Progress in Essential Oils

Brian M. Lawrence, Consultant

Madagascan Helichrysum Oil

Oil produced from *Helichrysum faradifani* Scott-Elliot, an endemic plant of Madagascar, can be found commercially available in limited quantities. The composition of this oil was the subject of analysis by Cavalli et al. (2001). The authors determined that it possessed the following composition:

α-pinene (2.2%)
camphene (0.4%)
β-pinene (0.5%)
myrcene (1.5%)
p-cymene (0.8%)
limonene (4.6%)
1,8-cineole (2.9%)
(Z)-β-ocimene (0.3%)
(E)-β-ocimene (0.6%)
terpinolene (0.3%)
linalool (16.1%)
borneol (0.6%)
α-terpineol (1.9%)
α-copaene (0.6%)
β-caryophyllene (34.6%)
aromadendrene (0.4%)
allo-aromadendrene (0.6%)
α-humulene (5.4%)
γ-muurolene (0.5%)
ar-curcumene (1.3%)
germacrene D (0.8%)
γ-cadinene (1.2%)
calamenene* (0.3%)
δ-cadinene (1.5%)
caryophyllene oxide (4.3%)
humulene epoxide II (0.5%)
T-cadinol (1.3%)
β-eudesmol (0.7%)

*correct isomer not identified

Ralijerson et al. (2005) compared the composition of oils produced by steam distillation from fresh and dried plants of *H. faradifani* using GC and GC/MS. The results of this comparative study are presented in **T-1**. The analyses listed in T-1 relate to oils produced over a full year from plants in various stages of growth. It is of interest to note the high level of α-fenchene found in the fresh plant oil as this is (to this reviewer's memory) the highest level found in an essential oil. Also, it is surprising that Ralijerson et al. characterized β-himachalene as the major component of the oils because in the other study β-himachalene was not detected.

Cavalli et al. (2006) analyzed a commercially available oil of *H. faradifani* and found that it contained the following constituents:

α-pinene (1.7%)
α-fenchene (32.3%)
camphene (0.3%)
β-pinene (1.2%)
myrcene (0.4%)
α-phellandrene (0.3%)
p-cymene (0.4%)
limonene (2.8%)
1,8-cineole (0.7%)
β-phellandrene (0.2%)
(E)-β-ocimene (0.2%)
terpinolene (0.3%)
linalool (1.0%)
α-fenchyl alcohol (0.2%)
α-fenchene hydrate[a] (1.7%)
lavandulol (0.4%)
borneol (0.5%)
terpinen-4-ol (0.2%)
α-terpineol (0.5%)
α-fenchyl acetate (0.2%)

Comparative percentage composition of oils of *Helichrysum faradifani* produced from fresh and dried plant material

T-1

Compound	Fresh plant oil	Dried plant oil
tricyclene	0–0.8	–
α-pinene	0.4–1.3	0–0.7
α-fenchene	13.1–27.3	t–1.8
camphene	0.1–0.5	–
β-pinene	0.5–0.9	0–0.2
myrcene	0.2–0.8	0–0.2
α-terpinene	0–0.3	0–0.1
limonene	1.9–3.8	0–2.2
β-phellandrene	0.1–0.4	0–3.0
1,8-cineole	0–0.7	–
γ-terpinene	0.1–0.5	0–0.4
(E)-β-ocimene	0–0.3	0–t
2-heptyl acetate	t–0.2	–
p-cymene	0.3–0.7	0–0.2
terpinolene	0.1–0.5	0–0.5
α-fenchyl acetate	0.2–0.5	0–0.4
α-copaene	0.8–1.9	0.2–1.2
α-cedrene	1.0–1.3	0.9–1.5
linalool	1.2–3.3	0.1–2.6
linalyl acetate	0–0.2	0–0.3
bornyl acetate	2.5–5.2	0.3–5.1
α-bergamotene*	0–0.6	0.3–1.0
α-fenchyl alcohol	0–0.5	t–0.8
β-caryophyllene	14.8–20.5	15.4–29.2
aromadendrene	0–0.2	–
terpinen-4-ol	0.6–1.3	0.2–1.4
allo-aromadendrene	0–0.2	0–0.2
α-himachalene	0–0.3	0–0.3
α-humulene	1.2–1.9	1.5–2.5
(Z)-β-farnesene	0–0.8	0.4–1.3
methyl chavicol	0–0.3	0–0.2
γ-muurolene	0.3–0.7	0.2–1.1
β-himachalene	15.7–32.8	30.0–36.6
α-terpineol	0.9–3.2	1.0–3.5
borneol	0–0.4	t–2.2
β-selinene	0–0.3	0–1.0
γ-cadinene	0–0.4	t–0.7
zingiberene	0–0.2	0–0.3
β-bisabolene	1.1–2.3	1.8–3.7
β-cadinene	0–0.3	0–0.3
geranial	0.9–1.7	1.9–2.3
δ-cadinene	0.7–2.0	0.9–1.9
ar-curcumene	2.2–7.9	2.5–3.7
geraniol	0–0.2	0–0.1
caryophyllene oxide	0–1.2	t–0.3
cadinol*	0–0.4	0–1.0
eudesmol*	0.4–1.8	2.1–4.2
bisabolol*	0.4–1.9	1.4–4.0
(Z,Z)-farnesol	0–0.1	0–0.5

