Progress in Essential Oils

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Nagarmotha Oil

Nagarmotha oil is produced by steam distillation of the dried rhizomes of *Cyperus scariosus* R. Br. collected in India. It was estimated (Vaze 2003) that ca. 6,200 kg of oil are produced annually. The oil possesses a warm, woody vetiver-amber-patchouli-like aroma and can be used in a similar way in fragrances as vetiver.

A survey of the literature reveals that not much is known about the composition of this oil other than the fact that Gupta and Chandra (1951) reported that it had good fixative properties. Gildemeister and Hoffmann (1956) reported that the oil contained mostly sesquiterpenes, of which only α-cyperone had been identified.

Dhingra and Dhingra (1957) reported that the color of the aromatic tubers obtained from *C. scariosus* ranged from reddish brown to black. Although the authors did not characterize the oil they did note that it contained ca. 60% of a sesquiterpenoid ketone, as well as an unidentified sesquiterpene hydrocarbon, alcohol and ester.

Nigam (1965) used alumina column chromatography to isolate a major component of the oil, which was characterized as being cyperenone after IR, NMR and derivatization studies.

Hikino et al. (1967) isolated isopatchoulenone (also known as cyperenone) and cyperotundone from a lab-distilled oil of *C. scariosus.*

Nerali and Chakravarti (1967) determined that cyperenol and patchoulenol were two sesquiterpenoid alcohols found in *C. scariosus* oil.

Neville et al. (1968) used a combination of ^{1}H-NMR, MS and derivatization to prove that cyperenone isolated from *C. scariosus* oil was identical to isopatchoulenone and articulone.

Nerali and Chakravarti (1967 and 1969) determined that an Indian oil of *C. scariosus* contained cyperenol and patchoulenol, and scaridione, respectively.

Baslas (1970) reported that an oil produced from *C. scariosus* tubers of Indian origin was found to contain the following components:

β-pinene (0.4%)
camphene (2.8%)
limonene (2.6%)
1,8-cineole (0.2%)
p-cymene (1.2%)
cyperene (41.0%)
citronellol (0.7%)
α-cyperone (30.0%)
cyperenone (0.5%)
cyperol (6.0%)
eugenol (0.8%)
S-guaiazulene (2.0%)

Nerali and Chakravarti (1970) isolated two new tricyclic sesquiterpenes which they named rotundene and rotundenol.

Paknikar et al. (1977) used spectroscopic techniques to structurally elucidate rotundene and rotundenol. Gopichand et al. (1978) identified β-selinene and isopatchoula-3,5-diene in the hydrocarbon fraction of *C. scariosus* oil.

An oil of Nagarmotha (ex. *C. scariosus*) that was produced in India was the subject of analysis by Vaze (2003). He found that the oil possessed the following composition:

α-pinene (0.13%)
verbenene (0.01%)
β-pinene (0.22%)
limonene (0.03%)
γ-terpinene (0.25%)
isopinocamphone (0.03%)
verbenone (0.05%)
α-cubebene (0.04%)
calamenene*† (0.83%)
α-copaene (3.22%)
cyperene (24.42%)
β-caryophyllene (0.26%)
α-guaiene (0.06%)
α-gurjenene (0.48%)
isopatchoul-3-ene (7.53%)
γ-gurjunene (0.63%)
β-cyperene (0.60%)
β-selinene (2.22%)
valencene (1.44%)
α-selinene (1.33%)
7-epi-α-selinene (0.63%)
δ-cadinene (1.34%)
ar-himachalene (1.90%)
α-calacorene (0.16%)
patchouli alcohol (3.46%)
calamenol* (2.09%)
rotundenol (0.92%)
agarol (1.15%)
rotundone (3.51%)
corymbolone (11.91%)
patchoulenone (0.79%)
cyperolone (1.64%)
isopatchoulenone (2.29%)
nootkatone (0.31%)

* correct isomer not identified
† incorrect identification based on GC elution order

An oil produced from the rhizomes of *C. scariosus* found in the vicinity of Chittagong (Bangladesh) was analyzed by Chowdhury et al. (2005) The components identified in this oil were:

o-xylene (0.8%)
α-pinene (8.8%)
β-pinene (11.3%)
p-cymene (0.6%)
1,8-cineole (0.7%)
trans-pinocarveol (10.5%)
verbenol* (3.2%)
p-mentha-1,5-dien-8-ol (1.0%)
myrtenal (6.4%)
α-terpineol (0.7%)
verbenone (2.3%)
myrtenol (3.5%)
α-copaene (7.6%)
cyperene (2.5%)
β-maaliene (0.6%)
β-bulnesene (1.4%)
spathulenol (6.0%)
caryophyllene oxide (7.2%)
β-selinene (2.8%)

* correct isomer not identified

The authors also reported the identification of nine other compounds; however, as these were misidentified they have not been included.

