Progress in Essential Oils

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Lebanon Cedar Needle Oil and Extract

The needles of *Cedrus libani* A. Rich. Subsp. *libani* or *C. libani* subsp. *stenocoma* (O. Schwarz) P.H. Davis are the two sources of Lebanon cedar needle isolates.

Kolesnikova et al. (1980) reported that a needle oil of *C. libani* (no subspecies given) contained α-pinene (90.9%) as its major constituent.

The components identified in three needle extracts of *C. libani* subsp. *libani* by Fleisher and Fleisher (2000) were as follows:

α-pinene (15.7–26.9%)
camphene (0.3–0.7%)
β-pinene (2.1–12.8%)
sabinene (0.1–0.4%)
δ-3-carene (0.1–0.5%)
myrcene (2.7–6.3%)
limonene (4.5–7.1%)
β-phellandrene (0.6–1.6%)
γ-terpinene (0.1–0.2%)
p-cymene (0.1%)
terpinolene (0.1–0.2%)
(Z)-3-hexenyl acetate (0.0–0.1%)
(Z)-3-hexenol (0.3–0.4%)
acetic acid (0.4–0.7%)
α-copaene (0.2–0.6%)
β-bourbonene (t–1.0%)
bornyl acetate (0.0–0.4%)
β-cubebene (0.0–0.2%)
β-caryophyllene (2.9–7.1%)
β-sesquiphellandrene (0.0–0.2%)
α-humulene (0.5–0.7%)
α-amorphene (0.0–0.8%)
α-terpineol (t–0.1%)
germacrene D (5.3–19.8%)
borneol (0.0–0.5%)
neryl acetate (0.0–0.7%)
geranial (0.0–0.3%)
(Z)-α-bisabolene (2.5–4.7%)
δ-cadinene (0.0–0.1%)
geranyl acetate (0.0–0.1%)
α-muurolene (0.0–0.4%)
2-methylbutyric acid (0.0–0.2%)
benzyl alcohol (t–1.2%)
2-phenethyl alcohol (0.4–1.5%)
caryophyllene oxide (0.1–0.7%)
germacrene-D-4-ol (0.0–0.1%)
dodecanoic acid (0.0–0.8%)
phenylacetic acid (0.0–4.1%)
tetradecanoic acid (0.0–0.2%)
cinnamic acid (0.0–1.2%)
hexadecanoic acid (0.0–3.0%)
octadecanoic acid (0.0–0.4%)

t = trace (<0.1%)

Trace amounts (<0.1%) of β-bisabolene and 2-phenethyl acetate were also found in this needle extract. It should be noted that the authors of this study only characterized between 58.6% and 87.5% of the three extracts.

Loizzo et al. (2007) used GC/MS to analyze a needle oil of *C. libani* subsp. *libani* produced from the leaves of Lebanese origin. The constituents identified in this oil were as follows:

α-pinene (2.2%)
β-pinene (0.5%)
myrcene (0.7%)
limonene (0.4%)
bornyl acetate (0.3%)
α-cubebene (0.5%)
α-ylangene (0.3%)
α-copaene (0.7%)
β-bourbonene (0.8%)
β-caryophyllene (5.6%)
β-copaene (1.0%)
α-himachalene (1.7%)
4β,10β-guia-1(5),6-diene (0.6%)
α-humulene (1.3%)
muurola-4(5),5-diene* (0.3%)
γ-muurolene (4.8%)
germacrene D (29.4%)
γ-amorphene (0.5%)
α-muurolene (1.2%)
α-himachalene (0.3%)
γ-cadinene (2.9%)
δ-cadinene (5.6%)
cadina-1,4-diene (0.4%)
(E)-α-bisabolene (5.9%)
dodecanoic acid (1.7%)
salvia-4-(14)-en-1-one (4.0%)
1-epi-cubenol (6.3%)
T-cadinol (3.4%)

*incorrect nomenclature; compound listed cannot exist

In addition, trace amounts (<0.1%) of γ-terpinene, terpinolene, *trans*-pinocarveol, *cis*-verbenol, terpinen-4-ol, isopimara-7,15-diene, isopimara-8,15-diene and manool were also characterized in this oil.

