Progress in Essential Oils

Brian M. Lawrence, Consultant

Coriander Seed Oil and Extract

A commercial sample of coriander seed oil (ex *Coriandrum sativum* L.) was analyzed by Giampeii et al. (2002). The oil, which was screened against a variety of fungi, was found to possess the following composition:

α-thujene (0.1%)
α-pinene (8.5%)
camphene (0.9%)
sabinene (0.3%)
β-pinene (0.6%)
myrcene (0.9%)
α-terpinene (0.1%)
p-cymene (2.2%)
β-phellandrene (0.2%)
limonene (1.9%)
γ-terpinene (7.1%)
terpinolene (0.4%)
linalool (66.3%)
camphor (3.8%)
borneol (0.6%)
terpinen-4-ol (0.3%)
α-terpineol (0.4%)
geraniol (2.0%)
geranyl acetate (2.7%)
β-caryophyllene (0.1%)

Trace amounts (<0.1%) of tricyclene, (Z)-anethole and carvacrol were also found in this oil.

Charchari et al. (2005) examined the kinetics of extraction of coriander seed with methanol. They found that the kinetic function (the time taken to extract divided by the time necessary for system equilibrium) was independent of extraction temperature and added water absorbed by the seeds. The components identified in the methanol extract were as follows:

myrcene (0.5%)
1,8-cineole (0.5%)
linalool (62.6%)
camphor (1.8%)
terpinen-4-ol (0.3%)
octanal† (1.5%)
dodecane (0.2%)
geranyl acetate (2.3%)
dodecanal (0.3%)
β-caryophyllene (0.2%)
α-humulene (0.5%)
tetradecanoic acid (7.8%)

†incorrect identification based on GC elution order

In addition, trace amounts (<0.05%) of α-pinene, p-cymene, γ-terpinene, α-terpineol and an isomer of nerolidol were also characterized in this extract.

Zorca et al. (2006) compared the composition of a hydrodistilled coriander oil with the volatile concentrate produced by supercritical CO_2 extraction of coriander seeds obtained in Romania. The authors incorrectly referred to this volatile concentrate as an essential oil, which it is not. Essential oils must be produced by physical means only, whereas, as the name suggests, CO_2 extraction produces an extract that is not an oil, even though with the use of two-stage separation a volatile concentrate can have a composition similar to that of the oil. Using GC/MS as the only method of analysis, the results of this comparative study are presented in **T-1**.

Analyses of coriander seed oils produced by hydrodistillation of eight seed accessions obtained from different locations in India were performed by Ravi et al. (2007). Using GC/MS as the only method of analysis, the range in composition of the oils was found to be as follows:

α-pinene (2.4–23.2%)
β-pinene (0.3–1.1%)
myrcene (0.4–0.6%)
p-cymene (0.0–0.5%)
limonene (0.1–0.8%)
camphene† (t–0.3%)
γ-terpinene (t–0.9%)
cis-linalool oxide[f] (0.0–2.6%)
octanol (0.0–2.0%)
linalool (56.7–75.1%)
isoborneol (t–0.1%)
α-terpineol (0.0–5.4%)
decanal (0.0–0.6%)
cuminaldehyde (0.1–0.5%)
citronellol (0.0–0.7%)
geraniol (t–3.9%)
geranial (t–0.4%)
hexadecanal† (0.1–0.9%)
undecanoic acid (0.0–0.3%)
tridecanal (0.2–1.0%)
geraniol† (0.0–0.2%)
geranyl acetate (9.0–24.5%)
undecanal† (0.0–0.5%)
tetradecanoic acid (0.0–1.4%)
hexadecanoic acid (0.0–1.8%)

[f]furanoid form
†incorrect identification based on GC elution order

Msaada et al. (2007) compared the composition of coriander seed oils produced from immature intermediate ripeness and fully mature seeds that were harvested from plants grown in the region of Menzel Temime (northeastern Tunisia). The comparative oil compositions are shown in **T-2**. Trace amounts (<0.05%) of heptanal, α-thujene, α-pinene, sabinene, α-terpinene, p-cymene, limonene, γ-terpinene, terpinen-4-ol, (Z)-β-hexenyl butyrate, geraniol and neryl acetate were also found in one or more of the oils.

