Progress in Essential Oils

Brian M. Lawrence, Consultant

Stoechas Oil

The headspace volatiles isolated from *Lavandula stoechas* L. by a solid-phase trapping extraction technique in which the volatiles were trapped in Porapak Q after 3 h of 400 mL/min N_2 flow through were analyzed by GC/MS by Kim and Lee (2002) and found to be as follows:

ethyl benzene[†] (0.05%)
m- or p-xylene[†] (0.16%)
o-xylene[†] (0.09%)
α-thujene (0.07%)
α-pinene (0.78%)
camphene (2.30%)
β-pinene (0.15%)
myrcene (0.09%)
p-cymene (0.54%)
limonene (0.15%)
1,8-cineole (12.50%)
trans-p-menth-2-en-1-ol (0.03%)
linalool oxide[°] (0.70%)
fenchone (24.30%)
linalool (0.11%)
cis-sabinol (0.19%)
camphor (53.40%)
borneol (0.38%)
terpinen-4-ol (0.56%)
p-cymen-8-ol (0.56%)
verbenone (0.28%)
carvone (0.43%)
linalyl acetate (0.50%)
bornyl acetate (1.14%)
α-terpinyl acetate (0.09%)
geranyl acetate (0.02%)
β-caryophyllene (0.02%)
linalool (18.7%)
1-octen-3-yl acetate (0.45%)
camphor (0.45%)
lavandulol (0.25%)
borneol (1.88%)
terpinen-4-ol (4.63%)
p-cymen-8-ol (0.53%)
linalyl acetate (35.4%)
bornyl acetate (5.88%)
geranyl acetate (0.27%)
β-caryophyllene (9.39%)
farnesene[°] (2.60%)
calamenene[°] (1.21%)
caryophyllene oxide (1.80%)
bis(2-ethylhexyl) phthalate[‡] (3.00%)

[°]correct isomer not identified
[†]impurity from the pet ether used to elute the volatiles from Porapak Q
[‡]plasticizer, not a component of lavender flowers

The authors further showed that the choice of fiber used for SPME headspace isolation had a profound effect on the volatile composition obtained.

Dedalioglu and Evrendilek (2004) screened a few Turkish oils for their antibacterial activity. Among the oils screened was a water-distilled oil of *L. stoechas* that was produced from Turkish grown plants. The oil screened was determined to possess the following composition:

α-pinene (1.31%)
camphene (1.40%)
1,8-cineole (8.03%)
fenchone (55.79%)
linalool (0.29%)
camphor (18.18%)
myrtenal (0.25%)
α-fenchyl acetate (0.32%)
carvone (0.33%)
bornyl acetate (1.32%)
myrtenyl acetate (6.25%)
δ-cadinene[‡] (0.90%)
carveol[°] (0.73%)
γ-cadinene (0.80%)
caryophyllene oxide (0.33%)
γ-selinene[†] (2.54%)
aromadendrene[†] (0.41%)
δ-cadinene[‡] (0.50%)

[°]correct isomer not identified
[†]incorrect identification based on GC elution order
[‡]compound listed twice

Angioni et al. (2006) compared the composition of oils produced from stems/leaves and flowers of *L. stoechas* subsp. *stoechas* growing in its natural environment in Cagliari (Italy). The comparative oil analyses can be found in **T-1**.

Moon et al. (2007) reported that an oil produced in Australia from the 'Avonview' cultivar of *L. stoechas* possessed the following major components:

α-pinene (1.1%)
1,8-cineole (9.2%)
linalool (1.9%)
camphor (48.6%)
borneol (1.1%)
terpinen-4-ol (0.3%)
fenchone (21.9%)
α-terpineol (0.5%)
linalyl acetate (0.4%)
camphor (34.6%)
cis-verbenol (0.1%)
trans-verbenol (0.3%)
pinocarvone (1.4%)
borneol (0.3%)
p-cymen-8-ol (1.4%)
α-terpineol (0.3%)
verbenone (0.4%)
trans-carveol (0.1%)
carvone (0.3%)
linalyl acetate (0.1%)
bornyl acetate (0.1%)
lavandulyl acetate (0.2%)
eugenol (0.2%)
β-caryophyllene (0.2%)
germacrene D (0.1%)
1-epi-cubenol (0.1%)

[f]furanoid form

In addition, trace amounts (<0.05%) of tricyclene, 6-methyl-5-hepten-2-on, α-phellandrene, α-terpinene, (Z)-β-ocimene, γ-terpinene, the furanoid form of *trans*-linalool oxide, p-methylacetophenone and myrtenal were also characterized in this oil.