In contrast, Loizzo et al. found that the composition of Lebanon cedar cone oil was as follows:

α-pinene (51.0%)
camphene (2.2%)
myrcene (13.0%)
β-phellandrene (0.7%)
δ-3-carene (0.7%)
α-terpinene (0.6%)
p-cymene (0.7%)
limonene (2.3%)
γ-terpinene (0.6%)
terpinolene (3.1%)
terpineol* (0.7%)
α-terpineol (0.4%)
bornyl acetate (0.4%)
longifolene (0.2%)
(E)-β-farnesene (0.6%)
(E)-α-bisabolene (1.4%)
abietatriene (1.0%)
abieta-7,13-diene (3.2%)
abieta-8(14),13(15)-diene (0.3%)

*correct isomer not identified

R.D. Kolesnikova, A.I. Chernodubov and R.I. Deryuzhkin, *Composition of essential oils of some* Pinus *and* Cedrus *species.* Rastit. Resur., **16**(1), 108–112 (1980).

A. Fleisher and Z. Fleisher, *Aromatic Plants of the Holy Land and the Sinai. Part XIV. The volatiles of the leaves and wood of Lebanon cedar (*Cedrus libani *A. Rich.).* J. Essent. Oil Res., **12**, 763–765 (2000).

M.R. Loizzo, A.M. Saab, G.A. Statti and F. Menichini, *Composition and α-amylase inhibitory effect of essential oils from* Cedrus libani. Fitoterapia, **78**, 323–326 (2007).

Eucalyptus citriodora Oil

The oil of *Eucalyptus citriodora* is produced from the leaves of *Corymbia citriodora* (Hook.) K.D. Hill ex L.A.S. Johnson (syn. *Eucalyptus citriodora* Hook.). As the synonym is generally used in the essential oil trade, it will be used throughout this review.

A commercial oil of *Eucalyptus citriodora* was analyzed by Hethelyi et al. (2000) and found to contain the following components:

α-pinene (0.7%)
camphene (0.4%)
citronellal (82.4%)
citronellol (7.5%)

The authors also characterized two p-menthanediols but their acceptance as the constituents requires corroboration.

A commercial sample of *E. citriodora* oil of Chinese origin was screened for its antioxidant activity by Jirovetz et al. (2007). The oil used in this study was found to possess the following composition:

isobutyl isobutyrate (0.1%)
α-pinene (0.9%)
camphene (0.1%)
sabinene (0.1%)
β-pinene (0.7%)
myrcene (0.1%)
α-phellandrene (0.1%)
p-cymene (0.1%)
limonene (0.2%)
1,8-cineole (0.5%)
β-phellandrene (0.2%)
citronellal (76.3%)
γ-terpinene (0.1%)
terpinolene (0.1%)
linalool (0.5%)
neoisopulegol (5.5%)
isopulegol (2.8%)
neoiso(iso)pulegol (0.3%)
terpinen-4-ol (0.2%)
α-terpineol (0.1%)
citronellol (5.7%)
geraniol (0.4%)
citronellyl acetate (0.9%)
geranyl acetate (0.1%)
β-caryophyllene (1.2%)
longifolene (0.3%)

An oil produced from the leaf litter of *E. citrodora* growing in Hawaii was analyzed by GC and GC/MS by Chen et al. (2007). The components characterized in this oil were:

α-pinene (2.2%)
camphene (0.1%)
β-pinene (1.3%)
myrcene (0.7%)
α-terpinene (11.2%)
limonene (2.4%)
γ-terpinene (0.5%)
linalool (1.3%)
isopulegol (3.3%)
citronellal (42.8%)
α-terpineol (1.6%)
citronellol (17.9%)
β-caryophyllene (0.2%)

