Progress in Essential Oils

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Chamomile Oil

Wagner (1993) reported that the yield of dry flowers of chamomile [*Chamomilla recutita* (L.) Rauschert] was highest when the plants were grown in sandy well-drained soils. In Slovenia the average yield of chamomile flowers is ca. 500kg/ha. Wagner further reported that the main components of a good quality chamomile oil produced in Slovenia were as follows:

(E)-β-farnesene (15.1%)
α-bisabolol (2.9%)
chamazulene (26.8%)
cyclic ethers (6.2%)
bisabolol oxides (25.4%)

Das et al. (2002) analyzed oils produced from different floral parts (whole capitula, disc florets and ray florets) of chamomile grown in an experimental garden in Lucknow (U.P., India) using GC-FID and GC/MS. The results of this study are summarized in **T-1**. In addition to analyzing the flowers, the authors also analyzed oils produced from leaves, stems and roots. They found that the major component of the leaf oil was (E,E)-α-farnesene (9.3%), while the major components of the stem oil were limonene (23.9%) and (Z)-en-yn-dicycloether (15.7%). The root oil was found to be rich in (E)-β-farnesene (44.4%) and the same (Z)-en-yn-dicycloether (10.7%).

Five samples of chamomile oil produced from plants grown in the vicinity of Curitiba (Parana, Brazil) were analyzed by Presibella et al. (2006) using only GC/MS. The range of constituents reported by the authors was as follows:

artemisia ketone (0–0.4%)
decanoic acid (0–4.5%)
(E)-β-farnesene (1.5–21.9%)
spathulenol (0.8–3.7%)
β-eudesmol (0.7–4.5%)
α-bisabolol oxide B (25.3–33.0%)
α-bisabolol (7.7–16.4%)
chamazulene (0–1.5%)
α-bisabolol oxide A (11.6–16.7%)
(Z)-en-yn-dicycloether (0–8.6%)
hexadecanoic acid (1.6–4.9%)
hexatriacontane (0–2.2%)

A trace amount of (<0.1%) ethyl hexadecanoate was also found in two oil samples.

Further, Presibella et al. compared their results to that of an oil produced from Egyptian chamomile. The Egyptian oil was found to contain:

p-cymene (0.1%)
artemisia ketone (0.6%)
decanoic acid (5.6%)
ethyl decanoate (0.8%)
(E)-β-farnesene (5.6%)
spathulenol (3.0%)
β-eudesmol (2.1%)
α-bisabolol oxide B (9.9%)
α-bisabolol (12.3%)
chamazulene (1.4%)
α-bisabolol oxide A (46.6%)
(Z)-en-yn-dicycloether (5.1%)
(E)-en-yn-dicycloether (0.7%)
hexadecanoic acid (1.9%)
ethyl hexadecanoate (0.4%)
hexatriacontane (1.3%)

Gosztola et al. (2006) determined that the farnesene, α-bisabolol oxide B, α-bisabolol, α-bisabolol oxide A and chamazulene contents of the oils of 32 accessions of chamomile grown in Hungary ranged as follows:

farnesene* (1.7–6.8%)
bisabolol oxide B (2.3–21.7%)
α-bisabolol (4.7–48.4%)
bisabolol oxide A (0–41.2%)
chamazulene (1.2–24.5%)

* correct isomer not identified

In a follow-up report Gosztola et al. (2007) examined the major components of the oils of eight chamomile populations over two seasons growing wild in Hungary. They found that the components ranged as follows:

farnesene* (1.6–4.4%)
bisabolol oxide A (1.1–42.7%)
α-bisabolol (7.5–57.9%)
chamazulene (3.7–15.4%)

* correct isomer not identified

Cluster analysis of the results showed that the oils could be grouped into two clusters, which were geographically distinct.