Matos et al. (2009) described the analysis of a lab-distilled oil of *L. stoechas* subsp. *lusitanica*. Although stoechas oil is usually produced from *L. stoechas* subsp. *stoechas*, this oil has been included because wild harvested subsp. *stoechas* material could be confused with subsp. *lusitanica*. The composition of this oil was found to be as follows:

α-pinene (2.8%)
camphene (0.7%)
β-pinene (0.1%)
myrcene (0.1%)
p-cymene (0.3%)
1,8-cineole (0.8%)
limonene (1.2%)
(E)-β-ocimene (0.2%)
cis-linalool oxide[f] (0.3%)
fenchone (41.9%)
terpinolene (0.3%)
linalool (2.7%)
α-fenchyl alcohol (1.2%)
α-campholenal (0.3%)

[f]furanoid form

Kirmizibekmez et al. (2009) compared the compositions of the flower and leaf oils of *L. stoechas* subsp. *stoechas* of Turkish origin. Using a combination of GC-FID and GC/MS, the oils were found to contain 55 and 66 constituents, respectively. A summary of the oil compositions can be seen in **T-2**.

Tzakou et al. (2009) used GC-FID and GC/MS to compare the composition of flower and leaf oils of *L. stoechas* subsp. *stoechas* of Greek origin. The results of this study are summarized on **T-3**. In addition, trace amounts of (<0.1%) of tricyclene, verbenene, sabinene, β-pinene, myrcene, α-terpinene, p-cymene, limonene, γ-terpinene, terpinolene, linalool, α-campholenal, sabina ketone, pinocarvone, borneol, myrtenal, *trans*-carveol, *cis*-carveol, cuminaldehyde, 2-phenethyl acetate, geranial, lavandulyl acetate, p-cymen-7-ol, *trans*-pinocarvyl acetate, α-cubebene, eugenol, neryl acetate, longifolene, isocaryophyllene, β-caryophyllene, β-copaene, α-guaiene, allo-arowmadendrene, cadina-1(6),4-diene, γ-muurolene, β-selinene, 1,11-epoxycalamenene, α-muurolene, (Z)-α-bisabolene, α-calacorene and α-muurolol were also characterized in the flower, leaf or both oils. The authors also determined that only (+)-fenchone was found in the oil while both enantiomers of camphor were detected.

Mahboubi and Kazempour (2009) used both GC-FID and GC/MS to characterize the composition of a lab-distilled oil of Iranian grown *L. stoechas*. The oil was found to contain the following components:

α-pinene (0.6%)
camphene (0.2%)
sabinene (0.5%)
β-pinene (1.1%)
1-octen-3-ol (0.2%)
myrcene (0.9%)
β-phellandrene (0.2%)
δ-3-carene (1.5%)
1,8-cineole (33.6%)

T-1. Comparative percentage composition of the leaf/stem and flower oils of *Lavandula stoechas* subsp. *stoechas*