An oil produced in the laboratory from coriander seeds obtained from

Comparative percentage composition of an oil and a volatile concentrate of Romanian coriander seeds **T-1**

Compound	Oil	Volatile concentrate
tricyclene	0.1	0.1
α-thujene	0.1	-
α-pinene	2.9	3.1
camphene	0.2	0.2
δ-3-carene[†]	0.1	-
sabinene	0.1	0.2
β-pinene	0.1	0.1
myrcene	1.0	1.0
α-phellandrene	0.1	0.1
p-cymene	12.4	4.0
limonene	2.9	3.3
γ-terpinene	2.0	3.5
cis-linalool oxide[f]	0.1	0.4
trans-linalool oxide[f]	0.1	0.4
terpinolene	0.2	0.1
linalool	45.3	72.1
camphor	0.7	2.7
borneol	-	0.2
terpinen-4-ol	0.1	t
α-terpineol	0.2	0.4
nerol	0.1	0.3
geraniol	0.6	2.0
carvone	0.1	-
bornyl acetate	2.5	0.2
menthyl acetate‡	4.5	0.3
citral[a]	0.2	0.4
(E)-anethole	4.0	0.1
neryl acetate	8.7	0.3
geranyl acetate	10.6	2.9
β-caryophyllene	-	0.2
β-farnesene[*]	0.1	0.1
α-humulene	-	0.1
germacrene D	-	0.1
γ-cadinene	0.1	0.3
nerolidol[*]	-	0.1

t = trace (<0.1%)
[f]furanoid form
[*]correct isomer not identified
[†]incorrect identification based on GC elution order
[a]citral is a commercial name for a mixture of neral and geranial
[‡]probably incorrect identification

plants growing in a garden in Addis Ababa (Ethiopia) was analyzed by Mikre et al. (2007) using GC-FID and GC/MS. This oil was found to contain the following components:

α-pinene (3.2%)
camphene (0.3%)
sabinene (0.2%)
β-pinene (0.4%)
myrcene (0.8%)
p-cymene (0.8%)
β-phellandrene (0.1%)
limonene (1.8%)
γ-terpinene (1.0%)
trans-linalool oxide[f] (0.2%)
octanol (0.2%)
cis-linalool oxide[f] (0.1%)
terpinolene (0.4%)
nonanal (0.2%)
linalool (74.9%)
camphor (5.8%)
citronellal (0.1%)
terpinen-4-ol (0.1%)
α-terpineol (0.4%)
decanal (0.5%)
citronellol (0.2%)
geraniol (2.3%)
thymol (3.4%)
carvacrol (0.1%)
trans-sabinyl acetate (0.1%)
α-copaene (0.4%)
dodecanal (0.1%)
tetradecanal (0.1%)

[f]furanoid form

In addition, trace amounts (<0.05%) of α-thujene, (E)-β-ocimene and *cis*-sabinene hydrate were found in this oil.

The nematicidal activity of a number of essential oils was determined by Kim et al. (2008). Of the 28 oils tested against the pine wood nematode, an oil of coriander seed was found to possess significant activity. The composition of the oil that was tested was determined to be as follows:

heptanal (0.4%)
nonane (1.2%)
α-pinene (3.9%)
camphene (0.5%)
β-pinene (0.4%)
octanal (0.8%)
p-cymene (5.3%)
limonene (1.2%)
γ-terpinene (0.3%)
cis-linalool oxide[f] (1.5%)
trans-linalool oxide[f] (1.1%)
nonanal (0.5%)
linalool (49.4%)
camphor (2.9%)
borneol (0.7%)
terpinen-4-ol (0.6%)
α-terpineol (0.3%)
decanal (3.8%)
geraniol (1.1%)
(E)-2-decenal (7.6%)
(E)-2-decenol (4.5%)
decanol (2.1%)
undecanal (0.2%)
carvone (0.2%)
geranyl acetate (2.0%)
dodecanal (1.1%)

[f]furanoid form

Williams (2008) reported that an oil of coriander seed contained the following components:

α-pinene (1.6%)
camphene (0.4%)
sabinene (0.1%)
β-pinene (0.3%)
myrcene (0.8%)
p-cymene (4.0%)
limonene (4.6%)
γ-terpinene (10.5%)
cis-linalool oxide[f] (0.4%)
trans-linalool oxide[f] (0.1%)

Comparative percentage compositions of coriander seed oils produced from seeds of different maturity **T-2**

