Progress in Essential Oils

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Lavender Oil

A review of the literature reveals that lavender oil has been the subject of a number of reviews (Lawrence, 1976, 1978, 1980, 1985, 1987, 1993, 1994, 1996, 2000, 2004, 2008 and 2010). Since then and earlier, lavender oil composition has been the subject of numerous studies.

Schmaus and Kubeczka (1985) compared the composition of lavender oil produced by hydrodistillation (pH: 7.0 water) with the volatiles obtained by extraction. Their results are shown in **T-1**. As can be seen from the results, there are a number of minor changes in the quantitative data of many constituents, as well as the extensive hydrolysis of linalyl acetate to linalool.

Chatzopoulou et al. (2003) produced an oil from the flowering tops of a lavender clone, a 4.4% yield that was grown in an experimental plantation in northern Greece. Analysis of this oil using GC-FID and GC/MS revealed that it had the following composition:

α-thujene (0.2%)
α-pinene (0.2%)
sabinene (0.1%)
1-octen-3-ol (0.2%)
β-pinene (0.1%)
3-octanone (1.4%)
myrcene (0.6%)
3-octanol (0.3%)
δ-3-carene (0.1%)
p-cymene (0.2%)
limonene (0.9%)
1,8-cineole (0.7%)
(Z)-β-ocimene (4.3%)
(E)-β-ocimene (2.7%)
γ-terpinene (0.2%)
linalool (50.6%)
1-octen-3-yl acetate (0.1%)
camphor (0.1%)
borneol (0.3%)
lavandulol (1.5%)
terpinen-4-ol (7.8%)
cryptone (1.2%)
α-terpineol (1.5%)
nerol (0.3%)
cuminaldehyde (0.3%)
carvone (0.1%)
linalyl acetate (15.7%)
cumin alcohol (0.1%)
lavandulyl acetate (2.7%)
neryl acetate (0.5%)
geranyl acetate (0.9%)
β-caryophyllene (2.0%)
α-santalene (0.4%)
trans-α-bergamotene (0.1%)
α-humulene (0.1%)
β-farnesene* (0.1%)
germacrene D (0.2%)
caryophyllene oxide (0.3%)
T-cadinol (0.1%)

*correct isomer not identified

In addition trace amounts (< 0.05%) of camphene, α-phellandrene and an isomer of allo-ocimene were also characterized in this oil.

Maia et al. (2004) reported that the main components of a lab-distilled lavender flower oil produced from an unknown cultivar grown in Brazil were as follows:

myrcene (3.6%)
α-phellandrene (5.7%)
1,8-cineole (28.3%)
camphor (28.0%)
isoborneol (9.9%)

This is one of the first studies on lavender flower oil in which the typical main

T-1. Comparative percentage composition of lavender oil produced by hydrodistillation and lavender extract volatiles

Compound	Hydrodistilled oil	Extract volatiles
myrcene	1.9	0.5
limonene	0.6	0.2
1,8-cineole + β-phellandrene	0.5	0.5
(Z)-β-ocimene	4.5	4.5
(E)-β-ocimene	6.2	3.4
3-octanone	1.5	0.8
p-cymene	0.7	0.3
terpinolene	0.4	–
1-octen-3-yl acetate	1.9	1.7
cis-linalool oxide[f]	0.3	0.5
trans-linalool oxide[f]	0.2	0.3
camphor	0.5	0.4
linalool	40.9	25.0
linalyl acetate	13.3	43.0
terpinen-4-ol	2.4	2.8
β-caryophyllene	4.0	5.5
α-terpineol	5.4	–
α-terpinyl acetate + borneol	2.2	1.7
neryl acetate	1.2	–
geranyl acetate	2.5	–
nerol	1.0	–
geraniol	3.2	–

f = furanoid form

constituents of lavender oil such as linalool and linalyl acetate were not found.