Compound	Leaf/stem oil	Flower oil	Compound	Leaf/stem oil	Flower oil
α-thujene	t	-	pinocarvone	t	t
α-pinene	3.0	0.7	lavandulol	t	-
camphene	2.8	0.1	borneol	1.6	0.7
verbenene	0.1	t	pinocamphone	0.1	0.1
sabinene	t	t	terpinen-4-ol	0.1	0.1
β-pinene	-	t	p-cymen-8-ol	0.3	0.3
cis-pinane‡	-	t	myrtenal	1.42	0.8
myrcene	t	-	verbenone	0.1	0.1
β-phellandrene	0.1	t	*trans*-carveol	t	t
δ-3-carene	0.1	-	carvone	0.1	0.2
α-terpinene	t	t	bornyl acetate	2.4	5.1
o-cymene	0.1	-	lavandulyl acetate	0.2	0.4
p-cymene	0.4	0.4	thymol	t	t
limonene	1.1	0.9	myrtenyl acetate	5.0	3.7
1,8-cineole	0.2	t	isoledene	0.1	t
β-phellandrene	0.2	0.2	α-copaene	0.15	t
(Z)-β-ocimene	0.1	t	longifolene	t	-
(E)-β-ocimene	t	-	β-caryophyllene	t	t
γ-terpinene	0.1	0.1	aromadendrene	-	t
terpinolene	0.1	0.1	α-humulene	t	-
fenchone	54.5	73.0	allo-aromadendrene	0.1	-
p-cymene	t	-	γ-gurjunene	t	t
linalool	0.4	0.3	germacrene D	t	-
thujone	t	t	valencene	t	-
α-fenchyl alcohol	0.5	0.4	bicyclogermacrene	t	-
chrysanthenone	0.1	t	*cis*-β-guaiene	0.2	0.2
α-campholenal	0.2	0.2	α-selinene	0.4	0.2
trans-pinocarveol	t	t	rosifoliol	t	-
cis-verbenol	t	0.1	viridiflorol	t	-
camphor	15.4	9.3	cadinol*	t	-
p-mentha-1,5-dien-8-ol	t	t			

‡doubtful natural occurrence; *correct isomer not identified; t = trace (<0.05%)

β-ocimene° (0.4%)
γ-terpinene (0.2%)
cis-β-terpineol† (0.1%)
terpinolene (0.7%)
linalool (16.6%)
allo-ocimene (0.1%)
terpinen-1-ol (0.3%)
camphor (10.0%)
borneol (17.2%)
terpinen-4-ol (1.9%)
hexyl butyrate (0.5%)
p-cymen-8-ol (0.3%)
cryptone (1.7%)
α-terpineol (1.4%)
cryptone (1.7%)
α-terpineol (1.4%)
myrtenal (0.4%)
p-menth-1-en-3-ol[a] (0.1%)
[3,3,3]-propellane† (0.2%)
trans-carveol (0.2%)
nerol (0.2%)
bornyl acetate (0.8%)
cuminaldehyde (0.7%)
carvone (0.3%)
geraniol (0.4%)
piperitone (0.1%)
phellandral (0.2%)
lavandulyl acetate (0.5%)
bornyl acetate‡ (0.20%)
p-cymen-7-ol (0.2%)
hexyl tiglate (0.1%)
neryl acetate (0.1%)
geranyl acetate (0.3%)
α-gurjunene (0.2%)
β-caryophyllene (0.8%)
(E)-β-farnesene (0.6%)
germacrene D (0.1%)
geranyl isovalerate (0.2%)
α-amorphene (0.6%)
caryophyllene oxide (0.3%)
α-cadinol (0.5%)
α-bisabolol (0.2%)

[a]*cis*-piperitol
°correct isomer not identified
†incorrect identification based on GC elution order
‡component listed twice

The oil composition is abnormal because commercially important stoechas oils are rich in fenchone and camphor. It is possible that this is an example of a new chemotypic form of *L. stoechas* or the authors misidentified the plants from which their oil was isolated.

T-2. Comparative percentage composition of the flower and leaf oils of *Lavandula stoechas* subsp. *stoechas* of Turkish origin