*correct isomer not identified; t = trace (< 0.1%)

bornyl acetate (0.2%)
lavandulyl acetate (2.1%)
α-copaene (0.6%)
isoitalicene (0.2%)
italicene (1.0%)
α-cedrene (0.3%)
β-caryophyllene (14.2%)
trans-α-bergamotene (0.4%)
α-guaiene (0.1%)
α-himachalene (0.2%)
(E)-β-farnesene (0.2%)
α-humulene (1.4%)
allo-aromadendrene (0.1%)
γ-muurolene (0.1%)
γ-curcumene (19.4%)
ar-curcumene (2.9%)
γ-himachalene (0.1%)
β-selinene (0.3%)
β-himachalene (0.1%)
β-bisabolene (1.5%)
γ-cadinene (0.4%)
δ-cadinene (0.6%)
(E)-α-bisabolene (0.3%)
(E)-nerolidol (0.1%)
caryophyllene oxide (0.2%)
β-bisabolol (0.2%)
α-bisabolol (0.3%)

[a]also known as exo-2,7,7-trimethylbicyclo[2.2.1]-2-heptanol

J-F. Cavalli, L. Ranarivelo, M. Ratsimbason, A-F. Bernadini and J. Casanova, *Constituents of the essential oil of six* Helichrysum *species from Madagascar.* Flav. Fragr. J., **16**, 253–256 (2001).

L.B. Ralijerson, D.J.R. Rabehaja, J.F. Rajaonarison, S. Ratsimamanga Urverg, M-F. Hérent, H. Mavar-Manga and B. Tilquin, *Comparison between the fresh and dry essential oil of* Helichrysum faradifani *Scott Elliot from Madagascar.* J. Essent. Oil Res., **17**, 597–600 (2005).

J-F. Cavalli, F. Tomi, A-F. Bernadini and J. Casanova, *Chemical variability of the essential oil of* Helichrysum faradifani *Sc. Ell. from Madagascar.* Flav. Fragr. J., **21**, 111–114 (2006).

Cascarilla Oil and Extract

An authentic sample of West Indian cascarilla oil was analyzed by both GC/MS and Kovats indices on both a nonpolar and a polar SCOT capillary column (Anon 1993). From the analysis of the oil on the polar GC column it was found to contain:

α-pinene + α-thujene (12.0%)
camphene (0.9%)
β-pinene (0.9%)
sabinene (0.3%)
myrcene (1.1%)
α-phellandrene (0.3%)
α-terpinene (0.5%)
limonene (1.2%)
β-phellandrene + γ-terpinene (1.2%)

p-cymene (26.0%)
terpinolene (0.2%)
α-copaene (0.6%)
β-elemene (5.4%)
terpinen-4-ol (1.7%)
calacorene* (1.4%)

*correct isomer not identified

Analysis on the nonpolar column revealed that linalool (5.4%), borneol (0.8%) and eugenol (0.4%) were also components of this same oil. This analysis of cascarilla oil is incomplete, as approximately 40% of the oil was not identified. For a more complete summary of the components found in cascarilla oil, see Lawrence (1993).