The use of ultra-fast GC analysis (1-minute analysis time) of commercial sample of lavender oil (origin unknown) was reported (Anon, 2004) in which the composition of lavender was shown to be as follows:

limonene (5.3%)
1,8-cineole (0.9%)
β-ocimene* (2.1%)
linalool (30.8%)
lavandulol (1.0%)
borneol (1.0%)
terpinen-4-ol (4.4%)
α-terpineol (1.8%)
linalyl acetate (40.1%)
lavandulyl acetate (3.9%)
neryl acetate (0.5%)
geranyl acetate (0.8%)
α-santalene (0.6%)
β-caryophyllene (3.9%)
β-farnesene[a] (2.1%)
cadinol* (0.6%)

[a]should be (E)-form; *correct isomer not identified

Zhang et al. (2006) examined the composition of lavender oil produced in China. Analysis of this oil revealed that it contained:

α-pinene (0.2%)
β-pinene (0.5%)
δ-3-carene (0.3%)
p-cymene (0.6%)
1,8-cineole (1.1%)
(E)-β-ocimene (1.1%)
(Z)-β-ocimene (0.7%)
linalool (37.6%)
camphor (0.6%)
terpinen-4-ol (4.5%)
linalyl propionatea (2.1%)
linalyl acetate (35.8%)
lavandulyl acetate (4.1%)
neryl acetate (0.5%)
geranyl acetate (0.5%)
(Z)-β-farnesene (0.9%)

[a]should be linalyl formate

In addition, the authors misidentified five other so-called constituents that have not been included in the above list of constituents.

Lavender oil that was produced from a 3.0% yield from flowers harvested from a cultivation site in an experimental garden located near Pancevo (Serbia) was screened for its antibacterial activity by Sokovic et al. (2007). Analysis of the oil using GC-FID and GC/MS revealed that it contained the following constituents:

tricyclene (< 0.1%)
α-thujene (0.6%)
α-pinene (0.2%)
α-terpinene (0.3%)
limonene (8.5%)
1,8-cineole (3.3%)
cis-linalool oxide[f] (2.4%)
fenchone (0.6%)
linalool (27.2%)
α-fenchyl alcohol (0.1%)
camphor (1.1%)
borneol (2.5%)
terpinen-4-ol (2.1%)
α-terpineol (4.2%)
linalyl acetate (27.5%)
bornyl acetate (0.1%)
lavandulyl acetate (6.5%)
trans-pinocarvyl acetate (0.2%)
neryl acetate (2.0%)
geranyl acetate (3.0%)

[f]furanoid form

Kiran Babu and Singh (2007) compared the composition of lavender oil produced in Palampur (Himachal Pradesh, India). The oil was recovered from the water from lavender steam distillation, and a combination of the two oils. The authors analyzed the three oils using GC-FID and GC/MS. The results of this study are presented in **T-2**.

Cerpa Chavez (2007) examined the distillation process for a number of Spanish essential oil-containing plants. He performed 12 distillations of the same batch of lavender flower heads grown in Spain and determined that the oil compositions ranged as follows:

α-pinene (0.1–0.2%)
camphene (0.1%)
β-pinene (0.1–0.2%)
3-octanone (t–0.2%)
myrcene (0.3–0.7%)
limonene (0.3–0.4%)
1-8-cineole (1.9–4.2%)
(Z)-β-ocimene (0.8–1.3%)
(E)-β-ocimene (0.9–1.9%)
linalool (29.9–35.4%)
camphor (4.9–6.9%)
borneol (3.7–4.7%)
terpinen-4-ol (0.8–1.3%)
α-terpineol (1.3–1.9%)

T-2. Percentage composition of lavender oil, lavender distillate water oil (hydrosol) hydrodistillation and lavender extract volatiles

Compound	Lavender oil	Hydrosol oil
α-pinene	0.2	–
camphene	0.4	–
β-pinene	0.1	–
sabinene	0.1	–
δ-3-carene	0.2	–
myrcene	2.0	0.2
limonene	1.1	0.1
1,8-cineole	1.4	1.5
(Z)-β-ocimene	2.3	0.1
(E)-β-ocimene	3.0	0.3
p-cymene	0.3	–
terpinolene	0.4	0.2
1-octen-3-yl acetate	0.9	–
cis-linalool oxide[f]	–	1.6
trans-linalool oxide[f]	–	1.2
camphor	0.2	0.8
linalool	28.8	54.6
linalyl acetate	35.3	–
α-santalene	0.7	–
bornyl acetate	0.2	–
trans-α-bergamotene	0.3	–
β-caryophyllene	6.3	–
terpinen-4-ol	0.5	2.0
lavandulyl acetate	1.8	0.1
α-humulene	0.3	–
cryptone	–	2.9

[f]furanoid form

linalyl acetate (31.1–39.9%)
neryl acetate (0.4–1.2%)
β-caryophyllene (2.3–3.1%)
γ-cadinene (0.2–1.4%)
coumarin (0.6–1.4%)

t = trace (< 0.05%)

Boeckelmann (2008) studied the production and composition of lavender cultivars grown in the Okanagan valley (British Columbia, Canada). She examined the borneol, camphor, limonene and linalool contents of the following cultivars: 'Royal Velvet', 'Royal Purple', 'Munstead', 'Lavender Lady', 'Bowles', 'Premier', 'Hidcote' and 'Mailette'. It is a shame that Boeckelmarn didn't monitor the linalyl acetate contents of the cultivars studied in light of her hydrodistillation isolation of the oils.

