# Progress in Essential Oils

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## Cardamom Oil

The volatiles obtained from cardamom ground under normal (ambient) and cold (ice) conditions and produced by hydrodistillation were analyzed using GC/MS by Omanakutty and Joy (2007). They found that many volatiles were lost by grinding the cardamom at ambient temperatures. In fact the only constituents characterized in the oil were:

α-pinene (1.6%)
sabinene (3.8%)
1,8-cineole (42.4%)
terpinen-4-ol (1.0%)
α-terpinyl acetate (47.4%)
β-selinene (0.6%)

In contrast, oil produced from cardamom ground under cold (ice) conditions was determined to possess the following composition:

α-pinene (1.5%)
sabinene (3.8%)
β-pinene (0.8%)
myrcene (1.5%)
δ-3-carene (0.3%)
1,8-cineole (34.3%)
γ-terpinene (0.6%)
terpinolene (0.4%)
sabinene hydrate* (0.7%)
linalool (0.1%)
terpinen-4-ol (1.9%)
α-terpineol (2.3%)
linalyl acetate (0.4%)
geraniol (0.3%)
methyl geranate (0.1%)
α-terpinyl acetate (47.7%)
geranyl acetate (0.7%)
β-elemene (0.2%)
γ-muurolene (0.1%)
β-selinene (0.2%)
γ-cadinene (0.1%)
nerolidol* (0.1%)
retinal** (0.9%)

*correct isomer not identified
**doubtful correct identification

Several cardamom genotypes belonging to (a) the Malabar type (3), the Vazhukka type (3) and the Mysore type (1) were examined for their number of seeds per capsule (fruit), oil yield per capsule, and oil composition for immature capsules, physiologically mature capsules and ripe capsules. In all cases, Lee et al. (2008) found that the number of seeds per capsule was at a maximum for the ripe capsules, while the oil yield per capsule was lowest for ripe capsules. A summary of the oil compositional studies can be found in **T-1**.

Sokkar (2008) analyzed a lab-distilled oil of dried green cardamom capsules purchased in an Egyptian market and compared it with a lab-prepared hexane extract of the same batch of cardamom seed. His analyses, which were performed using only GC/MS, can be seen in **T-2**.

Export-grade cardamom capsules of Indian, Guatemalan and Sri Lankan origins were subjected to hydrodistillation by Thomas et al. (2009). Using GC/MS as the only method of analysis, the constituents found in these oils are summarized in **T-3**.

The main constituents of Indian cardamom oil were determined by Sultana et al. (2009) to be:

α-pinene (0.9%)
myrcene (1.0%)
α-terpinene (2.2%)
1,8-cineole (89.6%)
(Z)-β-ocimene (3.7%)
isomenthol (0.2%)
α-guaiene (0.1%)
caryophyllene oxide (0.2%)

**Percentage composition of the major components of cardamom oil produced from the three types of genotypes** **T-1**

| Compound | Malabar oils | Vazhukka oils | Mysore oil |
|---|---|---|---|
| α-terpinene | 0.0–1.3 | 1.2–1.5 | 0.7–0.9 |
| sabinene | 3.0–3.8 | 3.7–4.4 | 2.6–3.0 |
| myrcene | 1.4–2.4 | 1.8–2.5 | 2.0–2.2 |
| 1,8-cineole | 21.7–24.5 | 21.7–25.3 | 16.1–17.6 |
| linalool | 1.5–5.3 | 0.0–4.2 | 8.7–9.0 |
| terpinen-4-ol | 2.2–2.7 | 2.3–2.5 | 2.5–2.7 |
| α-terpineol | 6.3–7.4 | 2.3–6.8 | 5.3–6.0 |
| nerol | 2.3–5.0 | 0.0–3.0 | 6.2–6.8 |
| α-terpinyl acetate | 39.3–45.5 | 42.6–47.9 | 39.8–40.4 |
| geranyl acetate | 0.9–3.4 | 0.8–3.3 | 1.6–2.7 |
| nerolidol* | 0.9–2.7 | 0.3–1.4 | 2.8–3.0 |

*correct isomer not identified

This analysis is of little value as it is not a normal cardamom oil composition; however, it is included for review completeness.