Compound	IMSO	INSO	FMSO
β-pinene	t	0.2	0.1
δ-3-carene	0.1	0.1	t
1,8-cineole	0.2	0.1	0.2
(Z)-β-ocimene	0.1	t	t
cis-linalool oxide[f]	0.3	0.3	0.3
terpinolene	t	0.2	0.2
linalool	11.0	76.3	87.5
trans-linalool oxide[f]	0.3	t	t
camphor	0.9	0.1	0.2
borneol	0.1	0.3	0.3
menthol	0.1	0.2	0.1
p-cymen-8-ol	1.4	t	t
α-terpineol	0.4	t	0.1
cis-dihydrocarvone	t	3.2	2.4
nerol	1.5	t	t
citronellol	0.1	t	0.5
neral	1.4	0.1	0.1
carvone	0.1	0.1	0.1
geranial	0.7	t	t
(E)-anethole	0.1	1.4	t
thymol	t	1.0	1.9
carvacrol	1.0	0.1	0.5
δ-elemene	t	0.1	t
eugenol	0.1	t	t
geranyl acetate	46.3	2.9	0.8
β-caryophyllene	t	0.1	t
α-humulene	0.1	t	t
germacrene D	t	0.2	0.1
eugenyl acetate	t	t	0.1

IMSO = immature seed oil
INSO = intermediate maturity seed oil
FMSO = fully mature seed oil
[f]furanoid form

terpinolene (1.7%)
linalool (69.1%)
camphor (3.5%)
2-phenethyl acetate (0.1%)
geraniol (0.7%)
geranyl acetate (0.2%)

[f]furanoid form

Grosso et al. (2008) compared the composition of coriander seed oils produced by hydrodistillation of seeds ground to particle sizes of 0.4–0.8 mm with volatile concentrates (mistakenly referred to as essential oils by the authors) produced by supercritical CO_2 extraction of the same particle size coriander seed at pressures of 90–150 bar, temperatures of 40–50°C and CO_2 flow rates of 0.79–1.56 kg/hr. A summary of the compositions of the oils and volatile concentrates are presented in **T-3**. The authors found that the best supercritical fluid CO_2 extraction conditions were 90 bar, 40°C, CO_2 flow rate of 1.10 kg/hr and a particle size of 0.6 mm.

L. Giamperi, D. Fraternale and D. Ricci, *The in vitro action of essential oils on different organisms.* J. Essent Oil Res., **14**, 312–318 (2002).

S. Charchari, E-H. Benyoussef and F. Amorkrane, *Determination and use of the kinetic function during the extraction of the coriander seed essences with methanol.* In: *Processing, Analysis and Application of Essential Oils.* Edits., L. Jirovetz and G. Buchbauer, pp. 91–99, Har Krishan Bhalla & Sons, Dehradun, India (2005).

M. Zorca, I. Gäinar and D. Bala, *Supercritical CO_2 extraction of essential oil from coriander fruits.* An. Univ. Bucharest Chimie, **2**, 79–83 (2006).

R. Ravi, M. Prakash and K. Keshava Bhat, *Aroma characterization of coriander* (Coriandrum sativum *L.) oil samples.* Eur. Food Res. Technol., **225**, 367–374 (2007).

K. Msaada, K. Hosni, M. Ben Taarit, T. Chahed, M.E. Kchouk and B. Marzouk, *Changes on essential oil composition of coriander* (Coriandrum sativum *L.) fruits during three stages of maturity.* Food Chem., **102**, 1131–1134 (2007).

W. Mikre, J. Rohloff and A. Hymete, *Volatile constituents and antioxidant activity of essential oils obtained from important aromatic plants of Ethiopia.* J. Essent. Oil Bear. Plants, **10**, 465–474 (2007).

J. Kim, S-M. Seo, S-G. Lee, S-C. Shin and I-K. Park, *Nematicidal activity of plant essential oils and components from coriander* (Coriandrum sativum) *oriental sweetgum* (Liquidambar orientalis) *and Valerian* (Valeriana wallichi) *essential oils against pine wood nematode* (Bursaphelenchus xylophilus). J. Agric. Food Chem., **56**, 7316–7320 (2008).

D.G. Williams, *The chemistry of essential oils.* 2nd Edn., p. 178, Micelle Press, Port Washington, NY (2008).

