) of α-cubebene and β-gurjunene were also found in the lemon verbena oils.

DiLeoLira et al. (2008) analyzed 23 samples of *A. citriodora* using GC-FID and GC/MS. The authors determined that three chemotypes of lemon verbena were found. The most commonly encountered chemotype was a neral-geranial-rich lemon verbena oil. It was found to possess the following composition:

1-octen-3-ol (0.1%)
6-methyl-5-hepten-2-one (0.5%)
limonene (10.3%)
linalool (0.5%)
β-thujone (0.1%)
trans-p-mentha-2,8-dien-1-ol (0.4%)
cis-limonene oxide (0.5%)
photocitral A (0.4%)
trans-verbenol (0.1%)
α-terpineol (0.2%)
nerol (1.1%)
neral (20.0%)
carvone (1.0%)
piperitone (0.2%)
geraniol (0.5%)
geranial (29.0%)
neryl acetate (3.0%)
gernyl acetate (3.9%)
β-caryophyllene (0.7%)
geranyl propionate (0.3%)
ar-curcumene (2.6%)
(Z)-nerolidol (0.3%)
spathulenol (2.6%)
ar-turmerol (0.4%)
caryophyllene oxide (11.1%)
humulene epoxide II (0.2%)
α-muurolol (1.7%)

The major constituents of one of the other chemotypes were: sabinene (11.2%), limonene (40.3%) and citronellal (21.6%), while the other chemotype contained β-thujone (73.4%) as the only major constituent.

An oil of lemon verbena that was obtained commercially in Italy by Romeo et al. (2008) was screened for its antimicrobial activity. The composition of this oil was found to be as follows:

Comparative percentage composition of lemon verbena oils produced from plants harvested at two different development stages **T-1**

Compound	Full vegetative growth oil	In bloom oil
α-pinene	0.4	1.0
sabinene	0.7	1.8
6-methyl-5-hepten-2-one	0.4	0.5
myrcene	0.6	0.7
limonene	5.8	17.7
(Z)-β-ocimene	1.3	1.9
γ-terpinene	-	0.1
cis-sabinene hydrate	0.2	0.4
linalool	0.3	0.4
trans-sabinene hydrate	0.3	0.3
trans-chrysanthemal	0.3	0.5
cis-chrysanthenol	0.5	0.6
terpinen-4-ol	-	0.2
trans-chrysanthenol	0.6	1.0
α-terpineol	0.9	1.8
nerol	0.9	0.8
neral	24.5	21.8
geraniol	6.0	0.8
geranial	38.7	26.8
δ-elemene	0.3	0.2
α-copaene	0.1	t
geranyl acetate	1.1	0.8
β-cubebene	0.1	0.2
cis-α-bergamotene	0.1	-
α-cedrene	0.2	0.3
β-caryophyllene	1.8	1.6
β-copaene	0.1	t
α-humulene	-	0.1
aromadendrene	0.1	-
allo-aromadendrene	0.2	0.1
β-acoradiene	0.2	-
geranyl propionate	0.2	0.1
germacrene D + ar-curcumene	3.1	2.5
zingiberene	0.6	0.3
bicyclogermacrene	2.4	1.2
δ-cadinene	0.3	0.2
trans-cadina-1(2),4-diene	0.1	t
α-cadinene	0.1	0.2
(E)-nerolidol	0.9	0.9
germacrene D-4-ol	1.0	2.0
spathulenol	0.9	3.1
caryophyllene oxide	0.8	0.9
T-cadinol	0.7	0.8
α-cadinol	-	0.5

t = trace (<0.05%)

α-pinene (0.3%)
β-pinene (0.1%)
2-octanone (0.1%)
p-cymene (0.4%)
1,8-cineole (6.4%)
linalool (1.5%)
α-terpineol (0.4%)
neral (36.2%)
piperitone (0.7%)
linalyl acetate (2.9%)
geranial (41.9%)
geranyl formate (0.6%)
geranyl acetate (3.9%)

Gillij et al. (2008) compared the composition of two oils of lemon verbena (one produced in Cordoba and the other in Traslasierra, Argentina). The compositions of these two oils are reported in **T-2**.

Comparative percentage composition of lemon verbena oils of Argentinian origin **T-2**

Compound	Cordoba oil	Traslasierra oil
α-thujene	0.7	0.1
α-pinene	1.1	t
camphene	0.5	0.1
myrcene	1.9	0.1
limonene	7.0	19.7
(Z)-β-ocimene	0.4	t
γ-terpinene	0.4	t
p-cymene	0.2	t
camphor	5.2	-
camphenilone	0.6	t
6-methyl-5-hepten-2-one	-	t
linalool	0.5	0.2
menthone	t	t
α-thujone	14.2	0.3
terpinen-4-ol	0.4	t
α-terpineol	0.4	t
borneol	1.2	-
carvone	0.8	0.2
2,2-dimethyl-3,4-octadienal	0.4	0.5
neral	19.4	14.0
geranial	22.7	21.0
(E)-tagetenone[a]	0.5	0.3
cis-carveol	0.2	0.1
α-copaene	0.7	0.7
β-cubebene	0.3	0.1
β-bourbonene	0.8	0.8
β-caryophyllene	0.4	0.3
α-cedrene	3.0	2.8
α-humulene	0.6	0.7
β-curcumene	t	0.9
bicyclogermacrene	4.1	8.0
germacrene D	3.3	6.9
zingiberene	0.4	0.4
δ-cadinene	0.2	t
caryophyllene oxide	0.9	7.7
cubebol	t	1.4
globulol	0.8	0.3
guaiol	0.3	0.2
(E)-nerolidol	0.5	1.0
spathulenol	0.9	9.9
viridiflorol	0.4	1.1

[a]also known as (E)-ocimenone; t = trace (<0.1%)

The main constituent of a commercial oil of lemon verbena (ex *Lippia citriodora*) were determined by Romeo et al. (2010) to be:

α-pinene (0.2%)
β-pinene (0.1%)
p-cymene (0.3%)
1,8-cineole (5.2%)
linalool (1.2%)
α-terpineol (0.3%)
neral (29.6%)
piperitone (0.5%)
linalyl acetate (2.3%)
geranial (34.2%)
geranyl formate (0.3%)
geranyl acetate (0.3%)

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