M. Omanakutty and B. Joy, *A study on the retention of fresh flavor of cardamom oil by cold grinding.* J. Essent. Oil Bear. Plants, **10**, 490–493 (2007).

N.K. Leela, D. Prasath and M.N. Venugopal, *Essential oil composition of selected cardamom genotypes at different maturity levels.* Indian J. Hort., **65**, 366–369 (2008).

N.M. Sokkar, *Investigations of essential oil and n-hexane extract of* Elettaria cardamomum *seed.* J. Essent. Oil Bear. Plants, **11**, 365–375 (2008).

E. Thomas, J. Kizhakkayil, T.J. Zachariah, S. Syamkumar and B. Sasikumar, *GC/MS analysis of essential oil of export grade Indian, Guatemalan and Sri Lankan cardamoms.* J. Med. Arom. Plant Sci., **31**, 206–208 (2009).

S. Sultana, M. Ali, S.H. Ansari and P. Bagri, *Effect of physical factors on the volatile constituents of* Elettaria cardamomum *fruits.* J. Essent. Oil Bear. Plants, **12**, 287–292 (2009).


## Brazilian Pepper (Fruit), or Pink Pepper, Oil

Brazilian pepper (or pink pepper as it is known in the culinary trade) originates from *Schinus terebinthifolius* Raddi, a tree native to Brazil that has been grown as an ornamental and a source of the exotic spice pink pepper.

Morton (1967 and 1978) reported that when the tree is in bloom it causes contact dermatitis and respiratory difficulties. She also reported that the fruits, when consumed in quantity, intoxicate birds and cause fatal trauma to four-footed animals. Furthermore, if children eat more than a few fruits, they experience severe digestive problems including vomiting.

Stahl (1982 and 1983) determined that the irritancy and toxicity associated with *S. terbinthifolius* originated from the non-volatiles among which was cardanol 15:1 and an anacardic acid. Stahl concludes by saying that the health damage caused by *S. terebinthifolius* berries was sufficient grounds to not use pink pepper as an exotic spice.

The volatiles of the fruits of *S. terebinthifolius* have been the subject of a number of studies. For example, Lloyd et al. (1977) determined that the volatiles comprised:

α-pinene (20.0%)
β-pinene (0.8%)
sabinene (0.6%)
δ-3-carene (20.8%)
α-phellandrene (12.8%)
limonene (8.8%)
β-phellandrene (6.4%)
p-cymene (8.0%)
terpinolene (0.8%)

In addition, the authors also characterized unknown amounts of *cis*-sabinol, α-cubebene, β-cubebene, β-caryophyllene and carvotanacetone as volatiles of *S. terebinthifolius*.

Pieribattesti et al. (1980) determinted that the monoterpene hydrocarbons found in an oil of *S. terebinthifolius* of Reunion origin were as follows:

α-pinene (26.5%)
camphene (0.9%)
β-pinene (7.0%)
sabinene (1.7%)
δ-3-carene (<0.1%)
α-phellandrene (22.3%)
α-terpinene (1.0%)
limonene (16.0%)
β-phellandrene (15.0%)
γ-tepinene (1.0%)
p-cymene (7.0%)
terpinolene (1.4%)

Lawrence (1984) analyzed lab-distilled oils of pink pepper of two

**Comparative percentage composition of laboratory-prepared oil (hydrodistillation) and extract (hexane) of cardamom** **T-2**

| Compound | Oil | Extract |
|---|---|---|
| hexanone* | - | 1.3 |
| hexanol | - | 0.4 |
| 3-methyl-4-heptanone** | - | 2.4 |
| α-thujene | 0.1 | - |
| sabinene | 1.2 | - |
| β-pinene | - | 0.1 |
| 3-octanone | - | 0.3 |
| δ-3-carene | 1.9 | - |
| limonene | 2.0 | 0.3 |
| β-phellandrene | 0.1 | - |
| 1,8-cineole | 22.0 | 2.5 |
| terpinolene | 0.4 | - |
| linalool | 1.7 | 0.4 |
| *cis*-β-terpineol | 1.2 | - |
| α-terpineol | 16.7 | 36.2 |
| *cis*-sabinene hydrate acetate | 1.1 | - |
| neral | - | 0.8 |
| geranial | - | 1.5 |
| α-terpinyl acetate | 33.7 | 2.1 |
| carvyl acetate* | - | 3.9 |
| isobornyl isobutyrate** | - | 3.6 |
| neryl acetate | 3.1 | - |
| α-terpinyl propionate | 0.5 | - |
| γ-gurjunene | 0.1 | - |
| neryl acetone** | 0.2 | - |
| geranyl propionate | 0.2 | - |
| allyl decanoate** | 0.1 | 0.3 |
| germacrene D | 0.4 | - |
| β-selinene | 0.8 | 3.6 |
| α-selinene | 0.3 | - |
| α-muurolene | 0.1 | - |
| globulol** | - | 1.6 |
| guaiol** | - | 2.8 |
| butylhexylbenzene*** | - | 1.3 |