C. Grosso, V. Ferraro, A.C. Figueiredo, J.G. Barroso, J.A. Coelho and A.M. Palavra, *Supercritical carbon dioxide extraction of volatile oil from Italian coriander seeds.* Food Chem., **111**, 197–203 (2008).

Lemon Thyme Oil

The taxonomic origin of lemon thyme is *Thymus* x *citriodorus* (Pers.) Schereb., a perennial member of the Labiatae family. It is a spreading subshrub, which will eventually form a 20–30 cm high broad mound. It possesses erect stems, although the lower branches are decumbent at the base. The leaves are small, 8–14 mm long, 3–6 mm wide, and are broadly elliptic or ovate. The flowers are pale rose to lavender in color. Some cultivars, such as 'aureus,' have variegated yellow-colored—rather than dark green—leaves. The cultivar is also known as golden lemon thyme (Lawrence, 1999). *Thymus* x *citriodorus* is known as lemon thyme because of its pronounced lemonlike odor. It is estimated that less than 500 kg of lemon thyme oil is produced annually. Oils of *T.* x *citriodorus* have not been the subject of much study.

Rovesti (1971) determined that an oil of *T.* x *citriodorus* produced from flowering plants collected in Sicily contained:

p-cymene (23.0%)
linalool (5.2%)
linalyl acetate (9.0%)
citronellal (11.0%)
geraniol (9.2%)

The author also reported that an oil from flowering plants harvested in Lombardy possessed:

p-cymene (26.0%)
linalool (12.0%)
citronellal (8.8%)
geranial + neral (2.5%)
geraniol (10.0%)

An oil of *T.* x *citriodorus* produced by Stahl-Biskup and Holthuijzen (1995) from authenticated plants grown in an experimental garden in Hamburg contained:

α-pinene (0.5%)
camphene (0.8%)
β-pinene (0.1%)
sabinene (0.1%)
myrcene (0.1%)
(Z)-β-ocimene (0.2%)
p-cymene (0.1%)
1,8-cineole (0.5%)
trans-sabinene hydrate (0.1%)
citronellal (0.1%)
camphor (0.2%)
linalool (0.8%)
neral (5.5%)
borneol (0.2%)
α-terpineol (2.2%)
geranial (8.2%)
geranyl acetate (1.0%)
citronellol (0.3%)
nerol (2.8%)
geraniol (61.3%)
geranyl butyrate (0.8%)
thymol (0.5%)
β-bourbonene (0.2%)
β-caryophyllene (3.7%)
germacrene D (1.1%)
β-bisabolene (1.3%)
caryophyllene oxide (0.3%)
germacrene D-4-ol (0.2%)

Trace amounts (<0.1%) of limonene, linalyl acetate, bornyl acetate and methyl thymol were also found in this oil.

Omidbaigi et al. (2005) produced an oil from *T.* x *citriodorus* plants grown in Iran from authentic Hungarian rootstock. The main components identified in this oil were:

camphene (0.8%)
3-octanone (3.3%)
3-octanol (1.1%)
p-cymene (0.6%)
1,8-cineole (0.7%)
borneol (3.2%)
nerol (5.2%)
methyl thymol (1.2%)
neral (10.1%)
geraniol (54.4%)

Comparative percentage composition range of the oils and volatile concentrates of coriander seed of Italian origin **T-3**

Compound	Oils	Volatile concentrates
α-thujene	t	0.0–t
α-pinene	2.2–3.4	1.2–3.4
camphene	0.3–0.4	0.1–0.3
sabinene	0.1–0.2	0.1–0.3
β-pinene	0.3–0.4	0.2–0.8
myrcene	2.0–2.8	0.9–1.2
α-terpinene	0.4–0.5	0.1–0.2
p-cymene	1.2–1.5	0.7–1.1
limonene	2.5–3.4	1.3–1.7
(Z)-β-ocimene	t	0.0–0.2
(E)-β-ocimene	1.1–1.7	0.3–0.6
γ-terpinene	6.3–7.2	5.0–6.7
trans-sabinene hydrate	t	0.1
cis-linalool oxide[f]	t	t
octanol	t	t–0.2
terpinolene	0.8–1.0	0.5–0.6
linalool	66.5–72.3	65.2–78.8
camphor	3.0–3.3	2.5–3.4
citronellal	0.1	0.0–0.1
borneol	0.1	t–0.2
terpinen-4-ol	0.2	0.1–0.2
α-terpineol	0.4	t–0.1
citronellol	t	t–0.5
geraniol	2.6–2.8	0.9–2.9
geranyl acetate	2.4–2.8	1.5–3.5

