Progress in Essential Oils

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Cinnamon Leaf Oil

A commercial oil of cinnamon leaf was screened against four Gram–positive, four Gram–negative bacteria, two fungi and yeast by Lopez et al. (2005). The headspace composition of this oil as determined by poly dimethylsiloxane SPME–GC/MS was found to be as follows:

α-pinene (1.1%)
camphene (0.4%)
β-pinene (0.8%)
α-phellandrene (1.2%)
p-cymene (1.2%)
limonene (0.9%)
1,8-cineole (1.2%)
linalool (3.0%)
camphor (0.4%)
citronellal (0.2%)
borneol (0.2%)
terpinen-4-ol (0.3%)
α-terpineol (0.5%)
methyl chavicol† (1.7%)
(E)-cinnamaldehyde (0.4%)
safrole (2.8%)
thymol† (0.1%)
(E)-cinnamyl alcohol (0.1%)
α-cubebene (0.1%)
eugenol (67.0%)
hydrocinnamyl acetate (0.1%)
α-copaene (2.1%)
β-caryophyllene (8.6%)
aromadendrene (0.1%)
(E)-cinnamyl acetate (0.7%)
α-humulene (1.7%)
γ-muurolene (0.2%)
ledene (0.2%)
eugenyl acetate (0.6%)
δ-cadiene (0.3%)
cis-calamenene (0.1%)
benzyl benzoate (1.1%)

† identification in error

Cinnamon leaf oil of Sri Lankan origin was analyzed by Schmidt et al. (2006) and found to possess the following composition:

(Z)-3-hexenol (0.1%)
styrene (0.1%)
α-thujene (0.2%)
α-pinene (1.2%)
camphene (0.3%)
benzaldehyde (0.1%)
β-pinene (0.3%)
myrcene (0.1%)
α-phellandrene (0.9%)
(Z)-3-hexenyl acetate (0.1%)
α-terpinene (0.1%)
p-cymene (0.8%)
limonene (0.5%)
α-phellandrene (0.2%)
δ-3-carene (0.6%)
1,8-cineole (0.6%)
benzyl alcohol (0.2%)
(E)-β-ocimene (0.1%)
γ-terpinene (0.1%)
terpinolene (0.2%)
linalool (2.5%)
2-phenethyl alcohol (0.1%)
benzyl acetate (0.1%)
α-terpineol (0.3%)
cinnamaldehyde † (1.1%)
safrole (1.3%)
α-cubebene (0.9%)
eugenol (74.9%)
isoeugenol * (0.1%)
β-caryophyllene (4.1%)
cinnamyl acetate † (1.8%)
α-humulene (0.6%)
(E, E)-α-farnesene (1.1%)
eugenyl acetate (2.1%)
(E)-nerolidol (0.1%)
(Z)-3-hexenyl benzoate (0.1%)
caryophyllene oxide (0.5%)
benzyl benzoate (3.0%)

* Correct isomer not identified
† the (E)-form

Rajeswara Rao et al. (2006) examined the oil composition of cinnamon leaves of different sizes, positions on shrubs grown in Hyderabad, India, and from different sections of the leaf. They found that there was some variation in oil composition; however, it is of little importance to oil producers as the largest variations were found in oils obtained from different sections of the leaf. The range of composition determined was found to be as follows:

α-pinene (t–1.1%)
camphene (0.1–0.2%)
β-pinene (0.1–0.2%)
myrcene (0.3–1.1%)
limonene (0.1–0.2%)
1,8 cineole (0.1–0.2%)
p-cymene (0.1–0.3%)
linalool (0.2–1.3%)
linalyl acetate (0.4–0.8%)
terpinen-4-ol (t–0.2%)
α-terpineol (t–0.3%)
piperitone (t–0.3%)
geraniol (t–0.2%)
safrole (t–0.2%)
(E)-cinnamaldehyde (0.1–1.4%)
(Z)-cinnamyl acetate (t–0.1%)
eugenol (79.0–91.0%)
eugenyl acetate (1.6–8.0%)
(E)-cinnamyl alcohol (0.1–0.2%)
benzyl benzoate (0.2–6.8%)

t= trace (< 0.1%)

Trace amount of sabinene, α-terpinene, (E)-β-ocimene and β-caryophyllene were also found in the oils.