different geographical origins. The composition of these two oils can be seen in **T-4**.

Barbosa et al. (2007) examined the composition of oils of ripe fruit of *S. terebinthifolius* hydrodistilled over a 3-hour period. Oils obtained at 20-minute intervals were analyzed by GC-FID (for quantitation and retention indices) and GC/MS (for identification corroboration). A selection of the results obtained in this study is represented in **T-5**.

Atti dos Santos et al. (2009) examined the composition of fruit of *S. terebinthifolius* collected from Rio Grande do Sol (Brazil). They found that the composition of the oil was as follows:

α-pinene (6.0%)
β-pinene (2.6%)
sabinene (2.9%)
δ-3-carene (0.2%)
myrcene (20.4%)
α-phellandrene (3.9%)
α-terpinene (2.2%)
limonene (17.0%)
γ-terpinene (0.3%)
p-cymene (0.8%)
α-cubebene (0.2%)
α-copaene (3.5%)
β-caryophyllene (1.4%)
terpinen-4-ol (0.8%)
α-humulene (1.0%)
(E)-β-farnesene (0.9%)
germacrene D (10.9%)
bicyclogermacrene (0.6%)
δ-cadinene (3.3%)
γ-cadinene (0.5%)
α-cadinene (t)
caryophyllene oxide (t)
α-amorphene* (0.2%)
spathulenol (0.4%)
α-cadinol (0.3%)

t = trace (<0.1%)
*incorrect identification based on GC elution order

**Comparative percentage composition of laboratory-prepared oil (hydrodistillation) and extract (hexane) of cardamom** **T-2 (Cont.)**

| Compound | Oil | Extract |
|---|---|---|
| 1-propylheptyl benzene*** | - | 0.7 |
| 1-ethyloctyl benzene*** | - | 7.7 |
| γ-cadinene | 0.7 | - |
| germacrene B | 0.3 | - |
| nerolidol***** | 3.0 | - |
| cedrol** | - | 4.0 |
| T-cadinol | 6.0 | 0.7 |
| 1-methylnonyl benzene*** | - | 1.0 |
| γ-terpineol**** | - | 1.1 |
| T-muurolol | 0.3 | - |
| 1-butylheptylbenzene*** | - | 4.5 |
| epi-α-bisabolol | 0.3 | - |
| 1-ethylnonylbenzene*** | - | 0.3 |
| α-cadinol | 0.1 | - |
| juniper camphor | 0.1 | - |
| tetradeca-2,13-dione*** | 0.1 | - |
| 1-pentylheptylbenzene*** | - | 1.2 |
| 1-propylnonylbenzene*** | - | 2.5 |
| (Z,E)-farnesol | 0.4 | - |
| (Z,Z)-farnesol | 0.1 | - |
| (E,E)-farnesol | 2.0 | 1.4 |
| 1-methylundecylbenzene*** | - | 1.4 |
| 1-methyldecylbenzene*** | - | 1.2 |
| (E,Z)-farnesol | 0.5 | 0.3 |
| benzyl benzoate | - | 2.8 |
| 2-heptadecanone | 0.1 | - |
| heptadecanol | 0.1 | - |
| hexadecanoic acid | 0.1 | - |
| farnesyl acetate* | 0.1 | - |

*correct isomer not identified
**incorrect identification based on GC elution order
***either plant waxes and/or hexane contaminants
****does not exist naturally
*****should be (E)-nerolidol


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H.A. Lloyd, Tayser, M. Jaouni, S.L. Evans and J.F. Morton, *Terpenes of* Schinus terebinthifolius. Phytochemistry, **16**, 1301–1302 (1977).