Chamomile oil that was produced from plant material collected in Serbia was determined by Sokovic et al. (2007) to contain the following:

tricyclene (0.2%)
camphene (0.1%)
sabinene (0.4%)
α-terpinene (0.1%)
p-cymene (0.2%)
limonene (0.3%)
1,8-cineole (0.4%)
(Z)-β-ocimene (1.7%)
(E)-β-ocimene (1.9%)
γ-terpinene (0.1%)
trans-sabinene hydrate (0.3%)

Comparative percentage composition of oils produced from different floral parts of *Chamomilla recutita* **T-1**

Compound	Whole capitula oil	Disc floret oil	Ray floret oil
(E)-2-hexenol	1.0	2.1	0.1
(Z)-3-hexenol	0.1	t	t
tricyclene	0.1	0.4	0.2
α-pinene	0.5	0.6	0.3
camphene	0.2	0.2	0.5
6-methyl-5-hepten-2-one	5.4	3.4	0.5
myrcene	0.1	0.2	0.2
(Z)-3-hexenyl acetate	0.7	0.6	0.5
α-phellandrene	t	–	0.1
p-cymene	0.3	0.3	0.9
limonene	0.2	0.2	0.3
(Z)-β-ocimene	0.2	0.2	–
(E)-β-ocimene	0.7	0.6	0.2
artemisia ketone	10.6	10.7	0.8
γ-terpinene	1.6	1.3	0.2
artemisia alcohol	1.9	1.5	0.6
linalool	0.2	0.1	2.4
camphor	0.7	1.3	0.3
isoborneol	–	0.2	0.5
borneol	1.2	1.2	–
terpinen-4-o1	0.1	0.2	0.6
α-terpineol	0.2	0.1	0.5
nerol	–	0.1	6.2
pulegone	0.5	0.3	–
geraniol	–	0.1	1.9
geranyl acetate	t	0.1	1.0
α-copaene	0.2	0.2	–
β-bourbonene	0.1	0.1	0.7
β-caryophyllene	0.1	0.2	–
(E)-β-farnesene	7.4	2.9	1.1
γ-muurolene	–	0.1	–
germacrene D	1.2	0.1	–
α-patchoulene	0.1	0.1	0.7
(E,E)-α-farnesene	0.1	0.1	0.4
γ-cadinene	0.1	0.1	0.5
δ-cadinene	0.2	0.1	0.3
(E)-nerolidol	0.1	0.2	0.3
spathulenol	–	0.2	0.4
caryophyllene oxide	0.2	0.2	0.3
T-cadinol	1.9	0.9	1.2
β-eudesmol	1.3	1.0	1.6
α-bisabolol oxide B	12.0	13.6	8.6
α-bisabolone oxide	0.6	0.3	3.1
α-bisabolol	8.0	16.8	0.2
chamazulene	2.9	1.9	1.4
α-bisabolol oxide A	17.4	20.4	8.9
(Z)-en-yn-dicycloether	4.3	4.6	2.5
(E)-en-yn-dicycloether	0.2	0.1	0.5
isophytol	0.2	0.2	2.7

t = trace (<0.1%)

β-caryophyllene (0.4%)
(E)-β-farnesene (43.5%)
germacrene D (0.4%)
bicyclogermacrene (5.2%)
(E)-γ-bisabolene (8.5%)
bisabolol oxide B (9.1%)
bisabolone oxide (6.1%)
chamazulene (5.6%)
bisabolol oxide A (8.5%)

The effect of fertilization on the oil composition of chamomile produced from wild and cultivated plants was the subject of study by Karami et al. (2008). The authors found that with the use of 90 kg/ha of NPK, the yield of flowers and oil was maximized in the experimental garden in Shiraz (Iran). The compositional range between the oils of the wild and cultivated chamomile was determined to be as follows:

α-thujene (0–0.1%)
α-pinene (0.1%)
sabinene (0.1–0.2%)
β-pinene (0–0.3%)
p-cymene (0.1%)
γ-terpinene (0.1%)
pinocarvone (0–2.9%)
(E)-β-farnesene (29.9–43.4%)
β-caryophyllene (0–0.2%)
germacrene D (2.2–2.4%)
bicyclogermacrene (0.1–0.2%)
β-bisabolene (4.1–5.2%)
spathulenol (0.3–0.5%)
α-bisabolol oxide B (0.8–0.9%)
α-bisabolol (29.5–35.0%)
chamazulene (5.6–6.6%)
α-bisabolol oxide A (6.5–8.3%)