Compound	Flower oil	Leaf oil	Compound	Flower oil	Leaf oil
α-pinene	6.1	0.7	α-terpineol	0.4	0.2
α-fenchene	0.2	0.1	borneol	0.1	0.2
camphene	1.0	0.6	verbenene	0.4	0.5
β-pinene	0.2	0.1	α-muurolene	0.2	0.2
sabinene	0.1	t	α-selinene	-	0.1
thuja-2,4(10)-diene	-	0.2	carvone	0.3	0.3
myrcene	0.2	-	geranyl acetate	0.4	0.3
limonene	3.0	0.2	δ-cadinene	0.3	0.7
1,8-cineole	3.8	15.6	p-methylacetophenone	-	0.1
(Z)-3-hexenol	-	0.1	myrtenol	1.6	0.3
γ-terpinene	-	0.1	2-phenethyl acetate	-	0.2
p-cymene	0.4	0.4	*trans*-carveol	0.3	0.2
1-octen-3-yl acetate	0.2	-	calamenene*	0.2	0.2
fenchone	39.2	41.9	p-cymen-8-ol	0.3	0.5
trans-linalool oxide[f]	0.2	0.4	1,11-oxido-calamenene	0.1	0.1
1-octen-3-ol	0.6	0.3	epi-cubenol	1.1	0.4
trans-sabinene hydrate	0.2	-	p-cymen-9-ol	-	0.1
cis-linalool oxide[f]	0.2	0.3	α-calacorene	-	0.1
α-fenchyl acetate	0.5	0.2	palustrol	-	0.1
cyclosativene	0.2	0.3	cubebol	0.8	0.4
α-copaene	0.4	0.1	γ-calacorene	-	0.1
α-campholenal	0.2	0.1	2-phenethyl 2-methylbutyrate	-	0.1
camphor	5.9	12.1	2-phenethyl isovalerate	-	0.1
linalool	2.1	0.7	caryophyllene oxide	0.4	0.5
pinocarvone	-	0.1	ledol	0.2	0.7
bornyl acetate	1.5	0.8	cubenol	0.2	0.2
α-fenchyl alcohol	0.8	0.4	1-epi-cubenol	0.5	0.4
terpinen-4-ol	0.2	0.3	globulol	t	0.1
lavandulyl acetate	0.2	0.2	viridiflorol	2.1	4.0
myrtenal	0.8	0.2	copaborneol	0.6	1.5
allo-aromadendrene	0.2	-	spathulenol	-	0.1
cis-verbenol	0.1	0.3	T-muurolol	0.2	0.2
trans-pinocarveol	0.2	0.2	α-muurolol	0.1	0.1
δ-terpineol	0.1	0.2	cadalene	-	0.2
trans-verbenol	1.5	1.0	α-ylangene oxide	0.1	0.3
myrtenyl acetate	9.5	1.9			

t = trace (<0.05%); *correct isomer not identified; [f]furanoid form

A supercritical CO_2 extract of *L. stoechas* that was produced from plants collected in the vicinity of Sadali (Sardinia, Italy) was screened for its biological activity by Marongiu et al. (2010). The main components of this extract that was determined by GC and GC/MS can be seen as follows:

α-pinene (<0.1%)
camphene (1.1%)
1,8-cineole (10.9%)
fenchone (20.7%)
camphor (31.7%)
borneol (0.2%)
m-cymen-8-ol (0.7%)
p-cymen-8-ol (0.6%)
verbenone (0.7%)
bornyl acetate (5.0%)
myrtenyl acetate (2.1%)
valencene (0.7%)
γ-cadinene (0.6%)

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B. Marongiu, A. Piras, S. Porcedda, D. Falconieri, A. Maxia, M.A. Frau, P. Molicotti and S. Zanetti, *Composition and biological activity of supercritical CO_2 extract of some Lamiaceae growing wild in Sardinia (Italy)*. J. Essent. Oil Bear. Plants, **13**, 625–632 (2010).

Moroccan Thyme Oil

Moroccan thyme oil is produced in limited quantities exclusively from *Thymus satureioides* Cosson collected from their natural habitat in Morocco.

Genuine samples of the plant material were provided by the French organization "Repression des Fraudes et Contrôle de la Qualité" and were subjected to hydrodistillation to yield oils of 1.0–1.3% yield by Miguel et al. (1976). Analysis of this oil was conducted using column chromatographic separation, GC-FID and preparative GC. All compounds were characterized by IR spectroscopy of isolated materials from preparative GC. The constituents identified in this oil were:

tricyclene (0.2%)
α-pinene (3.3%)
camphone (5.4%)
β-pinene (0.4%)
myrcene (0.3%)
α-terpinene (0.3%)
limonene (3.4%)
camphor (2.7%)
bornyl acetate (1.7%)
methyl carvacrol (1.4%)
terpinen-4-ol (4.8%)
β-caryophyllene (6.4%)
α-terpineol (12.2%)
borneol (26.2%)
thymol (19.2%)
carvacrol (4.3%)

Richard et al. (1985) collected *T. satureioides* above-ground plants from Tamoa, Asni, Ourika and Amizmiz (Morocco). Analysis of oils produced from these

