Progress in Essential Oils

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Lavender Oil

An oil of lavender that was obtained commercially in Trieste (Italy) was screened for its toxicity by Evandri et al. (2005). The oil, which was found to possess no mutagenic activity using the bacterial reverse mutation assay, was determined by GC/MS to contain the following major components:

2-octanone[a] + myrcene (2.4%)
limonene (0.3%)
1,8-cineole (0.6%)
(E)-β-ocimene (1.5%)
linalool (32.7%)
camphor (0.5%)
borneol (0.8%)
terpinen-4-ol (3.1%)
α-terpineol (1.0%)
linalyl acetate (43.1%)
β-caryophyllene (4.9%)
(E)-β-farnesene (0.8%)
α-humulene (0.4%)
caryophyllene oxide (0.5%)

[a]probably 3-octanone

The authors found that the lavender oil screened exerted strong antimutagenic activity and as would be expected the activity was concentration-dependent.

As part of a screening study of certain essential oils against the cabbage aphid, Pavela (2006) determined that a commercially available lavender oil, which was found to be quite toxic to the aphid, possessed the following composition:

camphene (0.3%)
α-terpinene (2.8%)
1,8-cineole (1.1%)
linalool (30.0%)
linalyl acetate (45.3%)
α-terpineol (15.3%)
geraniol (2.4%)

Lavender oil produced from the flowers of *L. angustifolia* grown in Iran (cultivar unknown) was used in an antifungal screening study by Hadian et al. (2008). The main components characterized in this oil were:

myrcene (1.4%)
(Z)-β-ocimene (2.7%)
linalool (49.2%)
borneol (1.2%)
terpinen-4-ol (5.9%)
α-terpineol (5.7%)
lavandulyl acetate (12.3%)
neryl acetate (6.5%)
geranyl acetate (1.5%)
β-caryophyllene (2.9%)
(Z)-β-farnesene (1.9%)

This oil was very atypical as linalyl acetate was not determined to be a major component.

Kiran Babu and Singh (2007) analyzed the composition of an oil and hydrosol oil of *L. angustifolia* "Sher-e-Kashmir" using both GC-FID and GC/MS. To obtain the hydrosol oil, the authors redistilled the distillation water. The composition of the oil was determined to be as follows:

α-pinene (0.2%)
camphene (0.4%)
β-pinene (0.1%)
sabinene (0.1%)
δ-3-carene (0.2%)
myrcene (2.0%)
limonene (1.1%)
1,8-cineole (1.4%)
(Z)-β-ocimene (2.3%)
(E)-β-ocimene (3.0%)
p-cymene (0.3%)
terpinolene (0.4%)
1-octen-3-yl acetate (0.9%)
camphor (0.2%)
linalool (28.8%)
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%)
lavandulyl acetate (1.8%)
α-humulene (0.3%)

In contrast, the hydrosol oil was found to possess the following composition:

myrcene (0.2%)
limonene (0.1%)
1,8-cineole (1.5%)
(Z)-β-ocimene (0.1%)
(E)-β-ocimene (0.3%)
terpinolene (0.2%)
cis-linalool oxiode[f] (1.6%)
trans-linlool oxide[f] (1.2%)
camphor (0.8%)
linalool (54.6%)
terpinen-4-ol (2.0%)
lavandulyl acetate (0.1%)
cryptone (2.9%)

[f]furanoid form

It is a shame that the authors did not compare the redistilled hydrosol oil with a solvent extract of the distillation water to see if the two compositions were comparable.

Stoyanova and Grozeva (2008) reviewed the production and published data on Bulgarian lavender oil. They reported that oil production has varied from a high of 84.4 tonnes in 1989 to a low of 21.1 tonnes in 1997. They also reported on the major components found in Bulgarian lavender oils produced from different cultivars grown there on a commercial basis. A summary of these results can be seen in **T-1**. Although all of these cultivars are grown, the main ones are "Druzba," "Hemus" and "Raya." Using chiral

GC, Stoyanova and Grozeva reported the chirality of three oil components as follows:

(3R)-(-)-linalyl acetate (100%):(3S)-(+)-linalyl acetate (0%)

(3R)-(-)-linalool (95.0–96.6%):(3S)-(+)-linalool (3.4–5.0%)

(3R)-(+)-camphor (27.4–52.2%):(3S)-(-)-camphor (47.8–78.6%)