Ranade (2009) reported that Nagarmotha oil comprised bicyclic sesquiterpene ketones (36–40%), sesquiterpene alcohols (30–35%), tricyclic sesquiterpenes (20–25%) and trace compounds (1–5%). Either the author has never run any analysis of this oil or he doesn't want to share the data, which makes this note in the literature superfluous.

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Cumin Oil

Lucchesi et al. (2004) compared the composition of cumin oil produced by hydrodistillation and solvent-free microwave distillation. A summary of the results obtained can be seen in **T-1**. Li and Jiang (2004) analyzed an oil produced from dried powdered seeds of *C. cyminum* collected from Urumqi (China). Using a combination of GC and GC/MS the authors determined that this lab-distilled oil contained the following components:

α-thujene (0.2%)
α-pinene (0.5%)
β-pinene (7.8%)
myrcene (0.6%)
α-phellandrene (0.1%)
δ-3-carene (0.1%)
α-terpinene (0.1%)
p-cymene (9.9%)
limonene (0.5%)
1,8-cineole (0.3%)
γ-terpinene (11.1%)
terpinolene (0.1%)
trans-pinocarveol (0.1%)
pulegone (0.1%)
terpinen-4-ol (0.6%)
isopulegone (0.4%)
myrtenol (0.1%)
cuminaldehyde (36.3%)
phellandral (0.2%)
safranal (10.9%)
cumin alcohol (0.3%)
p-mentha-1,4-dien-7-ol (0.3%)
β-caryophyllene (0.1%)
(E)-β-farnesene (0.4%)
germacrene D (0.1%)
acoradiene (0.1%)
β-bisabolene (0.1%)
carotol (0.1%)

In addition, trace amounts (< 0.1%) of *cis*-sabinene hydrate, linalool, an isomer of p-mentha-2-en-1-ol, nopinone, pinocarvone, *trans*-10-methydecalone, an α-bergamotene isomer and caryophyllene oxide were found in this oil.

It should be noted that the characterization of *trans*-pinocarveol, pulegone, isopulegone, phellandral, safranal, p-menta-1,4-dien-7-ol, acoradiene, nopinone, pinocarvone and 10-methyldecalone in cumin oil are questionable. It is more likely

Comparative percentage composition of oils of cumin produced by hydrodistillation and solvent-free microwave distillation **T-1**

Compound	Hydrodistilled oil	Microwave distilled oil
α-pinene	1.6	-
β-pinene	16.2	5.9
sabinene	1.1	-
myrcene	1.7	0.7
α-phellandrene	0.6	-
limonene	0.5	-
1,8-cineole	-	0.7
γ-terpinene	22.3	12.9
p-cymene	18.4	12.1
cuminaldehyde	22.8	37.4
p-mentha-1,4-dien-7-al	14.4	29.1
anethole *	-	1.3

* correct isomer not identified

that they were misidentified as can be seen from the previously published literature (Lawrence 1976–2004).

As part of an antibacterial screening study of essential oils, Iacobellis et al. (2005) examined the composition of cumin oil produced in the laboratory by hydrodistillation. They found that the oil possessed the following composition:

tricyclene (0.1%)
α-pinene (0.6%)
sabinene (0.5%)
β-pinene (11.4%)
myrcene (0.9%)
α-phellandrene (1.3%)
o-cymene (3.1%)
p-cymene (5.7%)
limonene (3.1%)
β-phellandrene (2.2%)
γ-terpinene (12.8%)
cuminaldehyde (16.1%)
cumin alcohol (0.4%)
p-mentha-1,3-dien-7-al (8.7%)
p-mentha-1,4-dien-7-al (27.4%)
perillaldehyde (0.6%)
perillyl alcohol (0.3%)
eugenol (0.7%)
geranyl acetate (1.7%)
β-caryophyllene (1.3%)

An oil produced in the laboratory from the ground cumin seeds of Indian origin was analyzed by Singh et al. (2006). The oil, which was found to possess good antifungal activity against two food pathogenic fungi, was determined to contain the following components:

tricyclene (0.1%)
α-pinene (0.3%)
sabinene (0.1%)
β-pinene (7.6%)
myrcene (0.3%)
α-phellandrene (0.1%)
α-terpinene (0.1%)
p-cymene (14.5%)
limonene (1.7%)
1,8-cineole (2.5%)
γ-terpinene (16.7%)
terpinolene (0.1%)
linalool (0.7%)
trans-pinocarveol (0.1%)
terpinen-4-ol (0.3%)
myrtenal (1.1%)
dihydrocarvone* (0.3%)
cuminaldehyde (40.7%)
carvone (2.5%)
phellandral (0.1%)
2-caren-10-al (6.7%)
β-caryophyllene (0.2%)
germacrene D (0.1%)
β-sesquiphellandrene (0.1%)
carotol (0.1%)