As part of an antifungal screening of oils obtained from the Myrtaceae family, Lee et al. (2009) analyzed an oil of *E. citriodora* and found that it contained the following constituents:

α-pinene (0.1%)
β-pinene (0.4%)
p-cymene (0.5%)
1,8-cineole (0.4%)
limonene (0.1%)
linalool (0.3%)
isopulegol (7.4%)
citronellal (68.9%)
terpinen-4-ol (0.2%)
citronellol (7.6%)
citronellyl acetate (1.1%)
β-caryophyllene (0.5%)

Sultana et al. (2008) analyzed an oil produced in the laboratory using both GC-FID and GC/MS of a supposedly authenticated *E. citriodora* grown in New Delhi (India). However, the authors found that the main component of the oil was 1,8-cineole and not the expected citronellal. This reviewer suggests that the taxonomic origin of the leaves that were used for oil production was probably incorrect as a survey of the literature does not reveal any 1,8-cineole-rich chemical forms that have been characterized to date.

Six samples of *E. citriodora* oil that were produced from trees grown in Congo were the subject of analysis by Loumouamou et al. (2009) by GC-IFD and GC/MS. The range of components found in these oils was as follows:

α-pinene (0.1–0.7%)
β-pinene (0.3–0.5%)
myrcene (t–0.1%)
α-terpinene (0.0–0.2%)
p-cymene (t–0.1%)
limonene (t–0.4%)
1,8-cineole (0.0–0.7%)
β-ocimene* (0.0–t)
bergamal (0.2–0.8%)
γ-terpinene (t–0.5%)
terpinolene (t–0.1%)
linalool (0.5–0.6%)
cis-rose oxide (t–0.2%)
trans-rose oxide (0.0–0.1%)
isopulegol (2.5–5.1%)
citronellal (57.1–75.4%)
iso(iso)pulegol (0.6–4.1%)
neoisopulegol (0.7–1.3%)
neoiso(iso)pulegol (0.2–0.4%)
α-terpineol (t–0.5%)
citronellol (8.0–14.1%)
neral (0.0–0.9%)
geraniol (0.0–0.3%)
geranial (0.0–0.1%)
citronellyl formate (0.0–0.2%)
eugenol (0.0–2.6%)
methyl eugenol (0.0–2.1%)
β-caryophyllene (0.2–0.7%)
α-humulene (t–0.2%)
bicyclogermacrene (0.0–0.2%)
γ-cadinene (0.0–t)
elemol (0.0–3.1%)
spathulenol (0.0–0.2%)
caryophyllene oxide (0.0–0.5%)
globulol (0.0–0.1%)
γ-eudesmol (0.0–2.2%)
T-cadinol (0.0–0.4%)
α-eudesmol (0.0–0.1%)

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

T-1 Comparative percentage composition of oils of *Eucalyptus citriodora* produced from immature, half-mature and fully mature leaves, and twigs harvested in two seasons