Lavender flowers that were collected from Provence (France) and shade-dried were subjected to a microwave steam distillation process in the laboratory (Sahroui et al., 2008). Analysis of the oil showed that the oil composition produced this way was comparable with the oil produced using the traditional steam distillation process. The obvious difference between the two processes was that the microwave process took 6 min, while the normal process took 30 min. The oil composition of the lavender flowers produced by the microwave steam distillation process was found to be as follows:

hexanol (0.3%)
α-pinene (0.7%)
camphene (0.8%)
sabinene (0.2%)
β-pinene (0.8%)
3-octanone (1.4%)
3-octanol (0.3%)
1,8-cineole (14.4%)
(Z)-β-ocimene (0.3%)
(E)-β-ocimene (0.5%)
cis-sabinene hydrate (0.3%)
cis-linalool oxide[f] (1.4%)
trans-linalool oxide[f] (0.6%)
linalool (42.5%)
camphor (8.1%)
citronellal (1.9%)
pinocarvone (0.1%)
borneol (9.4%)
terpinen-4-ol (0.1%)
α-terpineol (0.1%)
hexyl butyrate (1.1%)
verbenone (0.1%)
isobornyl acetate (0.3%)
carvone (0.3%)
linalyl acetate (3.9%)
bornyl acetate (0.1%)
lavandulyl acetate (0.3%)
hexyl tiglate (0.6%)
hexyl hexanoate (0.3%)
β-caryophyllene (0.5%)
(E)-β-farnesene (0.3%)
germacrene (0.1%)
caryophyllene oxide (1.4%)
α-bisabolol (0.3%)

[f]furanoid form

Trace amounts (<0.1%) of geranyl acetate, α-santalene, *trans*-α-bergamotene, a curcumene isomer and α-cadinol were also found in this oil. However, it is very peculiar that a lavender flower oil produced from lavender flowers collected from the lavender growing region of southern

Percentage composition of the main components of Bulgarian lavender cultivar oils **T-1**

Compound	1	2	3	4	5	6
3-octanone	0.1	2.6	1.3	2.5	1.6	2.3
limonene	0.3	0.2	0.2	0.8	0.4	0.6
1,8-cineole + β-phellandrene	0.8	1.1	0.2	2.2	1.0	1.7
(Z)-β-ocimene	6.4	3.6	7.5	3.1	9.0	4.8
(E)-β-ocimene	0.9	2.2	4.5	2.9	4.5	2.5
linalool	30.4	31.8	19.1	22.3	23.1	29.0
camphor	0.1	0.1	0.2	0.1	0.1	0.1
terpinen-4-ol	1.5	3.6	6.8	0.5	0.7	0.2
α-terpineol	0.9	0.8	0.7	0.9	0.7	0.8
linalyl acetate	43.8	39.1	42.7	35.6	43.5	37.7
lavandulyl acetate	0.7	t	4.5	4.7	2.5	3.7
β-caryophyllene	4.2	4.0	2.5	5.7	2.5	4.0
(Z)-β-farnesene	0.5	2.6	1.2	5.2	2.5	2.3

t = trace (<0.1%)
Cultivar oils: 1 = "Druzba," 2 = "Hemus," 3 = "Yubileina," 4 = "Sevelopolis," 5 = "Hebal," 6 = "Raya"

Percentage composition of the main components of lavender oils produced from different cultivars **T-2**

Compound	1	2	3	4	5	6	7	8	9	10
β-pinene	-	-	-	-	-	-	-	-	2.2	-
myrcene	9.7	9.8	9.3	5.6	12.9	12.5	11.9	10.8	6.4	12.8
limonene	2.7	3.0	4.0	2.2	3.8	3.7	3.2	3.9	1.3	7.4
1,8-cineole	5.1	8.2	6.9	3.7	3.8	6.8	-	5.7	2.7	-
(Z)-β-ocimene	7.7	12.3	6.5	14.3	9.7	8.5	4.3	7.7	11.4	2.6
(E)-β-ocimene	7.8	6.1	6.3	6.4	9.7	9.4	8.0	7.2	4.6	7.6
linalool	41.4	26.6	37.9	27.7	17.9	19.2	43.7	30.3	47.8	34.3
linalyl acetate	6.1	6.6	6.2	0.6	14.5	10.5	7.8	7.4	-	-
β-caryophyllene	-	-	-	-	0.7	-	-	-	-	-
terpinen-4-ol	4.1	7.2	3.5	19.0	2.5	2.0	-	-	-	0.6
lavandulyl acetate	2.3	1.4	7.1	2.8	6.5	9.4	-	7.7	-	-
lavandulol	2.1	2.1	2.4	5.1	0.5	-	-	2.5	1.8	-
α-terpineol	3.3	-	2.8	0.5	3.7	3.0	5.6	4.2	-	-
borneol	0.4	2.2	-	1.4	-	2.4	3.0	1.7	1.6	2.7