* correct isomer not identified

In addition, trace amounts (< 0.1%) of camphene, δ-3-carene, pinocarvone, *trans*-α-bergamotene, (E)-β-farnesene, zingiberene and caryophyllene oxide were found in this oil. In contrast, the authors also examined the composition of an acetone extract of the same batch of cumin seeds. Using a combination of GC-FID and GC/MS, the extract was found to possess the following composition:

3-hydroxy-4-methyl-2-pentanone (4.4%)
γ-terpinene (0.4%)
terpinolene (0.6%)
cuminaldehyde (5.4%)
α-terpin-7-al (0.5%)
cumin alcohol (4.4%)
carvacrol (0.3%)
β-caryophyllene (0.1%)
(E)-β-farnesene (0.2%)
germacrene D (0.2%)
ar-curcumene (0.3%)
zingiberene (0.1%)
β-bisabolene (0.1%)
β-sesquiphellandrene (0.3%)
carotol (0.2%)
α-atlantone (0.2%)
tetradecanoic acid (0.3%)
phytol (0.4%)
hexahydrofarnesyl acetone (0.3%)
pentadecanoic acid (0.2%)
hexadecanoic acid (4.4%)
1-octadecene (0.5%)
methyl linoleate (0.4%)
methyl oleate (0.3%)
linoleic acid (34.2%)
oleic acid (3.1%)
heptadecane (0.3%)
eicosane (0.2%)
squalene (0.3%)
tetracosane (0.6%)
α-tocopherol (0.1%)
stigmast-5-en-3-ol (0.5%)
3β-acetoxy-11-oxoursan-12-ene (0.8%)

Trace amounts (< 0.1%) of cuminic acid and methyl hexadecanoate were also found in this acetone extract.

The volatile components of an aqueous extract of cumin seed were analyzed using SPME combined with GC/MS by Perez et al. (2007). The components which were characterized were as follows:

p-cymene (0.38%)[a]
linalool (0.23%)
terpinen-4-ol (0.52%)
4-isopropenyltoluene† (0.79%)
3,6-dimethyl-2,3,3a,4,5,7a-hexahydrobenzofuran† (1.05%)
α-terpineol (0.27%)
2-methyl-5-(1-methylethyl)-1, 3-cyclohexadiene monoepoxide† (1.00%)
cuminaldehyde (38.90%)
cuminyl alcohol (0.58%)
carvacrol (0.40%)
β-damascenone* (0.29%)

[a] mg/g
* correct isomer not identified
† incorrect identification based on GC elution order

The major components of an oil of cumin produced from seeds grown in Iran that was screened for its antifungal activity by Hadian et al. (2008) were as follows:

α-thujene (0.4%)
β-pinene (20.1%)
α-phellandrene (0.5%)
p-cymene (5.8%)
γ-terpinene (29.2%)
perillaldehyde (1.2%)
cuminaldehyde (14.1%)
p-mentha-1,3-dien-7-al (10.2%)
p-mentha-1,4-dien-7-al (13.9%)

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Parsley Seed Oil

Kubeczka and Formacek (2002) used a combination of capillary GC and 13C-NMR to analyze a commercial sample of parsley seed oil obtained from *Petroselinum crispum* (Mill) Nym. ex A.W. Hill. They found that the oil contained the following constituents:

tricyclene (0.08%)
α-pinene + α-thujene (30.18%)
camphene (0.22%)
β-pinene (17.21%)
sabinene (0.29%)
myrcene (0.11%)
α-phellandrene (0.01%)
α-terpinene (0.02%)
limonene (0.41%)
β-phellandrene (0.25%)
γ-terpinene (0.40%)
(E)-β-ocimene (0.01%)
p-cymene (0.46%)
terpinolene (0.12%)
p-cymenene (0.14%)
α-copaene (0.06%)
β-caryophyllene + terpinen-4-ol (0.27%)
myrtenal (0.42%)
(E)-β-farnesene (0.06%)
α-humulene (0.11%)
α-terpineol (0.06%)
α-terpinyl acetate (0.07%)
bicyclogermacrene (0.17%)
caryophyllene oxide (0.03%)
carotol (0.11%)
elemicin (0.35%)
myristicin (8.31%)
apiole (39.69%)

The effect of the fermentation of parsley seeds on the oil yield and composition was examined by Stankovic et al. (2005). The authors found that the highest seed oil yield was obtained after the seeds had been fermented at 30°C for 4 hr with a seed to water ratio (hydromodulus) of 1:20. It is not surprising that they also found that the fermentation of ground seeds gave a better oil yield than the fermentation of the whole seeds. The main oil components of the seed oils produced from the fermented whole and ground seeds can be seen in **T-2.**

Kurowska and Galazka (2006) determined that 11 parsley seed cultivars (three leaf parsley and eight root parsley) were available in Poland. The leaf parsley cultivars were 'Festival', 'Karnaval' and 'Paramount'. The seed oil yield of these three cultivars, irrespective of the commercial seed source, was 1.5–2.2% whereas the seed oil yield of the root parsleys were lower (0.6–1.0%). The oil compositions of the seed oils of three leaf parsleys from different commercial sources are presented in **T-3.** The authors also found that the seed oils of the root parsley could be readily distinguished from the seed oils of leaf parsley because the root parsley seed oils contained high levels of apiole (16.6–74.9%) compared to t–10.2% in the seed oils of leaf parsley.