Rezazadeh et al. (2008) used GC/MS only to determine that a supercritical fluid CO_2 extract of lavender flowers grown in Iran contained the following major constituents:

linalyl acetate (73.5%)
lavandulyl acetate (7.5%)
β-caryophyllene (3.7%)
farnesene* (2.0%)
terpineol* (1.8%)
T-cadinol (0.9%)

*correct isomer not identified

The same authors also examined a hydrodistilled oi1 of lavender also using GC/MS only, and reported that it contained:

α-pinene* (35.9%)
lavandulyl acetate (14.1%)
geranyl acetate (7.4%)
β-caryophyllene (6.7%)
(E)-β-ocimene (4.8%)
neryl acetate (3.9%)
farnesene* (3.4%)
myrcene (2.2%)
linalyl acetate (2.2%)
β-pinene oxide† (2.2%)
T-cadinol (1.4%)
sabina ketone† (1.3%)
limonene (1.1%)
(Z)-β-ocimene (1.0%)
terpinolene (0.8%)
linalool (0.7%)
chamigrene† (0.5%)

*correct isomer not identified; †incorrect identification

This reviewer has no idea why this lavender oil was reported to be rich in a pinene isomer. Hopefully this was a typographical or language error for linalyl acetate.

A commercial oil of lavender that was obtained in Italy was found by Romeo et al. (2008) to possess the following composition:

α-thujene (0.1%)
α-pinene (2.2%)
camphene (0.2%)
sabinene (0.1%)
β-pinene (1.1%)
1-octen-3-ol (0.2%)
2-octanone[a] (0.6%)
ethyl hexanoate (0.1%)
δ-3-carene (0.1%)
p-cymene (0.3%)
limonene (0.3%)
1,8-cineole (8.4%)
(Z)-β-ocimene(0.3%)
(E)-β-ocimene(0.2%)
γ-terpinene (0.1%)
cis-linalool oxide[f] (0.2%)
trans-linalool oxide[f] (0.2%)
terpinolene (0.2%)
linalool (23.1%)
α-fenchyl alcohol (0.3%)
p-menth-3-en-1-ol* (0.3%)
camphor (6.6%)
(Z)-3-hexenyl isobutyrate (0.1%)
isoborneol (2.2%)
borneol (5.0%)
lavandulol (0.4%)
terpinen-4-ol (4.0%)
α-terpineol (5.0%)
hexyl butyrate (0.4%)
nerol (3.3%)
linalyl acetate (23.1%)
geraniol (0.3%)
geranyl formate (1.5%)
hexyl tiglate (0.2%)
citronellyl acetate (0.3%)
neryl acetate (0.6%)
geranyl acetate (0.8%)
longifolene† 0.1%)
cis-α-bergamotene (0.1%)
β-caryophyllene (1.4%)
trans-α-bergamotene (0.3%)
(Z)-β-farnesene (0.6%)
γ-muurolene (0.2%)
β-bisabolene (0.1%)
γ-cadinene (0.6%)
β-sesquiphellandrene (0.4%)
α-cadinol (0.6%)

*correct isomer not identified; [a]should be 3-octanone; †incorrect identification

Smigielski et al. (2009) analyzed an oil produced by hydrodistillation for 4 hr from dried lavender flowers (cultivar unknown) that were obtained from plants cultivated in the Wielkopolska region (Poland) using GC-FID and GC/MS. The constituents characterized in this oil were as follows:

α-thujene (0.1%)
α-pinene (0.1%)
camphene (0.2%)
sabinene (0.1%)
1-octen-3-ol (1.0%)
myrcene (2.7%)
hexyl acetate (0.4%)
m-cymene (0.2%)
p-cymene (0.2%)
1,8-cineole (2.0%)
limonene (0.5%)
(Z)-β-ocimene (3.9%)
(E)-β-ocimene (2.3%)
g-terpinene (0.1%)
trans-sabinene hydrate (0.1%)
cis-linalool oxide[f] (0.9%)
trans-linalool oxide[f] (0.7%)
terpinolene (0.3%)
linalool (30.6%)
1-octen-3-yl acetate (1.0%)
hotrienol (0.1%)
trans-rose oxide (0.3%)
camphor (0.5%)
pinocarvone (0.1%)
borneol (2.0%)
lavandulol (1.6%)
cryptone (0.1%)
terpinen-4-ol (3.4%)
myrtenal (0.1%)
α-terpineol (2.7%)
hexyl butyrate (0.4%)
bornyl formate (0.1%)
cuminaldehyde (0.3%)
nerol (0.6%)
piperitone (0.1%)
geraniol (5.3%)
linalyl acetate (14.2%)
bornyl acetate (0.3%)
lavandulyl acetate (4.4%)
neryl acetate (0.9%)
geranyl acetate (1.7%)
β-caryophyllene (4.7%)
α-santalene (0.4%)
trans-α-bergamotene (0.1%)
α-humulene (0.1%)
(E)-β-farnesene (1.0%)
germacrene D (0.3%)
g-cadinene (0.6%)
trans-calamenene (0.2%)
δ-cadinene (0.1%)
caryophyllene oxide (2.1%)
trans-sesquisabinene hydrate (0.1%)
globulol (0.1%)
1-epi-cubenol (0.2%)
ledol† (0.1%)
T-cadinol (1.8%)
α-muurolol (0.1%)
α-cadinol (0.1%)
cadalene (0.5%)
ledene epoxide II† (0.1%)

[f]furanoid form

In addition, trace amounts (< 0.05%) of δ-3-carene, *trans*-pinocarveol, isopulegol, *trans*-carveol, (E)-tagetenone, hexyl 2-methylbutyrate, cuminyl alcohol, carvacrol, isothujyl acetate, hexyl tiglate, α-copaene, an isomer of α-bergamotene, β-cedrene, ar-curcumene, cubebol, (E)-nerolidol, humulene epoxide II and *cis*-14-muurol-5-en-4-one were also characterized in this Polish lavender flower oil.

Dohi et al. (2009) screened a commercial oil of French lavender for its acetylcholinesterase activity. The composition of this oil was determined to be as follows:

α-pinene (0.1%)
camphene (0.2%)
β-pinene (0.1%)
limonene (0.5%)
1,8-cineole (1.2%)
linalool (34.0%)
camphor (0.5%)
borneol (1.0%)
terpinen-4-ol (1.7%)
α-terpineol (1.0%)
linalyl acetate (36.0%)
β-caryophyllene (4.5%)

Lavender oil produced from *L. angustifolia* plants grown and distilled in Indian Kashmir was determined by Inouye et al. (2010) to contain the following major components:

limonene (1.2%)
p-cymene (2.8%)
linalool (27.1%)
linalyl acetate (45.2%)
α-terpineol (2.2%)
β-caryophyllene (4.6%)

An oil produced from the fresh flowers of *L. angustifolia* by hydrodistillation for 3 hr that were harvested from an experimental garden in Bageshwer (Uttarakhand, India) was the subject of analysis by Verma et al. (2010). Using GC-FID and GC/MS as their method of analysis, the oil was found to contain the following constituents:

limonene (1.2%)
p-cymene (2.8%)
linalool (27.1%)
linalyl acetate (45.2%)
α-terpineol (2.2%)
β-caryophyllene (4.6%)

An analysis by Verma et al. (2010) using GC-FID and GC/MS as their method of analysis, the oil was found to contain the following constituents:

α-pinene (0.1%)
camphene (0.2%)
1-octen-3-ol (0.5%)
myrcene(0.6%)
hexyl acetate (0.1%)
p-cymene (0.1%)
limonene (0.6%)
1,8-cineole (1.1%)
(E)-β-ocimene (0.1%)
cis-linalool oxide[f] (0.2%)
trans-linalool oxide[f] (0.2%)
linalool (28.1%)
1-octen-3-yl acetate (0.4%)
camphor (0.1%)
lavandulol (0.3%)
borneol (0.9%)
terpinen-4-ol (0.6%)
p-cymen-8-ol (0.1%)
α-terpineol (3.8%)
myristol (0.1%)
nerol (0.6%)
geraniol (0.2%)
linalyl acetate (47.6%)
lavandulyl acetate (4.3%)
p-menth-8-enyl acetate (0.4%)
thymol acetate (0.1%)
neryl acetate (1.1%)
geranyl acetate (1.9%)
β-cadinene (0.1%)

T-3. Comparative percentage composition of lavender oil produced from fresh and dried flowers