Duplicate publications of a study by Begum et al. (2007) appeared

in two separate issues of *Indian Perfumer*. The study was on the composition and antifungal activity of cinnamon leaf oil produced in Bangladesh. The oil analysis, which was performed using GC/MS, contained numerous incorrect component identities. The components correctly characterized were:

1,8-cineole (0.2%)
linalool (0.8%)
cinnamaldehyde* (3.8%)
eugenol (72.5%)
hydrocinnamyl acetate (0.4%)
cinnamyl acetate* (2.9%)
α-copaene (0.8%)
β-caryophyllene (1.0%)
α-humulene (0.3%)
eugenyl acetate (10.0%)
caryphyllene oxide (0.1%)
benzyl benzoate (0.6%)

* the (E)-form

An oil produced from cinnamon leaves by steam distillation of leaves collected in Fiji was the subject of analysis by Patel et al. (2007). The oil was found to possess the following composition:

hexanal (0.3%)
(Z)-3-hexenal° (0.3%)
α-thujene (0.1%)
α-pinene (0.5%)
camphene (0.2%)
β-pinene (0.2%)
α-terpinene (0.1%)
p-cymene (0.1%)
limonene (0.2%)
β-phellandrene (0.5%)
1,8-cineole (0.2%)
γ-terpinene (0.1%)
trans-linalool oxide*(0.1%)
linalool (2.3%)
terpinen-4-ol (0.1%)
α-terpineol (0.1%)
(E)-cinnamaldehyde (0.3%)
eugenol (86.0%)
α-copaene (0.4%)
β-caryophyllene (5.7%)
allo-aromadendrene (0.1%)
α-humulene (0.9%)
valencene (0.2%)
bicyclogermacrene (0.2%)
δ-cadiene (0.1%)
nerolidol* (0.1%)
spathulenol (0.1%)
caryophyllene oxide (0.5%)

* correct isomer not identified
° probably (Z)-3-hexenol

Trace amounts (< 0.1%) of sabinene, benzaldehyde and myrcene were also found in this oil.

A sample of Indian cinnamon leaf oil was analyzed by Pawar and Thaker (2007) and the major constituents were found to be as follows:

benzaldehyde (11.2%)
phenylacetaldehyde (2.4%)
acetophenone (1.3%)
benzoic acid (3.6%)
(E)-cinnamaldehyde (58.5%)
cinnamic acid (16.6%)
diethyl phthalate (1.4%)

This analysis is ridiculous and is only included in this review to point out that incorrect data can find its way into the literature because of the poor editorial and reviewer programs used by journals that are recognized as authoritative sources of peer-reviewed information. This conclusion was reached because cinnamon leaf oil is rich in eugenol not cinnamaldehyde

Comparative percentage composition of two samples of cinnamon bark oil from India **T-1**

Compound	Bangalore oil	Mysore oil
α-thujene	0.07	0.05
α-pinene	1.91	0.31
camphene	0.72	-
6-methyl-5-hepten-2-one	t	-
sabinene	-	0.08
β-pinene	0.23	-
myrcene	0.09	0.09
α-phellandrene	0.39	0.22
δ-3-carene	0.10	-
α-terpinene	0.15	0.64
p-cymene	4.71	0.27
1,8-cineole	2.79	2.18
limonene	0.64	0.51
(Z)-β-ocimene	t	0.07
(E)-β-ocimene	0.08	t
γ-terpinene	0.14	0.11
cis-linalool oxide[f]	0.37	t
trans-linalool oxide[f]	0.42	0.05
terpinolene	0.10	t
linalool	13.78	4.41
hydrocinnamaldehyde	0.13	0.27
borneol	0.35	0.09
terpinen-4-ol	1.59	0.72
methyl chavicol	1.25	1.31
(Z)-cinnamaldehyde	0.07	0.06
nerol	0.12	t
neral	0.10	-
cuminaldehyde	t	-
(E)-cinnamaldehyde	59.30	60.49
bornyl acetate	t	-
(E)-cinnamyl alcohol	0.15	0.19
eugenol	1.42	1.70
3-phenylpropyl acetate	t	0.20
α-copaene	0.21	0.10
β-elemene	t	-
coumarin	0.36	-
(E)-cinnamyl acetate	t	13.58
β-caryophyllene	1.54	5.56
α-humulene	0.31	1.01
β-selinene	0.11	t
γ-cadinene	t	-
cis-calamenene	t	-
elemol	t	-
(E)-nerolidol	0.10	0.06
spathulenol	0.10	t
caryophyllene oxide	0.39	0.52
humulene oxide I	0.08	0.09
humulene oxide II	t	0.07
1-epi-cubenol	t	0.05
T-cadinol	0.06	0.16
α-cadinol	0.32	0.12
benzyl benzoate	1.51	2.18