T-3. Comparative percentage composition of the dried flower and leaf oils of *Lavandula stoechas* subsp. *stoechas* of Greek origin

Compound	Flower oil	Leaf oil
α-pinene	1.9	0.9
camphene	0.9	0.9
1,8-cineole	7.6	17.8
fenchone	39.9	21.0
β-fenchyl alcohol	0.7	t
camphor	24.2	26.3
p-mentha-1,5-dien-8-ol	t	1.2
terpinen-4-ol	0.5	0.5
p-cymen-8-ol	t	0.8
α-terpineol	0.5	t
myrtenol	2.8	0.4
verbenone	t	0.4
α-fenchyl acetate	1.1	0.5
carvone	0.5	t
bornyl acetate	1.2	1.0
myrtenyl acetate	4.9	0.8
α-copaene	t	0.5
geranyl acetate	0.6	t
epi-cubebol	1.1	0.7
cubebol	t	0.5
δ-cadinene	0.8	1.1
α-copaen-8-ol	0.9	1.7
caryophyllene oxide	t	1.1
viridiflorol	2.0	4.3
1-epi-cubenol	t	0.6
T-muurolol	t	1.1
eudesma-4(15),7-dien-1β-ol	t	0.9
14-oxy-α-muurolene	t	1.1

t = trace (<0.1%)

collections from the four locations by hydrodistillation revealed that they possessed the following composition range:

tricyclene (0.2–0.4%)
α-thujene (0.3–0.6%)
α-pinene (3.0–5.4%)
camphene (5.7–10.5%)
sabinene (0–0.2%)
β-pinene (0.8–1.3%)
myrcene (0.5–0.8%)
3-octanol (0.1–0.3%)
α-terpinene (0.2–0.5%)
p-cymene (4.7–9.9%)
limonene (0.7–0.9%)
γ-terpinene (0.3–2.6%)
cis-sabinene hydrate (0–0.4%)
linalool (3.6–5.8%)
trans-pinocarveol (0–0.2%)
camphor (0.3–0.6%)
borneol (27.0–33.3%)
terpinen-4-ol (1.6–2.3%)
p-cymen-8-ol (0.4–0.6%)
α-terpineol (5.8–10.3%)
cis-dihydrocarvone (0.2–1.0%)
trans-dihydrocarvone (0–0.8%)
isoborneol[a] (0.1–0.3%)
methyl carvacrol (0.9–6.4%)
thymol (0.3–21.3%)
carvacrol (0.7–9.2%)
α-copaene (0–0.1%)
β-caryophyllene (1.8–3.5%)
aromadendrene (0–0.1%)
α-humulene (t–0.2%)
γ-muurolene (0–0.2%)
δ-cadinene (t–0.3%)
caryophyllene oxide (0.6–1.3%)

t = trace (<0.05%)
[a]tentative identification

In addition, trace amounts of *cis*-linalool oxide (furanoid form), terpinolene and methyl thymol were also characterized in this oil.

Benjilali et al. (1987a and 1987b) collected 32 accessions of *T. satureioides* from across Morocco. Oils were produced from these collections by hydrodistillation and each oil was subjected to GC-FID, preparative GC and IR spectroscopy. The authors found that although the oils were all rich in borneol, they contained varying amounts of α-terpineol, carvacrol and thymol. As a result, this reviewer has separated the data into oils (as shown in **T-4**) that contain: (a) borneol > α-terpineol (15 examples); (b) borneol > carvacrol > α-terpineol (six examples); (c) borneol > α-terpineol > carvacrol (six examples); (d) borneol > α-terpineol > thymol; and (e) borneol-rich oils (1 example).