Compound	Fresh flower oil	Dried flower oil
tricyclene	0.1	t
α-thujene	0.1	0.1
α-pinene	0.2	0.2
camphene	0.4	0.3
1-octen-3-ol	0.1	0.3
3-octanone	1.7	1.4
β-pinene	0.4	0.4
butylbutyrate	0.1	0.1
myrcene	1.0	1.5
hexyl acetate	0.4	0.2
lavender lactone	–	t
δ-3-carene	t	t
m-cymene	0.1	0.1
p-cymene	0.3	0.4
1,8-cineole	0.2	0.5
limonene	0.5	1.0
(Z)-β-ocimene	1.4	2.0
(E)-β-ocimene	0.5	0.9
γ-terpinene	–	t
trans-sabinene hydrate	t	t
cis-linalool oxide[f]	1.6	1.0
trans-linalool oxide[f]	1.4	0.9
rose furan	0.1	0.1
linalool	27.3	34.7
1-octen-3-yl acetate	3.8	3.6
3-octyl acetate	0.4	0.3
cis-p-menth-2-en-1-ol	t	t
nopinone[†]	–	0.1
allo-ocimene[*]	0.5	0.7
(E)-myroxide[†]	t	0.1
camphor	0.2	0.3
trans-pinocarveol	0.2	0.2
cis-verbenol	0.1	0.1
nerol oxide[†]	–	t
pinocarvone	–	0.1
lavandulol	0.6	0.8
borneol	1.2	1.5
cryptone	0.6	0.9

β-caryophyllene (0.9%)
(E)-isoeugenol (0.2%)
γ-cadinene (0.1%)
elemol (0.1%)
caryophyllene oxide (1.4%)
T-cadinol (0.7%)

f = furanoid form

Smigielski et al. (2011) compared the composition of lavender oil produced by hydrodistillation from both fresh and dried flowers. The results of this comparative study can be seen in **T-3**.

A sample of English lavender oil produced in Yorkshire by steam distillation from an unknown cultivar was analyzed by GC/MS only (Tucker 2011). The oil was found to possess the following composition:

α-pinene (0.3%)
camphene (0.3%)
β-pinene (0.2%)
δ-3-carene (0.6%)
myrcene (1.1%)
α-phellandrene (0.1%)
limonene (0.7%)
1,8-cineole (1.3%)
(Z)-β-ocimene (2.2%)
(E)-β-ocimene (1.3%)
3-octanone (1.1%)
p-cymene (0.4%)
terpinolene (0.3%)
hexyl isobutyrate (0.1%)
1-octen-3-yl acetate (1.3%)
3-octanol (0.1%)
hexyl butyrate (0.2%)
1-octen-3-ol (0.6%)
cis-linalool oxide[f] (0.3%)
camphor (2.0%)
linalool (29.8%)
linalyl acetate (30.2%)
cis-α-bergamotene (0.1%)
α-santalene (1.6%)
trans-α-bergamotene (0.6%)
β-caryophyllene (3.9%)
(Z)-β-farnesene (0.1%)
(E)-β-farnesene (1.1%)
α-terpineol (4.4%)
borneol (2.8%)
germacrene D (0.4%)
neryl acetate (1.6%)
geranyl acetate (2.8%)
δ-cadinene (0.4%)
β-sesquiphellandrene (0.1%)
nerol (0.6%)
geraniol (1.9%)
caryophyllene oxide (0.6%)
T-cadinol (0.3%)
α-bisabolol (0.1%)
coumarin (0.2%)

f = furanoid form

T-3. Comparative percentage composition of lavender oil produced from fresh and dried flowers (Cont.)

Compound	Fresh flower oil	Dried flower oil
terpinen-4-ol	1.1	2.0
(Z)-3-hexenyl butyrate	0.7	0.7
hexyl butyrate	0.3	0.2
α-terpineol	4.6	5.1
myrtenol	0.1	0.1
verbenone	0.1	0.2
β-cyclocitral†	0.1	0.1
trans-carveol	0.1	0.1
nerol	0.5	0.7
isobornyl formate†	–	0.2
cuminaldehyde	0.2	0.2
carvone	t	0.1
linalyl acetate	22.4	19.7
geraniol	1.1	0.6
lavandulyl acetate	5.7	4.5
piperitenone†	0.2	0.1
α-terpinyl acetate	–	t
neryl acetate	1.4	1.2
geranyl acetate	2.6	2.3
hexyl hexanoate	0.2	0.1
α-copaene	0.1	t
cis-α-bergamotene	0.1	t
α-sentalene	0.6	0.4
β-caryophyllene	1.1	1.0
trans-β-bergamotene†	1.1	1.0
(Z)-β-farnesene	0.2	0.2
α-humulene	0.2	0.1
germacrene D	0.3	0.1
β-bisabolene	t	t
γ-cadinene	0.3	0.4
trans-calamenene	0.1	t
caryophyllene oxide	0.1	t
humulene epoxide II	0.1	0.1
1,10-di-epi-cubenol†	0.1	0.1
T-cadinol	1.1	1.0