Although the normal commercial source of cascarilla oil is the bark of *Croton eluteria* (L.) Schwartz—found in the Caribbean (particularly the Bahamas) and Central and South America—an oil known as El Salvador cascarilla, which originates from the bark of *C. reflexifolius* Vahl, has been found as an item of commerce over the past few years (Shapiro and Frances, 2001). The composition of this oil was determined to be as follows:

tricyclene (0.32%)
α-thujene (0.58%)
α-pinene (14.75%)
camphene (4.50%)
sabinene (0.60%)
β-pinene (9.50%)
myrcene (4.65%)
α-phellandrene (0.09%)
α-terpinene (0.16%)
p-cymene (2.45%)
1,8-cineole (2.90%)
β-phellandrene (1.00%)
limonene (2.00%)
(Z)-β-ocimene (0.05%)
(E)-β-ocimene (0.08%)
γ-terpinene (0.47%)
terpinolene (0.23%)
linalool (1.80%)
borneol (1.55%)
terpinen-4-ol (0.62%)
α-terpineol (0.65%)
eugenol (0.15%)
α-copaene (6.25%)
β-elemene (1.05%)
cascarillone (1.55%)
cascarilladiene (1.60%)
β-caryophyllene (1.15%)
α-humulene (0.90%)
germacrene D (2.40%)
β-selinene (3.05%)
α-selinene (0.95%)
δ-cadinene (0.68%)
γ-cadinene (1.70%)
spathulenol (1.65%)
caryophyllene oxide (1.05%)

According to Faltorusso et al. (2002), cascarilla bark is a commercially available, inexpensive source of polyfunctional diterpenes that belong to the clerodane parent skeletal type. It would be expected that these compounds, cascarillin (a bitter tasting triol) and some additional diterpenoids (eluterins) would be found in cascarilla bark extracts which are used in some herbal digestion aid products.

Appendino et al. (2003) further characterized other diterpenoid compounds and provided data to support the use of cascarilla extract in preparations to improve digestion. Animal studies showed that cascarillin was able to significantly increase gastric acid secretion caused by histamine inducement of this bitter principle.

B.M. Lawrence, *Cascarilla oil.* In: *Progress in essential oils.* Perfum. Flavor., **18**(6), 55–57 (1993).

Anon, *Analytical methods committee, application of gas-liquid chromatography to the analysis of essential oils. Part XVI. Monographs for five essential oils.* Analyst, **118**, 1089–1098 (1993).

R. Shapiro and J. Frances, *Cascarilla bark essential oil of El Salvador: New source and standard.* Perfum. Flavor., **26**(6), 22–26 (2001).

E. Fattorusso, O. Taglialatela-Scafati, C. Campagnuole, F.U. Santela, G. Appendino and P. Spagliardi, *Diterpenoids from cascarilla* (Croton eluteria *Benet).* J. Agric. Food Chem., **50**, 5131–5138 (2002).

G. Appendino, F. Borrelli, R. Capasso, C. Campagnuolo, E. Faltorusso, F. Patrucci and O. Taglialatela-Scafati, *Minor diterpenoids from cascarilla* (Croton eluteria *Bennet) and evaluation of the cascarilla extract and cascarillin effects on gastric acid secretion.* J. Agric. Food Chem., **51**, 6970–6974 (2003).

Myrtle Oil

Vidrich et al. (1988) compared the headspace volatiles of the leaves, flowers and fruits of *Myrtus communis* L. of Italian origin. The results of this study can be seen in **T-2**.

Comparative headspace volatiles of the leaves, flowers and fruits of *Myrtus communis* **T-2**

Compound	Leaves	Flowers	Fruits
α-pinene	41.0	43.2	40.4
camphene	1.2	–	0.7
β-pinene	0.2	t	–
δ-3-carene	0.7	0.8	1.3
myrcene	0.6	0.9	0.3
α-phellandrene	0.5	0.1	0.6
heptanone*	–	0.5	–
limonene	6.2	0.2	3.7
1,8-cineole	13.8	15.5	11.6
γ-terpinene	1.3	1.4	1.6
p-cymene	0.7	0.4	1.9
fenchone	–	t	–
3-octanol	1.6	0.1	1.3
nonanal	–	0.8	–
decanal	0.4	0.6	–
linalool	2.1	1.6	0.8
methyl chavicol	0.8	0.5	–
β-caryophyllene	1.1	–	0.6
geranyl acetate	1.0	1.4	1.4
α-terpineol	2.2	1.7	3.2
citronellol	1.0	1.5	0.7
myrtenol and nerol	2.0	1.5	1.6
geraniol	1.2	0.6	0.9
eugenol	1.1	1.2	0.8

t = trace (< 0.1%); *correct isomer not identified

Bradesi et al. (1997) examined the variation in leaf oil composition of Corsican commercial oils of *M. communis* subsp. *communis*. The components found in these oils can be seen as follows:

α-pinene (47.9–59.5%)
isobutyl isobutyrate (0.4–0.9%)
β-pinene (0.5–0.7%)
δ-3-carene (0.3–0.7%)
myrcene (0–0.8%)

Percentage composition of oils of *Myrtus communis* of Turkish origin

T-3

Compound	Leaf oil	Leaf & branch oil
2,4-dimethyl-3-pentanone	0.1	t
α-pinene	6.4	9.0
hexanal	t	0.1
isobutyl isobutyrate	0.1	1.0
β-pinene	0.1	0.1
δ-3-carene	0.1	0.1
myrcene	0.2	0.2
limonene	3.4	7.5
1,8-cineole	18.2	10.5
cis-anhydrolinalool oxide[†]	–	0.5
(Z)-3-hexenol	0.1	0.1
(Z)-β-ocimene	0.1	0.1
trans-anhydrolinalool oxide[†]	0.2	0.2
γ-terpinene	0.1	0.1
(E)-β-ocimene	0.3	0.1
p-cymene	0.6	1.3
terpinolene	0.3	0.1
(Z)-2-heptenal	–	0.1
6-methyl-5-hepten-2-one	t	0.1
(Z)-3-hexenol	t	0.1
(E)-2-hexenyl isobutyrate	–	0.1
(E)-2-octenal	–	0.1
trans-linalool oxide[†]	0.7	0.5
1-octen-3-ol	–	0.1
(E,Z)-2,4-heptadienal	–	0.1
cis-linalool oxide[†]	0.5	0.3
nerol oxide	–	0.1
α-campholenic aldehyde	t	0.1
camphor	–	0.2
benzaldehyde	–	0.1
linalool	16.3	18.6
linalyl acetate	6.8	5.5
methyl citronellate	0.1	0.1
pinocarvone	0.1	0.1
α-fenchyl alcohol	0.1	0.1
bornyl acetate	t	0.1
6-methyl-3,5-heptadien-2-one	t	0.1
terpinen-4-ol	0.3	0.3
hotrienol	0.5	–
β-caryophyllene	0.2	0.7
terpinen-4-yl acetate	0.1	–
cis-p-mentha-2,8-dien-1-ol	–	0.1
myrtenal	0.1	0.1
(E)-2-decenal	–	0.1
trans-pinocarvyl acetate	0.2	0.3
trans-pinocarveol	0.3	0.4
p-mentha-1,5-dien-8-ol	0.1	0.1
δ-terpineol	–	0.1
methyl chavicol	0.3	0.9
trans-verbenol	t	0.1
α-humulene	0.1	0.5
limonen-4-ol	0.1	0.2
myrtenyl acetate	14.5	10.8
α-terpineol	6.5	4.3
α-terpinyl acetate	2.6	0.8
borneol	–	0.7
verbenone	0.1	0.1
neryl acetate	1.1	0.8
β-selinene	0.2	–
trans-carvyl acetate	0.2	–
carvone	0.5	0.1
geranyl acetate	5.5	4.2
myrtenol	2.0	0.5
nerol	0.6	0.5
2-tridecanone	0.1	0.1
trans-carveol	0.4	0.4
geraniol	1.9	1.3
p-cymen-8-ol	0.1	0.3
geranyl acetone	t	0.1
cis-carveol	0.1	0.1
cis-p-mentha-1(7),8-dien-2-ol	t	0.1
(E)-β-ionone	–	0.1
caryophyllene oxide	0.3	0.8
methyl eugenol	1.3	1.8
humulene epoxide I	0.1	0.3
humulene epoxide II	0.2	2.0
humulene epoxide III	t	0.2
guaiol	–	0.1
spathulenol	0.2	–
nonanoic acid	–	0.2
thymol	t	0.3
T-cadinol	–	0.1
carvacrol	0.6	1.3
selin-11-en-4α-ol	0.1	–
decanoic acid	–	0.1
caryophylla-2(12),6(13)-dien-5β-ol	0.2	0.2
caryophylla-2(12),6-dien-5α-ol	0.2	0.2
caryophylla-2(12),6-dien-5β-ol	0.2	0.1

t = trace (< 0.1%); [†]furanoid form

Comparative percentage composition of myrtle oil produced from different regions of Morocco **T-4**