A lot of dried herbal materials are currently being sold as granulates. Granulation is used to obtain uniform mixtures of herbal materials, to minimize dust formation, to improve both storage and damage during transport or further use in mixing processes and to increase the volume/weight: bulk density. Another advantage of granulation can be to stabilize unstable biologically active materials.

Kowalski and Wawrzykowski (2008) compared the oil composition of dried and granulated chamomile flowers grown in Poland using GC-FID and GC/MS. Their results are summarized in **T-2**.

Based on the results reported in **T-2**, it would appear that granulation caused a reduction in the chamazulene and α-bisabolol oxide A and an

increase in α-bisabolol oxide B that is assuming the homogeneity of the chamomile flowers used.

The main components of chamomile oil produced from flowers collected from a temperate and a subtropical zone of Iran was the subject of study by Karami et al. (2009). The analytical data obtained from this study are shown in **T-3**. Trace amounts (<0.1%) of α-pinene, sabinene and p-cymene were found in the temperate zone oil while trace amounts of β-pinene, α-terpinene and p-cymene were found in the oil produced in the subtropical zone.

Yasudri et al. (2009) used column chromatography to elute a fraction of chamomile oil that was found to contain precocene I and precocene II.

In Poland three chamomile 'C3/41' (a high α-bisabolol, diploid), 'Promyk' (a diploid) and 'Zloty Lan' (a tetraploid) were studied by Seidler-Lozkowska (2010) for their variation in oil, α-bisabolol and chamazulene contents between 1994 and 2003. Ten samples of fresh flowers (2009) were randomly collected from each cultivar annually and then dried under controlled conditions at 28–30°C. Oils were produced from a sample (8 g) of each of the cultivars by hydrodistillation. Analyses performed on these oils revealed that each cultivate reacted differently to changes in weather conditions. For example the oil yield of 'Promyk' varied from 0.63–1.46%, the α-bisabolol content varied from 0.82–64.85%, and the chamazulene content varied from 3.11–23.81%. It was found that for the two main cultivars there was a strong negative correlation between the oil content and average daily temperature. Also there was a negative correlation between the oil content of both cultivars and number of sunshine hours. However, there was a positive correlation between the α-bisabolol content of 'Promyk' and 'C3/41' and a positive correlation between the chamazulene content of 'C3/41' and the sum of sunshine hours. A negative effect on the oil content was observed for 'Zloty Lan' and not for the other cultivars. Finally, Seidler-Lozykowska observed that the highest α-bisabolol content occurred when the sum of the sunshine hours was the greatest.

Percentage composition of the oils obtained from dried and granulated chamomile flowers **T-2**

Compound	Dried flower oil	Granulated flower oil
sabinene	0.3	t
p-cymene	0.2	0.2
1,8-cineole	0.2	0.2
γ-terpinene	t	0.3
linalool	0.3	1.6
α-thujone	t	0.2
β-thujone	t	0.1
camphor	0.1	0.6
borneol	0.3	0.6
β-bourbonene	t	1.0
β-elemene	t	1.2
β-caryophyllene	0.5	2.1
(Z)-β-farnesene	1.5	1.3
α-humulene	0.1	0.5
germacrene D	0.4	0.5
spathulenol	4.0	8.2
caryophyllene oxide	0.9	0.3
humulene epoxide II	0.6	1.3
α-bisabolol oxide B	30.6	42.6
chamazulene	11.7	7.2
α-bisabolol oxide A	33.9	18.3

t = trace (< 0.1%)

Percentage composition of Iranian chamomile oil produced in two climatic zones **T-3**