Compound	Immature leaf oil	Half-mature leaf oil	Mature leaf oil	Twig oil
α-pinene	0.2–0.3	0.0–t	0.0–0.3	0.5–1.2
camphene	-	-	-	0.0–t
β-pinene	0.6–	0.3–0.8	0.6–0.8	1.1–1.9
sabinene	0.0–t	-	-	-
myrcene	t–0.2	t–0.1	t	0.2
limonene	0.0–0.1	0.0–t	-	t–0.2
1,8-cineole	0.0–0.5	t–0.3	0.0–0.3	0.5–0.6
β-phellandrene	0.0–0.2	0.0–t	-	2.0–2.4
(Z)-β-ocimene	0.0–0.3	-	-	0.9–1.2
(E)-β-ocimene	-	-	-	t–0.2
p-cymene	0.0–0.5	-	-	-
cis-rose oxide	-	-	0.0–t	t
citronellal	79.9–80.0	85.0–86.0	82.8–83.5	66.5–70.2
linalool	0.2–0.3	0.3	0.2	0.4–0.8
linalyl acetate	1.4–1.8	0.8–1.5	1.3–1.6	1.1–1.6
isopulegol	3.5–4.2	2.2–3.6	3.1–3.8	2.6–4.6
β-caryophyllene	0.2–0.4	0.4–0.6	0.1–0.7	1.9–4.6
terpinen-4-ol	0.1	-	0.0–t	0.2–0.3
citronellyl acetate	0.8–1.1	0.0–0.3	-	-
neral	0.0–t	-	-	1.0–1.7
geranial	0.5–0.6	-	-	-
geranyl acetate	-	-	0.0–t	-
citronellol	4.2–5.1	4.1–4.5	4.6–5.5	4.4–5.2
nerol	0.2	0.0–t	0.0–t	t
geraniol	1.9–2.8	0.2–0.3	-	0.2–1.3
caryophyllene oxide	-	-	0.0–t	0.7–1.0
eugenol	-	t–0.9	t–0.4	1.6–3.2

t = trace (<0.1%)

Vaknin et al. (2009) investigated the influence of pot size on plant height, stem diameter, dry leaf biomass and oil composition of pot-grown *E. citrodora.* Although *E. citriodora* is generally considered as a tall tree that is grown extensively around the world for its use in the wood, pulp and paper industries as well as for leaf oil production, the authors examined pot-grown plants for the production of fresh leaves for culinary and tea infusion purposes. Oils produced from the leaves of plants grown in 1–10 L pots with stem diameters of 11–20 cm were analyzed by GC/MS. The oils ranged in composition as follows:

α-pinene (0.2–0.7%)
sabinene (0.1–0.2%)
β-pinene (1.0–1.6%)
myrcene (0.3–0.5%)
p-cymene (t–0.1%)
limonene (t–0.1%)
1,8-cineole (t–0.1%)
melonal* (0.1–0.2%)
γ-terpinene (t–0.2%)

terpinolene (t–0.1%)
linalool (0.2–0.4%)
neoisopulegol (t–1.9%)
citronellal (66.9–71.2%)
iso(iso)pulegol (1.3–2.3%)
neoiso(iso)pulegol (0.2–0.5%)
citronellol (11.6–15.9%)
geraniol (t–0.2%)
geranial (0.1–0.2%)
p-vinylguaiacol (0.8–1.7%)
bicycloelemene (0.1–0.2%)
δ-elemene (t–0.1%)
citronellyl acetate (1.2–2.4%)
eugenol (0.6–1.0%)
geranyl acetate (0.2–1.1%)
2-phenethyl isobutyrate (0.1–0.2%)
β-caryophyllene (5.5–6.5%)
citronellyl propionate (t–0.1%)
(E)-isoeugenol (t–0.3%)
α-humulene (0.4%)
bicyclogermacrene (0.2–0.3%)
spathulenol (t–0.1%)
caryophyllene oxide (0.2%)

*also known as 2,6-dimethyl-5-heptenal; t = trace (<0.1%)

Trace amounts (<0.1%) of (E)-β-ocimene, neryl acetate, allo-aromadendrene and geranyl isobutyrate were also characterized in these oils.

Vesma et al. (2009) compared the leaf oil compositions of *E. citriodora* that were produced from immature, half-mature and fully mature leaves, and twigs harvested from trees grown in the vicinity of Bageshwas (Uttarakhand, India). A summary of their findings is presented in **T-1**. In addition, the authors showed that the longer the harvested leaves were stored either under field conditions or in the shad, the citronellal content of the oil was reduced from 86.4–77.3% (field stored for five days) and from 85.5–76.9% (shade stored for five days). There were changes in the amounts of the other oil constituents; however, these are not important.

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