Compound	Temaru N	Temaru T	Dardara N	Dardara T
tricyclene	0.9	0.2	0.1	0.3
α-thujene	0.1	0.1	0.1	0.1
α-pinene	21.2	3.8	42.6	16.9
β-pinene	0.3	0.1	0.5	0.4
myrcene	0.5	t	0.2	0.2
α-phellandrene	0.5	0.5	0.1	0.2
δ-3-carene	0.1	0.2	–	–
α-terpinene	0.3	0.2	–	–
p-cymene	0.3	0.7	–	–
limonene + 1,8-cineole[a]	27.3	20.9	39.6	39.9
(E)-β-ocimene	0.5	0.1	0.3	0.2
γ-terpinene	0.1	0.2	t	0.1
terpinolene	0.2	0.3	0.1	0.1
linalool	16.3	0.7	1.2	2.3
α-thujone	0.5	0.5	0.2	0.2
terpinen-4-ol	0.2	0.1	0.2	0.2
α-terpineol	1.2	0.1	1.9	2.4
myrtenol	0.5	0.7	0.3	1.0
myrtenyl acetate	4.7	55.0	5.4	24.0
linalyl acetate	8.4	0.5	0.3	0.8
carvacrol	0.4	0.8	0.2	0.4
α-terpinyl acetate	1.3	0.2	–	–
neryl acetate	0.4	0.2	0.1	0.1
geranyl acetate	4.9	2.9	1.9	3.2
methyl eugenol	1.8	1.9	1.2	1.9
p-anisyl acetate	0.5	0.4	–	–
β-caryophyllene	1.4	1.2	0.5	0.8
neryl acetone	0.4	0.5	0.1	0.1
neryl propionate	0.9	2.0	0.2	0.4
α-selinene	0.2	0.1	0.1	0.1
eugenyl acetate	0.2	0.6	t	0.1
trans-calamenene	0.1	0.1	0.1	0.1
elemol	0.3	0.3	0.1	0.2
geranyl butyrate	0.2	0.4	0.2	0.2
globulol	0.6	0.5	t	0.1
(E)-isoeugenyl acetate	0.3	0.9	–	–
(Z)-asarone	0.1	0.2	t	0.1
γ-eudesmol	0.1	0.2	0.1	0.3
β-eudesmol	0.3	0.3	t	0.1

N = naturally occurring; T = transplants; t = trace (< 0.1%); [a]major component

α-phellandrene (0–0.8%)
isobutyl 2-methylbutyrate (0–0.6%)
limonene (4.6–5.9%)
1,8-cineole (19.8–28.1%)
γ-terpinene (0–0.8%)
(E)-β-ocimene (0–0.9%)
p-cymene (0.6–1.6%)
terpinolene (0–1.3%)
linalool (1.3–2.7%)
terpinen-4-ol (0.7–1.2%)
α-terpineol (1.3–1.5%)
geranyl acetate (1.0–1.8%)
methyl eugenol (0.4–0.7%)

Özek et al. (2000) analyzed oils produced either from the leaves, or leaves and branches, of *M. communis* collected from two different regions of Turkey. The results of this study are summarized in **T-3**. In addition, trace amounts (< 0.1%) of camphene, α-terpinene, γ-campholenic aldehyde, pinocamphone, octanol, *cis*-dihydrocarvone, *cis*-p-menth-2-en-1-ol, phenylacetaldehyde, citronellyl acetate, an α-farnesene isomer, perillyl acetate, piperitenone, neointermedeol and elemicin were characterized in the leaf oil. Trace amounts (< 0.1%) of camphene, butylbenzene, isobutyl 2-methylbutyrate, 2-methylbutyl isobutyrate, hexyl isobutyrate, hexanol, α-pinene oxide, nonanal, 3-octen-2-one, γ-campholenic aldehyde, (E)-2-nonenal, octanol, (E,Z)-2,4-nonadienal, 2-methyl-6-methylene-3,7-octadien-2-ol, *trans*-p-mentha-2,8-dien-1-ol, (E,E)-2,4-nonadienal, geranial, (E,Z)-2,4-decadienal, p-mentha-1,3-dien-7-al, (E,E)-2,4-decadienal, α-ar-himachalene, perillyl acetate, β-ionone epoxide, β-elemene, cuminyl alcohol, eugenol, bulnesol and dodecanoic acid were also characterized in the leaf and branch oil.