Tantaoui-Elaraki et al. (1993) used GC-FID as their method of analysis, and compared their data with previously published studies. The composition of the oil was found to be as follows:

α-pinene (17.5%)
camphene (27.4%)
β-pinene (3.1%)
3-octanol (2.1%)
myrcene (0.5%)
α-terpinene (0.4%)
p-cymene (4.6%)
limonene (0.1%)
terpinolene (1.5%)

T-4. Comparative percentage composition of *Thymus satureioides* oils

Compound	1	2	3	4	5
tricyclene	0.2–0.5	0.1–0.3	0.3–0.4	0–0.4	-
α-thujene	0.1–0.7	0.5–0.7	0.3–0.7	0–0.6	-
α-pinene	1.9–5.4	1.7–4.1	3.1–6.9	3.0–5.6	0.1
camphene	3.1–10.4	0.2–4.2	6.4–8.7	0.1–10.5	0.2
sabinene	-	-	0–0.1	0–0.2	-
β-pinene	0.4–1.3	0.5–0.9	0.7–1.0	0.8–1.3	0.1
myrcene	0.1–0.7	0.6–0.9	0.3–0.7	0.7–0.8	-
3-octanol	0–0.1	0.2–0.8	0–0.3	0.1–0.3	-
α-phellandrene	0–0.1	0–0.1	-	-	-
α-terpinene	0.1–0.3	0.3–0.7	0.2–0.6	0.3–0.5	-
p-cymene	0.6–2.3	3.1–8.1	2.2–9.9	4.7–8.0	-
limonene	0.4–1.1	0.4–0.8	0.5–1.1	0.7–0.8	-
1,8-cineole	-	0–0.1	-	-	-
γ-terpinene	0.2–1.6	0.8–2.6	0.7–2.8	0.3–2.6	-
cis-sabinene hydrate	0–0.4	0.1–0.5	0.1–0.2	0–0.4	-
linalool oxide[f]	0–0.1	0–0.1	0–0.1	-	-
terpinolene	0–0.2	0.1–0.3	0.1–0.3	-	-
linalool	1.6–2.6	1.9–12.3	1.9–5.8	3.6–5.1	0.4
campholenal	-	0–0.1	-	-	-
trans-pinocarveol	0.1–0.3	0–0.3	0.1–0.2	0–0.2	0.1
camphor	0.2–0.6	0.1–0.5	0.1–0.6	0.3–0.5	0.4
p-mentha-1(7),2-dien-8-ol	0–0.1	-	-	-	-
borneol	37.7–52.1	13.0–29.7	26.8–41.3	26.7–33.3	77.6
terpinen-4-ol	1.7–2.1	1.1–1.6	1.5–1.8	1.6–2.3	0.7
p-cymen-8-ol	0.2–0.7	0.1–0.6	0.1–0.4	0.4–0.6	0.2
α-terpineol	14.5–21.0	4.7–12.4	12.1–19.6	5.8–16.0	11.5
cis-dihydrocarvone	0.3–0.6	0–0.3	0.2–1.0	0.2–0.3	0.2
trans-dihydrocarvone	0–2.0	-	0–0.8	0–0.2	0.9
verbenone	0–0.1	0–0.1	-	-	0.1
methyl thymol	-	0–0.1	-	-	-
methyl carvacrol	0–0.3	0–0.3	0.1–0.2	5.9–7.1	-
bornyl acetate	1.1–3.5	0.1–0.9	0.6–2.8	0.2–5.4	0.2
thymol	0.1–0.3	0.2–0.7	0.2–0.5	11.4–21.3	0.2
carvacrol	0.9–6.1	21.1–49.5	9.2–20.8	0.6–3.7	0.5
α-irone[†]	0.2–0.5	0–0.2	0–0.4	-	0.1
α-copaene	0–0.1	0–0.1	0–0.1	0–0.4	-
β-bourbonene	0–0.1	-	0–0.1	0–0.1	0.1
β-caryophyllene	2.8–5.4	2.5–5.3	3.6–5.2	1.8–3.5	2.8
aromadendrene	0–0.3	0–0.2	0–0.2	-	0.3
α-humulene	0.1–0.3	0–0.3	0.1–0.3	0–0.4	0.1
allo-aromadendrene	0–0.1	0–0.1	0–0.1	0–0.2	-
γ-muurolene	-	0–0.1	0–0.2	0–0.1	-
α-muurolene	0–0.1	0–0.3	-	0–0.3	-
β-guaiene*	0.2–0.4	0–1.0	0.2–0.3	0–1.0	0.3
δ-cadinene	0.1–0.3	0–1.3	0.2–0.3	0–1.3	0.2
caryophyllene oxide	0.4–1.4	0.6–3.7	0.5–1.3	0.6–3.7	0.2