J-P. Pieribattesti, J-V. Conan and E.J. Vincent, *L'huile essentielle de* Schinus terebinthifolius *de la Reunion*. Rivista Ital. EPPOS, **63**, 301–302 (1980).

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L.C.A. Barbosa, A.J. Demuner, A.D. Clemente, V. Fonesca de Paula and F.M.D. Ismail, *Seasonal variation in the composition of volatile oils from* Schinus terebinthifolius *Raddi*. Quim. Nova, **30**, 1959–1965 (2007).

A.C. Atti dos Santos, M. Rosato, F. Agostini, L. Atti Serafini, P Luciana dos Santos, R. Molon, E. Dellacassa and P. Moyna, *Chemical composition of the essential oils from leaves and fruits of* Schinus molle *L. and* Schinus terebintifolius *Raddi from southern Brazil*. J. Essent. Oil Bear. Plants, **12**, 16–25 (2009).


## Brazilian Pepper Leaf Oil

A limited amount of Brazilian pepper leaf oil (ex *Schinus terebinthifolius* Raddi) is produced commercially each year, depending upon demand.

Singh et al. (1988) analyzed the leaves and infloressence of *S. terebinthifolius* that were harvested from trees growing in a government forest nursery in Nainital (Uttarakhand). The oil was found to possess the following composition:

α-pinene (24.4%)
camphene (0.2%)
β-pinene (0.9%)
sabinene (0.1%)
myrcene (0.1%)
α-phellandrene (7.2%)
α-terpinene (0.1%)
limonene (11.9%)
β-phellandrene (6.9%)
p-cymene (14.3%)
terpinolene (0.1%)
p-cymenene (0.1%)
δ-elemene (0.2%)
α-copaene (0.1%)
β-bourbonene (0.1%)
*trans*-p-menth-2-en-1-ol (0.1%)
β-elemene (3.8%)
β-caryophyllene (1.4%)
aromadendrene (0.2%)
*cis*-p-menth-2-en-1-ol (0.1%)
γ-elemene (0.7%)
menthyl acetate (0.7%)
α-terpineol + viridiflorene (1.0%)
α-terpinyl acetate (0.3%)
germacrene D (3.1%)
α-amorphene (0.9%)
β-selinene (0.4%)
bicyclogermacrene (0.3%)
δ-cadinene (0.8%)
cuminaldehyde (1.1%)
calamenene* (0.5%)
caryophyllene oxide (0.4%)
globulol (0.7%)
viridiflorol (0.5%)
spathulenol (3.7%)

*correct isomer not identified

Trace amounts (< 0.1%) of γ-terpinene, (E)-β-ocimene, α-cubebene, γ-cadinene and T-cadinol were also found in this oil.

Andria Agusta (2001) used GC/MS to analyzed a leaf oil of *S. terebinthifolius* obtained from trees grown in Indonesia. The components characterized in this oil that were not presented according to their GC retention indices were:

α-pinene (31.0%)
β-pinene (1.9%)
myrcene (0.5%)
β-phellandrene (0.3%)
terpinolene (0.4%)
δ-elemene (0.6%)
α-amorphene (0.2%)
β-bourbonene (0.6%)
β-elemene (6.6%)
ylangene* (0.4%)
isocaryophyllene (1.3%)
germacrene D (0.6%)
germacrene B (0.4%)

*incorrect identification based on GC elution order

The authors reported that they characterized two forms of δ-3-carene, α-phellandrene, p-cymene, α-copaene and β-selinene, but this was obviously in error as only one form of these compounds can exist.