Comparative main component composition of parsley seed oil produced from fermented whole and ground seed **T-2**

Compound	Whole seed oil	Ground seed oil
α-pinene	15.2	32.2
β-pinene	12.3	22.3
sabinene	5.0	4.8
myrtenal	0.8	-
myristicin	42.8	25.1
tetramethoxy-alkylbenzene	13.6	8.7
apiole	7.1	5.4
phthalic acid †	3.3	1.6

† probable decomposition product of phthalate plasticizers that has come in contact with the parsley seed

Zhang et al. (2006) analyzed an oil of parsley seed of unknown origin. The composition of this oil that was screened for its antioxidant activity was found to be as follows:

α-pinene (16.6%)
sabinene (0.5%)
β-pinene (11.5%)
p-cymene (0.3%)
limonene (0.6%)
β-phellandrene (4.2%)
γ-terpinene (0.3%)
p-cymenene (0.3%)
myristicin (32.8%)

Comparative percentage composition of parsley seed oils produced from three Polish cultivars **T-3**

Compound	Festival oils	Karnaval oil	Paramount oils
α-thujene	0.2–0.3	0.2	0.2
α-pinene	31.0–40.6	26.7	26.0–30.8
camphene	0.2–0.3	0.3	0.2–0.6
sabinene	0–0.7	0.9	0–0.4
β-pinene	19.0–27.2	19.7	18.6–19.9
myrcene	t–0.2	0.2	0–0.5
α-phellandrene	0.2-0.3	0.2	0.2-0.3
β-phellandrene	4.9–8.8	4.5	4.4–4.9
γ-terpinene	0–0.1	-	0–0.2
myrtenal	0.2–0.5	0.5	0–t
myristicin	12.4–18.3	31.0	41.1–42.2
elemicin	t–0.6	0.9	0–2.7
allylmethoxybenzene[a]	5.6–12.8	5.7	2.0–2.3
carotol	0.1–0.3	0.3	t–0.4
apiole	3.7–10.2	8.8	t–0.5

t = trace (< 0.1%)
[a] 1-allyl-2,3,4,5-tetramethoxybenzene

elemicin (4.1%)
1-ally-2,3,4,5-tetramethoxybenzene (10.0%)
carotol (0.8%)
apiole (17.5%)

The antioxidant activity screening of this oil was performed using three screening methods (β-carotene bleaching assay, DPPH free radical scavenging assay and the ferrous metal chelating assay). The authors found that the oil possessed some β-carotene bleaching capacity and free radical scavenging activity but almost no metal chelating capacity. The fact that the authors suggested that parsley seed oil had potential as a natural antioxidant is, in this reviewer's opinion, a bit of a quantum leap.

A commercial sample of parsley seed oil was determined by Wei and Shibamoto (2007) to contain the following constituents:

α-pinene (15.5%)
β-pinene (11.7%)
β-phellandrene (2.9%)
geranial (1.1%)
1-allyl-2,3,4,5-tetramethoxybenzene (4.4%)
myristicin (44.0%)
apiole (12.1%)

Nickavar (2008) reported that the fruit oil of *P. crispum* grown in Iran contained the following components:

α-thujene (0.4%)
α-pinene (7.6%)
camphene (0.2%)
sabinene (0.1%)
β-pinene (6.9%)
myrcene (0.3%)
α-phellandrene (0.1%)
α-terpinene (0.2%)
p-cymene (4.9%)
β-phellandrene (10.4%)
(Z)-β-ocimene (0.2%)
(E)-β-ocimene (0.3%)
γ-terpinene (0.6%)
linalool (0.4%)
p-mentha-1,3,8-triene (1.4%)
borneol (0.3%)
terpinen-4-ol (1.3%)
(E)-anethole (0.3%)
thymol (0.7%)
carvacrol (0.3%)
isocaryophyllene (0.6%)
β-caryophyllene (0.7%)
(Z)-β-farnesene (0.8%)
myristicin (27.4%)
elemicin (0.9%)
spathulenol (0.4%)
globulol (0.1%)
carotol (1.1%)
apiole (19.8%)

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