Compound	Temperate zone oil	Subtropical zone oil
α-pinene	t	–
sabinene	t	–
β-pinene	–	t
α-terpinene	–	t
p-cymene	t	t
γ-terpinene	0.2	0.6
pinocarvone	1.0	0.5
(E)-β-farnesene	37.2	30.3
germacrene D	2.4	1.9
bicyclogermacrene	–	6.6
β-bisabolene	3.9	1.4
spathulenol	0.5	0.4
α-bisabolol oxide B	0.9	1.2
α-bisabolol	32.3	43.1
chamazulene	4.8	3.7
α-bisabolol oxide A	8.3	8.5

t = trace (<0.1%)

From this study it would appear that weather conditions affect both the oil content and composition, and this effect is cultivar dependant.

Salamon et al. (2010) screened nine chamomile selections from different regions of Iran for the major oil components. It was determined that the oil yield of the chamomile flowers ranged from 0.42–0.90%. Among the chamomile plants screened, the oil of one accession that was rich in α-bisabolol contained the following major constituents:

α-bisabolol (61.5%)
chamazulene (6.5%)
α-bisabolol oxide A (8.5%)
α-bisabolol oxide B (2.0%)
cis- trans-bicyclochamomile ethers (4.0%)
(E)-β-farnesene (2.0%)

The main components of the oil of one of the accessions that is rich in chamazulene were as follows:

α-bisabolol (41.0%)
chamazulene (11.5%)
α-bisabolol oxide A (31.0%)
α-bisabolol oxide B (3.5%)
cis- and *trans*-bicyclochamomile ethers (3.0%)
(E)-β-farnesene (2.5%)

Examination of the range of data obtained from the oils of all chamomile accessions reveals that the percentage composition of the major constituents were found to range as follows:

α-bisabolol (6.5–61.5%)
chamazulene (2.0–11.5%)
α-bisabolol oxide A (8.5–59.0%)
α-bisabolol oxide B (2.0–6.5%)
cis- and *trans*-bicyclochamomile ethers (2.5–11.5%)
(E)-β-farnesene (2.0–4.0%)

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Clary Sage Oil

A lab-distilled oil of *Salvia sclarea* L. which was screened for its anti-microbial activities was determined by Jirovetz et al. (2006) to posses the following composition:

β-pinene (0.1%)
myrcene (1.2%)
limonene (1.3%)
(Z)-β-ocimene (0.5%)
(E)-β-ocimene (0.9%)
linalool (21.0%)
α-terpineol (4.0%)
nerol (0.8%)
geraniol (3.2%)
linalyl acetate (60.0%)
geranyl formate (0.1%)
neryl acetate (1.1%)
α-copaene (0.3%)
β-bourbonene (0.1%)
β-caryophyllene (1.3%)
germacrene D (2.2%)
(E,E)-α-farnesene (0.2%)
caryophyllene oxide (0.1%)
sclareol (0.5%)

Trace amounts (<0.05%) of α-pinene, p-cymene, 1,8-cineole, terpinolene, terpinen-4-ol, α-terpinyl acetate, geranyl propionate and α-humulene were also found in this oil.

Jirovetz et al. (2007) determined that an oil of clary sage produced in the laboratory from flowering plants collected in Bosnia Herzegovina contained linalool (21.0%) and linalyl acetate (60.0%) as main components. This oil which was screened for its antifungal activities was the same oil the chemical composition of which was reported in 2006 by Jirovetz et al.

Schmiderer et al. (2008) used scanning election microscopy to examine the essential oil glands of clary sage. In addition to showing that there was a vast variability in the morphological types of glandular trichomes, the authors also compared the compositions of a lab-distilled oil and headspace volatiles as shown in **T-4**.