f = furanoid form
*correct isomer not identified
t = trace (< 0.05%)
†identity requires corroboration

Trace amounts (< 0.05%) of tricyclene, sabinene, α-terpinene and (E,E)-1,3,5-undecatriene were also characterized in this oil.

An oil of lavender produced in the United States that was screened for its insect activity against the cotton leafworm by Pavela (2012) was determined by GC-FID and GC/MS to possess the following composition:

limonene (1.6%)
1,8-cineole(2.1%)
(Z)-β-ocimene (4.3%)
(E)-β-ocimene (1.6%)
linalool (31.2%)
borneol (1.7%)
terpinen-4-ol (2.7%)
α-terpineol (1.7%)
linalyl acetate (33.3%)
lavandulyl acetate (6.5%)
β-caryophyllene (6.2%)
α-humulene (1.5%)

Raina and Negi (2012) produced an oil of Lavender from the dried flowering spikes of plants grown in Bhowali (Uttarakhand, India) by hydrodistillaion in 1.56% yield. using GC-FID and GC/

MS. The oil was found to possess the following constituents:

α-pinene (0.1%)
camphene (0.2%)
3-octanol (0.4%)
myrcene (1.6%)
p-cymene (0.6%)
limonene (0.6%)
1,8-cineole (1.5%)
(Z)-β-ocimene (1.5%)
cis-linalool oxide[f] (0.2%)
trans-linalool oxide[f] (0.3%)
terpinolene (0.8%)
linalool (23.6%)
camphor (1.4%)
borneol (1.4%)
terpinen-4-ol (2.0%)
α-terpineol (6.3%)
nerol (0.1%)
geraniol (3.3%)
linalyl acetate (35.8%)
bornyl acetate (0.1%)
lavandulyl acetate (4.8%)
neryl acetate (0.2%)
geranyl acetate (1.3%)
β-caryophyllene (1.8%)
caryophyllene oxide (1.7%)

f = furanoid form

Saeidnia et al. (2012, 2014) determined using SPME-GC/MS that the headspace volatiles of young leaves of *L. angustifolia* were as follows:

myrcene (3.0%)
limonene (1.3%)
1,8-cineole (0.9%)
(E)-β-ocimene (2.2%)
linalool (31.0%)
camphor (0.9%)
borneol (1.2%)
terpinen-4-ol (2.9%)
α-terpineol (6.3%)
linalyl acetate (18.2%)
lavandulyl acetate (10.7%)
β-caryophyllene (5.2%)

Bovil (2013) noted that the main constituents of organic lavender oil were:

1,8-cineole (0–1.0%)
β-ocimene[a] (5.5–16.0%)
linalool (25.0–38.0%)
linalyl acetate (25.0–45.0%)
camphor (0–0.5%)
terpinen-4-ol (0.1–6.0%)

[a]both (Z)- and (E)-β-isomers

Lavender flowers that were harvested from a plantation in Wielkopolska (a region of Poland) were initially air-dried at 25°C. An aliquot of these dried flowers were subjected to hydrodistillation for 4 hr to produce an oil in 1.21% yield and the distillation waiter from which the hydrolate was obtained in a yield of 0.024%. Analysis of the oil and hydrolates was performed using GC/FID and GC/MS by Smigielski et al. (2013). The constituents characterized in the oil were:

α-pinene (0.3%)
camphene (0.6%)
1-octen-3-ol (0.2%)
3-octanone (1.5%)
myrcene (1.8%)
hexyl acetate (0.4%)
m-cymene (0.1%)
p-cymene (0.6%)
limonene (0.8%)
1,8-cineole (2.2%)
(Z)-β-ocimene (0.4%)
(E)-β-ocimene (0.4%)
cis-linalool oxide[f] (3.2%)
trans-linalool oxide[f] (2.1%)
linalool (24.6%)
1-octen-3-yl acetate (3.4%)
cis-p-menth-2-en-1-ol (0.4%)
allo-ocimene[*] (0.1%)
trans-pinocarveol (0.6%)
cis-verbenol (0.2%)
camphor (0.9%)
lavandulol (0.8%)
borneol (6.2%)
cryptone (2.7%)
terpinen-4-ol (2.3%)
hexy butyrate (0.2%)
α-terpineol (3.5%)
verbenone (0.4%)
myrtenol (0.1%)
β-cyclocitral[a] (0.3%)
trans-carveol (0.2%)
nerol (0.6%)
cuminaldehyde (0.4%)
linalyl acetate (14.4%)
geranial (0.2%)
cuminyl alcohol (1.0%)
lavandulyl acetate (3.5%)
neryl acetate (0.8%)
geranyl acetate (1.8%)
β-caryophyllene (1.7%)
(Z)-β-farnesene (0.2%)
δ-cadinene (1.2%)
caryophyllene oxide (5.2%)
carotola (0.6%)
α-cadinol (1.2%)
daucol[a] (0.3%)

[*]correct isomer not identified; f = furanoid form; [a]identify requires corroboration

In contrast, the hydrate (or hydrosol) was found to possess the following composition:

hexyl acetate (2.3%)
1,8-cineole (1.3%)
cis-linalool oxide[f] (6.6%)
trans-linalool oxide[f] (5.2%)
linalool (26.5%)
1-octen-3-yl acetate (0.8%)
trans-pinocarveol (0.4%)
cis-verbenol (0.2%)
camphor (0.6%)
lavandulol (1.1%)
borneol (9.0%)
cryptone (3.8%)
terpinen-4-ol (3.0%)
hexyl butyrate (0.4%)
α-terpineol (5.3%)
β-cyclocitral[a] (0.3%)
trans-carveol (0.6%)
nerol (0.6%)
geraniol (2.0%)
cuminyl alcohol (2.0%)
lavandulyl acetate (1.1%)
neryl acetate (3.2%)
geranyl acetate (4.8%)
α-cadinol (3.2%)

[f]furanoid form; [a]identify requires corroboration

It is surprising that Jianu et al. (2013) harvested lavender at full flowering from plants grown in western Romania. The oil produced from the fresh material in 1.13% yield was subjected to analysis by GC/MS only. The surprise was that the authors reported that the main components (those in excess of 10%) were b-phellandrene (16.0%), 1,8-cineole (15.7%) and β-caryophyllene (24.1%) and only minor amounts of linalool and linalyl acetate. The authors also examined the antimicrobial activity of this oil which will now become an example of inaccurate information in the public domain.

An oil of *L. angustifolia* that was produced in S. Africa was analyzed by de Rapper (2013). The constituents characterized in this oil that was examined by GC-FID and GC/MS were as follows:

α-pinene (0.1%)
camphene (0.1%)
myrcene (0.2%)
limonene (0.1%)
1,8-cineole (0.5%)
(E)-β-ocimene (3.0%)
γ-terpinene (0.1%)
(Z)-β-ocimene (2.1%)
3-octanone (0.4%)
p-cymene (0.1%)
hexyl butyrate (0.1%)
allo-ocimene[*] (0.5%)
1-octen-3-yl acetate (0.8%)
3-octanol (0.1%)

hexyl butyrate (0.3%)
cis-linalool oxide[f] (0.2%)
trans-linalool oxide[f] (0.1%)
camphor (0.3%)
linalool (31.4%)
linalyl acetate (36.7%)
α-santalene (0.4%)
α-bergamotene[*] (0.1%)
terpinen-4-ol (14.9%)
β-farnesene[*] (1.4%)
lavandulol (1.2%)
cryptone (0.2%)
α-terpineol (0.1%)
borneol (0.7%)
γ-cadinene (0.2%)
cuminaldehyde (0.1%)
p-cymen-8-ol (0.3%)
thymol (0.1%)

[*]collect isomer not identified; f = furanoid form

Trace amounts (< 0.1%) of α-thujene, β-methylbutyrate, α-cedrene, carvone and caryophyllene oxide were also found in this oil.