An oil of myrtle produced in Morocco was the subject of analysis by Lahlou et al. (2000). They found that the major constituents of this oil were:

camphene (9.3%)
β-pinene (0.5%)
α-pinene (37.6%)
1,8-cineole (20.0%)
limonene (12.0%)
α-terpineol (2.0%)
myrtenol (3.9%)
myrtenyl acetate (9.9%)
linalool (3.0%)
neryl acetate (1.0%)
geranyl acetate (4.0%)
methyl eugenol (4.0%)

Ismaili et al. (2001) compared the composition of the oils produced from natural stands and transplants of *Myrtus communis* growing in two different regions of Morocco. The results of this study can be found summarized in **T-4**.

The leaf oil of *M. communis* produced from plants harvested in northern Greece were analyzed by GC/MS by Koukos et al. (2001). The constituents characterized in this oil were as follows:

α-thujene (0.2%)
α-pinene (18.0%)
β-pinene (0.7%)
myrcene (0.7%)
α-phellandrene (0.1%)
δ-3-carene (0.2%)
p-cymene (0.9%)
limonene (21.8%)
linalool (1.1%)
methyl chavicol (0.6%)
trans-carveol (0.2%)
cis-carveol (0.2%)
carvone (0.2%)
linalyl acetate (31.4%)
bornyl acetate (0.3%)
α-terpinyl acetate (0.7%)
neryl acetate (1.2%)
geranyl acetate (6.5%)
β-caryophyllene (1.5%)
α-humulene (3.7%)
α-muurolene (0.5%)

An oil produced from *M. communis* from plants collected in Lebanon was determined by Traboulsi et al. (2002) to contain the following major components:

α-pinene (17.0%)
1,8-cineole (40.0%)
linalool (9.9%)
myrtenyl acetate (7.0%)
α-terpinyl acetate (2.0%)
geranyl acetate (4.5%)
α-terpineol (7.9%)

As part of an antimicrobial screening study of oils from Tunisian plants, Bouzouita et al. (2003) determined that an oil produced from *M. communis* collected near Sedjnane, Tunisia, contained the following constituents:

isobutyl isobutyrate (0.6%)
α-thujene (0.2%)
α-pinene (23.7%)
sabinene (0.5%)
β-pinene (0.2%)
isobutyl 2-methylbutyrate (0.4%)
δ-3-carene (0.5%)
1,8-cineole (61.0%)
γ-terpinene (0.4%)
terpinolene (0.2%)
linalool (1.7%)
trans-pinocarveol (0.3%)
p-mentha-1,5-dien-8-ol (0.2%)
terpinen-4-ol (0.8%)
α-terpineol (3.3%)
geraniol (0.6%)
exo-2-hydroxy-1,8-cineole acetate (0.2%)

geranyl acetate (1.9%)
methyl eugenol (0.3%)
β-caryophyllene (0.3%)
α-humulene (0.1%)
geranyl isobutyrate (0.1%)
caryophyllene oxide (0.3%)

An oil produced from *M. communis* growing in France was found by Curini et al. (2003) to possess the following composition:

α-pinene (52.90 ± 0.07%)
β-pinene (0.66 ± 0.05%)
isobutyl isobutyrate (0.64 ± 0.07%)
1,8-cineole (33.92 ± 0.04%)
δ-4-carene† (0.79 ± 0.02%)
linalool (4.21 ± 0.03%)
terpinen-4-ol (0.42 ± 0.03%)
α-terpineol (2.46 ± 0.06%)
linalyl butyrate (0.52 ± 0.06%)
α-terpinyl acetate (0.64 ± 0.05%)
geranyl acetate (1.64 ± 0.04%)
β-caryophyllene (1.33 ± 0.04%)
germacrene D (0.33 ± 0.05%)
α-humulene (0.54 ± 0.02%)

†incorrect identification based on GC elution order

Messaoud et al. (2005) analyzed oils produced from 12 populations of *M. communis* obtained from different regions of Tunisia. The average percentage composition of the constituents characterized can be seen as follows:

α-pinene (19.20%)
camphene (0.31%)
β-pinene (0.61%)
myrcene (0.26%)
α-terpinene (0.47%)
limonene (5.75%)
β-ocimene* (0.52%)
γ-terpinene (0.47%)
p-cymene (0.32%)
1,8-cineole (15.96%)
camphor (0.39%)
linalool (7.66%)
linalyl acetate (5.75%)
terpinen-4-ol (4.33%)
cis-verbenol (1.34%)
α-terpineol (7.51%)
borneol (0.29%)
verbenone (0.10%)
geranyl acetate (3.41%)
myrtenol (0.36%)
geraniol (0.90%)
methyl eugenol (2.16%)
eugenol (0.56%)
caryophyllene oxide (0.49%)

*correct isomer not identified

The composition of the volatiles obtained from alcoholic extracts of four samples of *M. communis* leaves was compared with the oils obtained from the same leaves using a combination of GC and GC/MS by Tuberoso et al. (2006). The results of this comparative study are shown in **T-5**.

Farah et al. (2006) analyzed a steam-distilled oil of myrtle produced from plant material collected in the al-Dardara region (Chechaoun, 800 m, northwestern Morocco). This oil was found to possess the following composition:

α-pinene (10.0%)
camphene (t)
sabinene (0.3%)
myrcene (0.1%)
α-phellandrene (0.2%)
α-terpinene (0.1%)
limonene (0.4%)
1,8-cineole (43.1%)
γ-terpinene (2.9%)
linalool (0.3%)
α-fenchol (t)
(E,Z)-allo-ocimene (t)
terpinen-1-ol (t)
trans-pinocarveol (0.1%)
cis-verbenol (0.2%)
terpinen-4-ol (0.3%)
α-terpineol (3.9%)

Comparative percentage composition of oils and the volatiles of alcoholic extracts of *Myrtus communis* of Italian origin

T-5

Compound	1		2		3		4	
	oil	extract	oil	extract	oil	extract	oil	extract
α-thujene	3.1	1.1	0.7	2.7	0.2	0.7	1.1	0.7
α-pinene	18.9	19.1	26.4	34.1	59.5	65.6	50.0	53.1
β-pinene	0.9	2.6	0.7	2.6	0.3	0.7	0.6	0.8
myrcene	0.8	1.9	0.2	1.1	0.1	0.1	t	0.4
α-phellandrene	1.3	2.1	2.2	2.7	0.1	0.2	t	0.2
δ-3-carene	2.7	2.8	t	0.9	0.1	0.1	t	0.3
α-terpinene	t	–	0.3	–	t	–	t	–
p-cymene	5.1	3.5	4.2	3.3	0.2	0.3	0.3	0.3
limonene	44.2	43.4	6.8	5.7	6.2	9.8	6.6	8.0
1,8-cineole	8.7	5.9	20.0	20.7	20.9	12.8	30.4	26.6
γ-terpinene	2.7	2.3	2.4	2.1	0.2	0.3	t	0.5
terpinolene	2.7	2.0	1.8	0.9	0.1	0.1	0.3	0.2
linalool	1.0	1.4	2.2	2.0	0.7	0.1	0.2	0.5
terpinen-4-ol	t	–	0.6	–	0.1	–	t	–
α-terpineol	0.9	0.9	1.9	2.0	1.6	0.3	3.3	0.4
linalyl acetate	0.5	1.7	2.0	2.6	0.9	2.2	1.8	0.9
α-terpinyl acetate	0.4	1.1	4.9	2.4	0.3	0.4	t	0.8
neryl acetate	t	–	0.3	–	0.1	–	t	–
geranyl acetate	0.9	1.7	10.8	8.2	2.0	2.1	1.9	2.3
methyl eugenol	3.1	1.1	2.2	1.6	1.3	0.3	0.5	0.3
β-caryophyllene	0.4	1.1	1.2	1.5	t	1.0	t	2.1
α-humulene	0.2	1.2	0.5	1.4	0.2	2.7	t	0.9
allo-aromadendrene	0.3	–	0.2	–	t	–	t	–
β-selinene	0.3	–	0.2	–	0.3	–	t	–
germacrene B	0.2	–	1.0	–	t	–	t	–
spathulenol	0.3	–	0.3	–	t	–	t	–
caryophyllene oxide	0.7	1.2	1.4	1.4	0.1	0.3	0.8	0.4

t = trace (< 0.1%)