[f]furanoid form
t = trace (<0.05%)

geranial (13.9%)
β-caryophyllene (0.1%)
β-bisabolene (0.8%)
geranyl butyrate (0.8%)
caryophyllene oxide (0.8%)

Two oils of *T.* x *citriodorus* were produced from different cultivars and analyzed by Horvath et al. (2006). The oil produced from an unnamed cultivar was reported to contain the following constituents:

α-pinene (0.2%)
camphene (0.4%)
β-pinene (0.3%)
limonene (0.3%)
1,8-cineole (2.9%)
p-cymene (4.5%)
γ-terpinene (3.7%)
cis-linalool oxide[f] (1.4%)
linalool (0.7%)
borneol (1.7%)
nerol (1.9%)
neral (7.1%)
geraniol (39.2%)
geranial (9.2%)
geranyl acetate (2.4%)
thymol (0.4%)
carvacrol (15.4%)
caryophyllenol[*] (0.7%)

[f]furanoid form; [*]correct isomer not identified

The oil produced from the 'Archers Gold' cultivar was found to possess the following different composition:

α-pinene (0.1%)
camphene (0.2%)
β-pinene (0.1%)
limonene (0.2%)
1,8-cineole (7.5%)
p-cymene (21.1%)
γ-terpinene (2.9%)
cis-linalool oxide[f] (1.5%)
linalool (0.5%)
borneol (2.1%)
β-caryophyllene (3.5%)
carvacrol (43.5%)
caryophyllenol[*] (1.5%)

[f]furanoid form; [*]correct isomer not identified

Ombidbaigi et al. (2009) examined the effect of plant growth on the oil

Comparative percentage composition of lemon thyme oil produced from two different growth stages **T-4**

Compound	Pre-flowering oil	Full-flowering oil
camphene	0.1	0.2
β-pinene	0.3	0.6
3-octanone	1.2	1.6
3-octanol	2.7	3.4
myrcene	0.7	1.2
α-phellandrene	t	0.2
α-terpinene	0.2	0.4
p-cymene	0.4	0.4
1,8-cineole	0.9	0.9
(Z)-β-ocimene	1.2	1.5
(E)-β-ocimene	0.2	0.2
cis-sabinene hydrate	t	0.6
trans-pinocarveol	0.3	0.5
borneol	0.6	1.3
nerol	1.3	2.6
methyl thymol	0.5	0.6
neral	2.2	6.0
geraniol	72.5	54.3
cis-thio-rose oxide†	-	3.8
β-caryophyllene	1.6	1.2
geranyl butyrate	0.2	-
caryophyllene oxide	0.3	0.2

t = trace (<0.05%); †doubtful correct identification

composition of lemon thyme grown in Iran. A summary of the results can be seen in **T-4**.

P. Rovesti, *Incidences écologiques sur la composition des huiles essentielles. Des variétés chemotaxonomique des thyms spontanés en Italie.* Parfum. Cosmet. Savons France, **1**, 139–147 (1971).

E. Stahl-Biskup and J. Holthuijzen, *Essential oil and glycosidically bound volatiles of lemon-scented thyme,* Thymus *x* citriodorus *(Pers.) Schreb.* Flav. Fragr. J., **10**, 225–229 (1995).

B.M. Lawrence, *Chemical composition of less commonly used essential oils in aromatherapy.* Presented at 2nd International Scientific Aromatherapy Symposium, March 19–21, Grasse, France (1999).

R. Omidbaigi, F. Sefidkon and M. Hajazi, *Essential oil composition of* Thymus citriodorus *L. cultivated in Iran.* Flav. Fragr. J., **20**, 237–238 (2005).

G. Horvath, L.G. Szabo, E. Hethelyi and E. Lemberkovics, *Essential oil composition of three cultivated* Thymus *chemotypes in Hungary.* J. Essent. Oil Res., **18**, 315–317 (2006).

R. Omidbaigi, F. Fattahi and A. Alirezalu, *Essential oil content and constituents of* Thymus *x* citriodorus *L. at different phonological stages.* J. Essent. Oil Bear. Plants, **12**, 333–337 (2009).