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

Comparative percentage composition of supercritical fluid CO_2 extracts, a solvent extract and an oil of *Cinnamomum zeylanicum* bark **T-2**

Compound	SFE	SE	Oil
α-thujene	-	-	0.3
α-pinene	0–0.1	-	2.2
camphene	-	-	1.0
sabinene	-	-	0.6
α-phellandrene	0.2–0.4	-	3.6
α-terpinene	0–0.2	-	2.2
p-cymene	0.2–0.5	t	5.4
β-phellandrene	1.0–1.7	t	11.3
linalool	1.2–2.6	0.4	9.4
terpinen-4-ol	0.2–0.7	t	2.2
α-terpineol	0.7–4.4	0.3	2.3
(E)-cinnamaldehyde	72.6–79.0	69.4	19.7
(E)-anethole	-	-	1.7
eugenol	3.0–4.1	3.3	2.0
α-copaene	0.7–0.9	0.3	1.4
β-caryophyllene	5.1–7.6	2.2	13.6
(E)-cinnamyl acetate	0–1.9	3.4	2.1
α-humulene	1.3–2.3	-	4.0
δ-cadinene	0–0.1	-	t
(E)-2-methoxycinnamaldehyde	0.4–2.2	3.0	-
caryophyllene alcohol	t–0.3	t	1.1
caryophyllene oxide	0.3–0.7	0.7	1.8
humulene oxide II	0.1–0.2	t	0.5
tetradecanal	-	0.5	0.8
benzyl benzoate	1.0–1.6	2.8	4.0
hexadecanoic acid	-	4.5	3.3
octadecanoic acid	-	0.7	-

SFE = Supercritical Fluid CO_2 Extracts produced at 90 bar, 50°C, 90 bar 40°C and 120 bar 40°C.
SE = Solvent Extract

and diethyl phthalate is a plasticizer that does not exist in nature.

P. Lopez, C. Sanchez, R. Battle and C. Nerin, *Solid- and Vapor-Phase antimicrobial activities of six essential oils: susceptibility of selected foodborne bacterial and fungal strains*. J. Agric. Food Chem., **53,** 6939–6946 (2005).

E. Schmidt, L. Jirovetz, G. Buchbauer, G.A. Eller, I. Stoilova, A. Krastanov, A. Stoyanova and M. Geissler, *Composition and antioxidant activities of the essential oil of cinnamon* (Cinnamomum zeylanicum *Blume) leaves from Sri Lanka*, J. Essent. Oil Bear. Plants, **9,** 170–182 (2006).

B.R. Rajeswara Rao, D.K. Rajput, K.P. Sastry, S.K. Kothari and A.K. Bhattacharya, *Leaf essential oil profiles of* Cinnamomum zeylanicum *Blume*. Indian Perfum., 50(4), 44–46 (2006).

J. Begum, M. Yusuf, J.U. Chowdhury, M.M. Hossain, M.E. Hossain, S. Ahmed and M.N. Anwar, *Composition and antifungal activity of essential oil of leaves of* Cinnamomum verum *Presl grown in Bangladesh*, Indian Perfum., 51(2), 69–71 (2007).

J. Begum, M. Yusuf, J.U. Chowdhury, M.M. Hossain, M.E. Hossain, S. Ahmed and M.N. Anwar, *Composition and antifungal activity of essential oil of leaves of* Cinnamomum verum *Presl grown in Bangladesh*, Indian Perfum., 51(4), 15–18 (2007).

K. Patel, S. Ali, S. Sotheeswaran and J–P. Dufoar, *Composition of the leaf essential oil of* Cinnamomum verum *(Lauraceae) from Fiji islands*. J. Essent. Oil Bear. Plants, **10,** 374–377 (2007).

V.C. Pawar and V.S. Thaker, *Evaluation of the anti-Fusarium oxysporum f. sp. cicer and anti-Alternaria porri effects of some essential oils*, World J. Microbial. Biotechnol., **23,** 1099–1106 (2007).