myrtenol (1.6%)
trans-carveol (0.1%)
nerol (0.1%)
geraniol (0.1%)
linalyl acetate (0.6%)
geranial (0.1%)
cis-verbenyl acetate (0.9%)
bornyl acetate (0.2%)
myrtenyl acetate (25.0%)
trans-carvyl acetate (0.3%)
δ-elemene (0.2%)
terpinen-4-yl acetate (0.2%)
α-terpinyl acetate (0.3%)
α-copaene (0.3%)
geranyl acetate (2.9%)
methyl eugenol (1.0%)
β-caryophyllene (0.3%)
γ-patchoulene (0.1%)
α-humulene (0.3%)
citronellyl isobutyrate (0.1%)
viridiflorene (0.1%)
geranyl isobutyrate (0.2%)
isobornyl 2-methylbutyrate (0.2%)
citronellyl butyrate (0.1%)
geranyl butyrate (0.2%)
isoeugenyl acetate* (0.1%)
caryophyllene oxide (0.3%)

t = trace (< 0.1%); * correct isomer not identified

V. Vidrich, M. Micholozzi, P. Fusi and D. Heimler, *Essential oils of vegetables species of the Mediterranean and alpine temperate climate areas.* In: *Biomass for Energy and Industry.* Edits., G. Grassi, B. Delmon, I-F. Molle and H. Zibetta, pp. 963–967, Elsevier Appl. Sci., London (1988).

P. Bradesi, F. Tomi, J. Casanova, J. Costa and A.F. Bernardini, *Chemical composition of myrtle leaf essential oil from Corsica (France).* J. Essent. Oil Res., **9**, 283–288 (1997).

T. Özek, B. Demirci and K.H.C. Başer, *Chemical composition of Turkish myrtle oil.* J. Essent. Oil Res., **12**, 541–544 (2000).

M. Lahlou, R. Berrada, A. Agoumi and M. Hmamouchi, *The potential effectiveness of essential oils in the control of human head lice in Morocco.* Internat. J. Aromatherap., **10**, 108–123 (2001).

R. Ismaili, M. Fechtal, A. Zine El Abidine, M. Hachmi and A. Sesbou, *Effet de la transplantation sur le rendement et la composition chimique des huiles essentielles du myrte (*Myrtus communis *L.).* Ann. Rech. For. Maroc, **34**, 87–93 (2001).

P.K. Koukos, K.I. Papadopoulou, A.D. Papagiannopoulos and D. Th. Patiaka, *Chemicals from Greek forestry biomass: Constituents of the leaf oil of* Myrtus communis *L. grown in Greece.* J. Essent. Oil Res., **13**, 245–246 (2001).

A.F. Traboulsi, K. Taoubi, S. El-Haj, J.M. Bessiere and S. Rammal, *Insecticidal properties of essential plant oils against the mosquito* Culex pipiens molectus *(Diptera: Culicidae).* Pest Managmt. Sci., **58**, 491–495 (2002).

N. Bouzouita, F. Kachouri, M. Hamdi and M.M. Chaabouni, *Antimicrobial activity of essential oils from Tunisian aromatic plants.* Flav. Fragr. J., **18**, 380–383 (2003).

M. Curini, A. Bianchi, F. Epifano, R. Bruni, L. Torta and A. Zambonelli, *Composition and in vitro antifungal activity of essential oils of* Erigeron canadensis *and* Myrtus communis *from France.* Chem. Nat. Compds., **39**, 191–194 (2003).

C. Messaoud, Y. Zaouali, A. Ben Suluh, M.L. Khoudja and M. Boussaid, Myrtus communis *in Tunisia: Variability of the essential oil composition in natural populations.* Flav. Fragr. J., **20**, 577–582 (2005).

C.I.G. Tuberoso, A. Barra, A. Angioni, E. Sarritzu and F.M. Pirisi, *Chemical composition of volatiles in Sardinian myrtle (*Myrtus communis *L.) alcoholic extracts and essential oils.* J. Agric. Food Chem., **54**, 1420–1426 (2006).

A. Farah, A. Afifi, M. Fechtal, A. Chhen, B. Satrani, M. Talbi and A. Chaouch, *Fractional distillation effect on the chemical composition of Moroccan myrtle (*Myrtus communis *L.) essential oils.* Flav. Fragr. J., **21**, 351–354 (2006).