Cultivar oils: 1 = 'Royal Velvet,' 2 = 'Royal Purple,' 3 = 'Munstead,' 4 = 'Bowles,' 5 = 'Premier,' 6 = 'Hidcote,' 7 = 'Mailette,' 8 = 'Lady,' 9 = 'LL Clone,' 10 = 'OK Farm, English'

France should contain such a minuscule amount of linalyl acetate and such a high level of 1,8-cineole and camphor. It would appear to this reviewer that the authors mistakenly collected spike lavender flowers, not lavender flowers which would explain their analytical anomaly.

The antimicrobial activity of a number of herb oils was examined to determine their effect on some potentially dangerous food contaminant microbes. Among the oils screened by Romeo et al. (2008) lavender oil obtained commercially in Italy was found 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[†] (0.1%)
ethyl hexanoate (0.1%)
δ-3-carene (0.1%)
p-cymene (0.3%)
limonene (0.3%)
1,8-cineole (8.4%)
(E)-β-ocimene (0.3%)
(Z)-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%)
geranial (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%)

[†]probably 3-octanone
[f]furanoid form

Furthermore, the authors found that the antimicrobial activity was directly related to the screening method used because different methods yielded different results.

Lane and Mahmoud (2008) examined the oil compositions of various lavender cultivars that were grown and lab-distilled in Canada. The cultivars examined are commercially available in the horticultural trade. In addition, three oils were obtained from a small commercial distiller in Kelowna (British Columbia (BC), Canada). The main components characterized in the various lavender oils are shown in **T-2**. A survey of the data presented in T-2 shows that the oils produced in the Kelowna area of BC do not have compositions similar to the commercially available lavender oils from France or Bulgaria. Not only are the extrinsic conditions found in BC dissimilar to those found in the above-noted growing regions in Europe, the intrinsic conditions (ie, clones grown) are certainly not the same. As a result, although the oils are all lavender oils, they have little resemblance to the lavender oils encountered in commerce.

Using electrothermal atomic absorption spectrometry, Bozhanov and Karadjova (2008) examined the trace metals found in Bulgarian lavender oil. The trace metals found in the oils in ng/g amounts were as follows:

bismuth:	2.39–4.92
cadmium:	0.32–0.82
copper:	5.8–9.7
chromium:	0.5–0.7
iron:	97–840
manganese:	20–450
nickel:	1.23–2.32
antimony:	3.1–5.7
lead:	0.84–1.32

The authors noted that the level of iron and manganese was directly related to the quality of the process equipment used to produce and store the oil.

Williams (2008) reported that Bulgarian lavender oil has been found to contain the following components:

α-pinene (0.2%)
camphene (0.2%)
1-octen-3-ol (0.2%)
sabinene + δ-octanone (0.5%)
myrcene (0.6%)
hexyl acetate (0.3%)
1,8-cineole (1.0%)
limonene (0.3%)
(Z)-β-ocimene (5.8%)
(E)-β-ocimene (2.6%)
linalool (24.0%)
1-octen-3-yl acetate (0.8%)
camphor (0.2%)
borneol (0.8%)
lavandulol (0.9%)
terpinen-4-ol (4.3%)
α-terpineol (0.9%)
linalyl acetate (39.1%)
bornyl acetate (0.2%)
lavandulyl acetate (3.8%)
neryl acetate (0.3%)
geranyl acetate (0.5%)
β-caryophyllene + α-santalene (4.4%)
(E)-β-farnesene (2.5%)
germacrene D (0.3%)
caryophyllene oxide (0.2%)

Trace amounts (assumed to be less than 0.1%) of β-pinene, δ-3-carene, p-cymene, γ-terpinene, terpinolene, an allo-ocimene isomer, cryptone, hexyl butyrate, *trans*-α-bergamotene, T-cadinol, 3-octanol, *cis*-linalool oxide (furanoid), *trans*-linalool oxide (furanoid), *cis*-α-bergamotene, nerol and geraniol were also found in this oil.

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