Cinnamon Bark Oil

A sample of cinnamon bark oil (ex *Cinnamomum zeylanicum* Blume) was analyzed by Ferhout et al. (1999) and screened for its antifungal activity. The oil composition was determined to be as follows:

α-pinene (0.3%)
camphene (0.2%)
β-pinene (0.2%)
limonene (0.1%)
β-phellandrene (0.6%)
p-cymene (0.9%)
fenchone (1.4%)
benzaldehyde (2.3%)
linalool (0.1%)
β-caryophyllene (2.3%)
terpinen-4-ol (0.8%)
α-terpineol (1.7%)
(E)-cinnamaldehyde (66.0%)
eugenol (11.8%)

An oil produced from ground, dried cinnamon bark of *C. zeylanicum* origin that was purchased from a local market in Italy was screened for its antioxidant activity against the peroxynitrite-induced oxidative process by Chericoni et al. (2005). They found that the oil and eugenol possessed good antioxidant activity, while (E)-cinnamaldehyde and linalool were found to be completely inactive. The oil used in this screening program was determined to contain the following components:

benzaldehyde (0.2%)
p-cymene (0.4%)
1,8-cineole (0.2%)
linalool (3.3%)
terpinen-4-ol (0.3%)
α-terpineol (0.7%)
(E)-cinnamaldehyde (32.7%)
carvacrol (1.6%)
eugenol (46.5%)
α-copaene (0.7%)
β-caryophyllene (2.8%)
(E)-cinnamyl acetate (2.8%)
α-humulene (0.9%)
eugenyl acetate (2.2%)
caryophyllene oxide (0.3%)
benzyl benzoate (1.4%)

A trace (< 0.1%) of camphor was also characterized in this atypical oil.

Mallavarapu and Rajeswara Rao (2007) compared the composition of oils produced from cinnamon bark obtained from Bangalore and Mysore (Karnataka, India). A summary of their findings can be seen in **T-1**. Trace amounts of safrole, δ-cadinene, eugenyl acetate and

2-phenethyl benzoate were found in both oils.

The main constituents of an Indian oil of cinnamon bark were found by Pawar and Thaker (2007) to be as follows:

linalool (10.3%)
(E)-cinnamaldehyde (64.1%)
eugenol (9.0%)
(E)-cinnamyl acetate (4.5%)
eugenyl acetate (0.8%)
benzyl benzoate (9.3%)

From the level of benzyl benzoate in this oil the authors who were screening the oil as a fungicide against *Fusarium oxysporum* and *Alternaria porri* should have realized that instead of working with a pure oil, the oil that they used was atypical. This makes the interpretation of their results somewhat confusing.

Marongiu et al. (2007) compared the composition of supercritical fluid CO_2 extracts of Sri Lankan cinnamon bark with a Soxhlet extract (using hexane/acetone) and hydrodistilled oil. The results of this study can be summarized in **T-2**. Trace amounts (< 0.1%) of myrcene and isocaryophyllene were also found in the oil while a trace of (E)-cinnamyl alcohol was found in the solvent extract. It should be noted that the bark oil produced by hydrodistillation from the Sri Lankan cinnamon is atypical for cinnamon bark oil.

A sample of Sri Lankan cinnamon (ex *C. zeylanicum*) was found by Rychlik (2008) to contain 2.5 mg/kg of coumarin.

A. Ferhout, J. Bohatier, J.Guillot and J-C. Chalchat, *Antifungal activity of selected essential oils, cinnamaldehyde and carvacrol against* Malassezia furfur *and* Candida albicans, J. Essent. Oil Res., **11,** 119–129 (1999).

S. Chericoni, J.M. Prieto, P. Iacopini, P. Cioni and I. Morelli, *In vitro activity of the essential oil of* Cinnamomum zeylanicum *and eugenol in peroxynitrite induced oxidative process.* J. Agric. Food Chem., **53,** 4762–4765 (2005).

G.R. Mallavarapu and B.R. Rajeswara Rao, *Chemical Constituents and Uses of* Cinnamomum zeylanicum *Blume. In: Aromatic Plants from Asia their chemistry and application in food therapy,* Edits., L. Jirovetz, N.X. Dung and V.K. Varshney, pp 49–75, H.K, Bhalla and Sons Dehradun, India (2007).

V.C. Pawar and V.S. Thaker, *Evaluation of the anti-Fusarium oxysporum f. sp. cicer and anti-Alternaria porri effects of some essential oils*, World J. Microbiol. Biotechnol., **23,** 1099–1106 (2007).

B. Marongiu, A. Piras, S. Porcedda, E. Tuveri, E. Sanjsut, M. Meli, F.Sollai, P. Zucca and A. Rescigno, *Supercritical CO2 extract of* Cinnamomum zeylanicum*: Chemical Characterization and anti-tyrosinase activity*, J. Agric. Food Chem., **55**, 10022–10027 (2007).

M. Rychlik, *Quantification of free coumarin and its liberation from glucosylated precursors by stable isotype dilution assays based on liquid chromatography-tandem mass spectrometric detector*, J. Agric. Food Chem., **56,** 796–801 (2008).