*correct isomer not identified; [†]incorrect identification; [f]furanoid form; 1. borneol > α-terpineol oils; 2. borneol > carvacrol > α-terpineol oils; 3. borneol > α-terpineol > carvacrol oils; 4. borneol > α-terpineol > thymol oils; 5. borneol-rich oils

linalool (6.3%)
trans-pinocarveol (0.1%)
camphor (0.1%)
borneol (31.2%)
terpinen-4-ol (0.4%)
α-terpineol (0.4%)
linalyl acetate (0.5%)
carvacrol (0.2%)

Trace amounts (<0.1%) of γ-terpinene, *cis*-sabinene hydrate, *cis*-linalool oxide (furanoid form) and p-cymen-8-ol were also characterized in this oil.

A commercial sample of Moroccan thyme oil (ex. *T. satureioides*) was screened for its insecticidal properties against the cotton leaf worm. Analysis of the oil using GC-FID and GC/MS by Pavela (2012) revealed that it possessed the following composition:

α-pinene (3.1%)
camphene (6.5%)
cis-pinene[†] (1.3%)
p-cymene (4.7%)
linalool (2.9%)
camphor (1.6%)
borneol (27.9%)
terpinen-4-ol (2.3%)
α-terpineol (6.5%)
thymol (15.3%)
carvacrol (12.1%)
β-caryophyllene (5.3%)

[†]doesn't occur naturally

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H. Richard, B. Benjilali, N. Banquour and O. Baritaux, *Etude de diverses huiles essentielles de thym du Maroc.* Wissenschaft u Technologie, **18**, 105–110 (1985).

B. Benjilali, H. Hammoumi and H. Richard, *Polymorphisme chimique des huiles essentielles de thym du Maroc. I. Caracterization des composants*. Sci. Aliment., **7**, 77–91 (1987a).

B. Benjilali, H. Hammoumi, A. M'Hamedi and H. Richard, *Composition chimique des huiles essentielles de diverses varieties de thym du Maroc. II. Analyse en composantes principals (ACP).* Sci. Aliment., **7**, 275–299 (1987b).

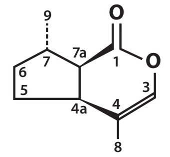
A. Tantaoui-Elaraki, N. Lattaoui, A. Errifi and B. Benjilali, *Composition and antimicrobial activity of the essential oils of* Thymus broussonettii, T. zygis *and* T. satureoides. J. Essent. Oil Res., **5**, 45–53 (1993).

R. Pavela, *Sublethal effects of some essential oils on the cotton leafworm* Spodoptera littosalis *(Boisduval).* J. Essent. Oil Bear. Plants, **15**, 144–156 (2012).

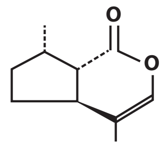
Correction

F-1, appearing on Page 48 of the July 2013 issue of *Perfumer & Flavorist* Magazine, omitted several key points of information.[a] The expanded figure appears below.

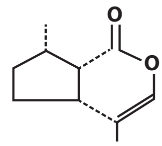
F-1. Nepetalactone isomers



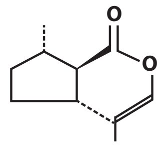
4aα,7α,7aα or (Z,E)- or *cis-trans*-nepetalactone



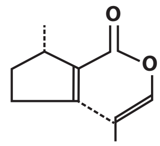
4aα,7α,7aβ or (E,Z)- or *trans-cis*-nepetalactone



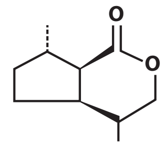
4aβ,7α,7aβ-nepetalactone



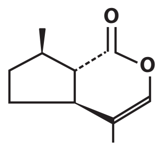
4aβ,7α,7aα-nepetalactone



dehydronepetalactone



3,4-dihydro-4aα,7α,7aα-nepetalactone



4aα,7β,7aβ- or (Z,Z)- or *cis-cis*-nepetalactone

[a]B.M. Lawrence, *Progress in Essential Oils: Catnip Oil.* Perfum. Flavor., **38**(7), 48–54 (2013).