Williams (2008) reported that a commercial oil of clary sage possessed the following composition:

α-pinene (0.3%)
myrcene (0.5%)
(E)-β-ocimene (0.3%)
linalool (11.5%)
α-terpineol (0.4%)
linalyl acetate (71.6%)
neryl acetate (0.5%)
geranyl acetate (0.5%)
α-copaene (1.0%)
β-bourbonene (0.4%)
β-elemene (0.4%)
β-caryophyllene (1.9%)
germacrene D (3.7%)
δ-cadinene (0.2%)
nerol (0.2%)
geraniol (0.6%)
caryophyllene oxide (0.3%)
sclareol (1.0.%)

Comparative percentage composition of the oil and headspace volatiles of clary sage **T-4**

Compound	Oil	Headspace volatiles
α-pinene	0.1	0.1
camphene	t	t
sabinene	t	t
β-pinene	0.2	0.2
myrcene	3.6	4.2
limonene	0.6	0.6
(Z)-β-ocimene	0.9	1.3
(E)-β-ocimene	1.5	2.3
terpinolene	0.1	0.3
linalool	13.5	15.5
α-terpineol	3.0	3.3
nerol	0.6	0.6
linalyl acetate	57.7	55.2
neryl acetate	2.0	1.8
α-copaene	3.8	3.4
geranyl acetate	0.4	0.4
β-cubebene	0.3	0.3
β-caryophyllene	1.7	1.7
germacrene D	2.9	5.1
sclareol	7.5	3.9

t = trace (<0.1%)

Comparative percentage composition of selected constituents of wild clary sage oil of Iranian origin produced from plants harvested at different ontogenetic stages **T-5**

Compound	Full flowering oil	Fruit setting oil
β-pinene	–	1.2
myrcene	3.0	2.2
1,8-cineole	0.9	3.9
(Z)-β-ocimene	1.8	1.3
(E)-β-ocimene	3.2	2.1
linalool	30.0	21.0
β-thujone†	–	4.8
α-terpineol	11.1	10.6
nerol	2.5	2.4
linalyl acetate	23.1	12.7
carvacrol	1.2	–
neryl acetate	4.7	4.1
α-copaene	–	4.1
geranyl acetate	8.4	6.5
β-ylangene	1.8	2.8
α-muurolene	3.3	4.1
(E,Z)-farnesol	–	2.0

† doubtful correct identification

Trace amounts (<0.1%) of camphene, sabinene, β-pinene, 1,8-cineole, limonene, (E)-β-ocimene and terpinolene were also reported as constituents of this oil.

Singh et al. (2008) showed that spacing and fertilizer level on *S. sclarea* grown in Palampur (Himachal Pradesh, India) had a minor effect on the oil composition. The major components were found to vary as follows:

myrcene (0.5–0.8%)
linalool (31.6–36.5%)
linalyl acetate (16.8–24.6%)
β-caryophyllene (1.7–2.4%)
α-terpineol (15.6–17.6%)
neryl acetate (2.8–3.1%)
geranyl acetate (5.3–5.7%)
nerol (1.7–2.0%)
geraniol (4.5–5.3%)

It should be noted that this clary sage clone produces an oil that is of little interest commercially.

Saharkhiz et al. (2009) examined the composition of oils produced from clary sage plants that were harvested from their natural habitat in the Golmakan Mountains near Mashad (Iran) at different stages of maturity. The author is determined that at the stem initiation stage of ontogeny the oil composition was as follows:

myrcene (1.1%)
1,8-cineole (< 0.1%)
(Z)-β-ocimene (1.2%)
(E)-β-ocimene (2.0%)
linalool (11.2%)
α-terpineol (4.4%)
nerol (0.9%)
geraniol (2.2%)
linalyl acetate (8.1%)
carvacrol (0.7%)
δ-elemene (1.6%)
neryl acetate (2.7%)
α-ylangene (2.3%)
geranyl acetate (5.5%)
β-cubebene (1.4%)
β-elemene (1.5%)
longifolene† (7.4%)
β-caryophyllene (0.8%)
α-himachalene (0.6%)
α-patchoulene (0.7%)
γ-muurolene (31.3%)
germacrene D (8.5%)
γ-cadinene (1.1%)
(Z)-isoeugenol acetate (0.8%)
(E)-β-santalol (0.6%)

† doubtful correct identification

In contrast, oil produced from plants harvested at the rosette stage contained:

1,8-cineole (1.5%)
δ-elemene (1.3%)
α-copaene (2.0%)
β-cubebene (1.2%)
β-elemene (1.3%)
longifolene† (4.9%)
β-caryophyllene (0.6%)
γ-muurolene (20.5%)
germacrene D (5.9%)
δ-cadinene (1.1%)
(Z)-isoeugenol acetate (2.3%)
(Z)-lanceol (5.6%)
(Z)-β-santalol acetate (51.1%)

† doubtful correct identification

The components found in amounts greater than 1.0% in oils produced from *S. sclarea* harvested at full flowering and the fruit setting stage are listed in **T-5**.

Yadav et al. (2010) analyzed oils produced from *S. sclarea* that was harvested when the plants were in full flower from three different climate zones in northern India. The oils, which were analyzed by GC-FID and GC/MS, were found to possess the following compositional range:

myrcene (0.5–1.1%)
limonene (t–0.3%)
(Z)-β-ocimene (0.2–0.3%)
(E)-β-ocimene (t–0.5%)
γ-terpinene (0–0.1%)
terpinolene (0.1%)
linalool (14.5–29.8%)
α-terpineol (1.8–5.3%)
nerol (0.4–0.9%)
linalyl acetate (45.7–60.8%)
geranyl formate (t–0.1%)
neryl acetate (0.9–1.5%)
geranyl acetate (2.2–3.3%)
β-bourbonene (t–0.2%)
β-cubebene (t–0.2%)
β-elemene (t–0.2%)
β-caryophyllene (0.3–3.2%)
germacrene D (0.2–2.6%)
valencene (0–0.1%)
(E,E)-α-farnesene (0–0.6%)
δ-cadinene (0–0.2%)
spathulenol (0–0.3%)
caryophyllene oxide (0–1.2%)
β-eudesmol (0–0.3%)
phytol (0.2–0.3%)
sclareol (1.3–2.3%)

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Labrador Tea Oil

A limited amount of Labrador tea oil is produced annually in Canada. The oil is obtained from *Ledum groenlandicum* Oeder [syn. *L. palustre* L. subsp. *groenlandicum* (Oeder) Hult., *L. latifolium* Jacq., *Rhododendron groenlandicum* (Oeder) K.A. Kron et W.S. Judd] a member of the heath or Ericaceae family.

Von Schantz and Hiltunen (1971) analyzed an oil of *L. groenlandicum* produced from plants collected in Finland. The constituents identified in this oil were as follows:

α-pinene (1.4%)
camphene (1.2%)
β-pinene (6.1%)
α-terpinene (0.3%)
limonene (0.8%)
β-phellandrene (1.2%)
α-terpinene (0.7%)
p-cymene (3.6%)
bornyl acetate + SHC (5.7%)
β-caryophyllene (2.8%)
myrtenal + allo-aromadendrene (14.8%)
α-humulene + UNK (8.4%)
germacrone (40.0%)

SHC = sesquiterpene hydrocarbon
UNK = unknown

Ledum groenlandicum plants were collected from Barry's Bay (Ontario, Canada), dried and subjected to hydrodistillation to produce an oil in 0.25%. Analysis of the oil was performed by Lawrence et al. (1974) using analytical and preparative GC and component identification by infra red spectroscopy. The oil was determined to contain the following constituents:

α-pinene (1.4%)
camphene (0.8%)
β-pinene (4.7%)
myrcene (0.1%)
p-cymene (0.7%)
bornyl acetate (2.4%)
β-elemene (4.1%)
terpinen-4-ol (0.2%)
β-caryophyllene (3.9%)
myrtenal (2.4%)
γ-elemene (1.2%)
trans-pinocarveol (0.7%)
α-terpineol (1.0%)
α-humulene (18.6%)
α-amorphene (0.8%)
germacrene D (0.9%)
α-selinene (13.7%)
β-selinene (0.8%)
δ-cadinene (0.2%)
selina-3,7(11)-diene (0.2%)
geraniol (0.6%)
germacrene B (15.6%)
isofuranogermacrene (11.7%)

Trace amounts (<0.5%) of α-terpinene, limonene, β-phellandrene, γ-terpinene, terpinolene, (Z)-3-hexenol, α-ylangene and myrtenol were also found in this same oil.