Maietti et al. (2013) analyzed an oil of lavender (cultivar unknown) and determined that it contained:

α-thujene (0.2%)
α-pinene (0.3%)
camphene (0.2%)
sabinene (0.1%)
3-octanone (1.6%)
myrcene (3.1%)
3-octanol (0.4%)
α-phellandrene (0.1%)
α-terpinene (0.2%)
p-cymene (0.3%)
limonene (0.9%)
(Z)-β-ocimene (0.9%)
(E)-β-ocimene (2.4%)
γ-terpinene (0.5%)
cis-sabinene hydrate (0.3%)
cis-linalool oxide[f] (0.3%)
trans-linalool oxide[f] (0.2%)
terpinolene (0.2%)
linalool (36.2%)
1-octen-3-yl acetate (0.2%)
allo-ocimene[*] (1.2%)
camphor (1.0%)
borneol (2.4%)
terpinen-4-ol (16.1%)
α-terpineol (0.3%
isobornyl formate (0.2%)
linalyl acetate (17.1%)
bornyl acetate (0.1%)
lavandulyl acetate (2.5%)
neryl acetate (0.8%)
geranyl acetate (1.5%)
β-caryophyllene (1.8%)
α-santalene (0.2%)
farnesene[*] (0.2%)
α-humulene (0.1%)
farnesene[*] (0.1%)
(E)-β-farnesene (5.4%)
caryophyllene oxide (0.1%)

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

Trace amounts (< 0.05%) of β-pinene, 1-octen-3-ol, hexyl acetate, 1,8-cineole, hexyl isobutyrate, hexyl butyrate and (Z)-β-farnesene were also characterized in this oil.

Zheliazkov et al. (2013) determined that the yield of lavender oil during steam distillation of dried lavender flowers (purchased commercially) did not increase after 60 min distillation time.

The allelopathic potential of some oils produced from aromatic plants found growing in Tunisia was the subject of study by Ben Haj Jilani et al. (2014). One of the oils screened which was analyzed by GC/FID and GC/MS was lavender flower oil. This oil was found to possess the following composition:

α-thujene (0.2%)
α-pinene (1.0%)
sabinene (0.4%)
1-octen-3-ol (0.6%)
myrcene (0.5%)
δ-3-carene (0.3%)
m-cymene (0.3%)
p-cymene (0.8%)
1,8-cineole (11.1%)
(Z)-β-ocimene (3.6%)
(E)-β-ocimene (0.4%)
γ-terpinene (0.3%)
cis-linalool oxide[f](0.4%)
terpinolene (0.4%)
linalool (38.0%)
camphor (12.6%)
borneol (8.0%)
lavandulol (1.5%)
terpinen-4-ol (8.2%)
cryptone (0.6%)
α-terpineol (1.0%)
bornyl acetate (0.3%)
lavandulyl acetate (1.2%)
carvacrol (0.5%)
cyclofenchene[†] (2.3%)
β-caryophyllene (0.5%)
(E)-β-farnesene (1.5%)
germacrene D (0.3%)
caryophyllene oxide (0.2%)

f = furanoid form; [†] = incorrect identification

As can be seen the composition of this oil that was produced form the flowers of *L. officinalis* is totally dissimilar to that normally found in a lavender oil. Fresh lavender flowers were purchased from a local market in southern Turkey by Süntar et al. (2014). Hydrodistillation of these flowers yielded an oil in 6.0% yield. The oil was analyzed using GC/MS only. The results of this analysis can be seen as follows:

3-octanone (0.1%)
1,8-cineole (3.1%)
limonene (3.1%)
trans-linalool oxide[f] (0.8%)

cis-linalool oxide[f] (0.2%)
linalool (33.3%)
camphor (9.8%)
hexyl isobutyrate (0.5%)
thujyl alcohol (0.8%)
borneol (2.9%)
terpinen-4-ol (0.1%)
myrtenol (0.1%)
α-terpineol (3.5%)
hexyl butyrate (3.9%)
γ-terpineol[†] (0.6%)
nerol (0.2%)
hexyl isovalerate (0.2%)
hexyl valerate (0.3%)
geraniol (1.4%)
linalyl acetate (19.7%)
(E)-anethole (0.7%)
isobornyl acetate (0.2%)
thymol (0.1%)
lavandulyl acetate (0.9%)
hexyl tiglate (1.3%)
neryl acetate (1.4%)
geranyl acetate (2.6%)
hexyl hexanoate (0.1%)
β-caryophyllene (0.3%)
(E)-β-farnesene (0.2%)
α-amorphene (0.1%)
valencene (0.3%)
caryophyllene oxide (6.2%)
T-cadinol (0.6%)
bisabolol oxide B (0.4%)
α-bisabolol (2.9%)

[†]does not occur naturally; f = furanoid form

Trace amounts (<0.05%) of p-cymene and *trans*-carveol were also characterized in this oil.

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