Belleau and Collin (1991) analyzed numerous oils produced from *L. groenlandicum* plants collected in Quebec (Canada). They found that the oils ranged in composition as follows:

α-pinene (0.5–16.0%)
camphene (0.3–2.7%)
β-pinene (0.7–8.1%)
sabinene (0.8–21.0%)
α-terpinene (0.1–2.2%)
limonene (0.1–4.3%)
β-phellandrene (0.1–2.2%)
γ-terpinene (0.5–4.4%)
p-cymene (0.3–2.1%)
ledol† (t–2.3%)
bornyl acetate (0.5–4.4%)
β-caryophyllene (t–4.2%)
terpinen-4-ol (0.3–9.0%)
myrtenal (t–3.5%)
α-humulene (t–17.5%)
germacrene D (t–2.3%)
α-selinene (2.5–9.0%)
β-selinene (t–12.6%)
α-farnesene* (t–2.0%)
γ-elemene (0.1–18.4%)
germacrone (0.3–52.6%)

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

Belleau and Collin (1993) again analyzed an oil of *L. groenlandicum* produced from plants grown in the Chicoutimi region (Quebec, Canada). The composition of this oil was found to be:

(E)-2-hexenal (0.1%)
tricyclene (0.1%)
α-thujene (0.4%)
α-pinene (1.9%)
camphene (1.5%)
sabinene (15.7%)
β-pinene (2.3%)
1-octen-3-ol (0.1%)
myrcene (0.3%)
α-phellandrene + p-menthatriene* (0.3%)
α-terpinene (1.5%)
p-cymene (1.3%)
limonene + β-phellandrene (1.1%)
(Z)-β-ocimene (0.3%)
(E)-β-ocimene (0.1%)
γ-terpinene (2.9%)
cis-p-menth-2-en-1-ol (0.1%)
terpinolene (0.6%)
trans-p-menth-2-en-1-ol (0.2%)
cis-sabinene hydrate (2.7%)
cis-pinene hydrate (1.2%)
trans-pinocarveol (2.6%)
trans-pinene hydrate (0.2%)
β-pinene oxide (2.5%)
pinocarvone (2.3%)
terpinen-4-ol (7.6%)
myrtenal (3.5%)
myrtenol (1.6%)
trans-carveol (0.9%)
(Z)-tagetenone (0.7%)
cis-carveol (1.5%)
cuminaldehyde (1.6%)
carvone (0.3%)
bornyl acetate (3.3%)
thymol (0.4%)
β-caryophyllene (0.5%)
α-humulene (2.2%)
germacrene D (0.4%)
β-selinene (5.7%)
α-selinene (1.9%)
isofuranogermacrene* (0.7%)
γ-elemene (3.1%)
isofuranogermacrene* (0.8%)
germacrone (0.7%)

* correct isomer not identified

The authors noted that the oil composition varied according to the plant part and the stage of development.

Idaomar et al. (2002) examined a few commercial oils for their genotoxic and antigenotoxic activities. A commercial oil of *L. groenlandicum*, which was among the oils screened, was determined to contain the following constituents:

α-pinene (0.9%)
β-pinene (0.9%)
sabinene (1.4%)
myrcene (0.5%)
α-phellandrene (2.6%)
limonene (36.2%)
γ-terpinene (0.6%)
p-cymene (5.0%)
terpinolene (1.1%)
β-thujone (1.2%)
terpinen-4-ol (8.7%)
myrtenal (1.4%)
α-terpineol (1.2%)
nerol (5.4%)
bornyl acetate (0.8%)
β-caryophyllene (1.5%)
α-humulene (0.9%)
germacrene D (9.0%)
ledol (0.2%)

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