Chowdhury and Tripathi (2001) determined that a leaf oil produced from *S. terebinthifolius* trees that were growing in the National Botanic Garden (Lucknow, UP, India) contained the following constituents:

α-pinene (51.8%)
camphene (0.1%)
β-pinene (2.2%)
sabinene (3.7%)
myrcene (0.2%)
*cis*-verbenol (1.5%)
β-caryophyllene (7.1%)
neral (1.7%)
α-terpinyl acetate (4.3%)
elemol (1.5%)
methyl farnesate* (1.5%)
thymol (2.2%)
α-cadinol (1.6%)

*incorrect identification based on GC elution order

Barbosa et al. (2007) analyzed a commercial sample of Brazilian pepper leaf oil. They found that the oil contained:

α-thujene (0.2%)
α-pinene (18.8%)
sabinene (2.3%)
β-pinene (2.5%)
myrcene (2.0%)
α-phellandrene (23.6%)
δ-3-carene (6.3%)
p-cymene (4.0%)
β-phellandrene (16.9%)
terpinolene (0.6%)
α-copaene (0.3%)
β-caryophyllene (2.3%)
α-humulene (0.1%)
γ-muurolene (0.1%)
germacrene D (11.9%)
bicyclogermacrene (1.4%)
δ-cadinene (0.3%)
elemol (1.9%)
germacrene B (0.6%)
spathulenol (1.1%)
caryophyllene oxide (0.3%)

A leaf oil of *S. terebinthifolius* of Brazilian origin was determined by

**Comparative percentage composition of oils produced from export grade Indian, Guatemalan and Sri Lankan cardamom** **T-3**

| Compound | Indian oil | Guatemalan oil | Sri Lankan oil |
|---|---|---|---|
| α-thujene | 0.1 | 0.2 | 0.3 |
| α-pinene | 2.0 | 1.8 | 2.1 |
| sabinene | 5.1 | 4.5 | 5.0 |
| β-pinene | 0.3 | 0.4 | 0.4 |
| myrcene | 2.6 | 2.8 | 2.7 |
| octanal | - | 0.2 | 0.1 |
| α-terpinene | - | 0.2 | - |
| 1,8-cineole | 28.3 | 25.8 | 25.2 |
| (E)-β-ocimene | t | 0.1 | 0.1 |
| γ-terpinene | 0.4 | 0.6 | 0.4 |
| *trans*-sabinene hydrate* | 0.3 | 0.2 | 0.2 |
| terpinolene | 0.2 | 0.3 | 0.3 |
| linalool | 1.3 | 7.3 | 6.8 |
| terpinen-4-ol | 2.7 | 2.4 | 2.4 |
| α-terpineol | 2.6 | 4.7 | 3.8 |
| neral | 0.2 | 0.5 | 0.3 |
| linalyl acetate | - | - | 6.9 |
| geranial | 0.4 | 0.9 | 0.5 |
| α-terpinyl acetate | 46.6 | 39.7 | 37.6 |
| neryl acetate | t | 0.2 | 0.3 |
| geranyl acetate | 0.7 | 0.5 | 1.3 |
| β-selinene | 0.9 | - | 0.6 |
| nerolidol** | 1.0 | 1.3 | 1.3 |

t = trace (<0.1%)
*misidentification; should be *cis*-sabinene hydrate
**correct isomer not identified

Atti dos Santos (2009) to possess the following composition:

α-pinene (7.9%)
α-thujene (0.6%)
β-pinene (2.5%)
sabinene (2.9%)
α-phellandrene (3.9%)
myrcene (1.6%)
α-terpinene (1.5%)
limonene (14.2%)
β-phellandrene (0.2%)
γ-terpinene (0.3%)
δ-3-carene* (0.2%)
p-cymene (0.2%)
terpinolene (< 0.1%)
α-cubebene (0.6%)
α-copaene (8.0%)
β-caryophyllene (2.1%)
terpinen-4-ol (0.4%)
aromadendrene (0.6%)
α-humulene (0.7%)
(E)-β-farnesene (1.7%)
germacrene D (11.5%)
bicyclogermacrene (2.1%)
δ-cadinene (9.2%)
γ-cadinene (0.8%)
α-amorphene* (1.4%)
spathulenol (0.2%)
α-cadinol (0.3%)

*incorrect identification based on GC elution order

**Comparative percentage composition of *Schinus terebinthifolius* berry oils from two different origins** **T-4**

| Compound | Reunion pink pepper oil | Madagascan[a] pink pepper oil |
|---|---|---|
| α-thujene | 0.1 | t |
| α-pinene | 22.2 | 3.6 |
| camphene | 0.2 | t |
| β-pinene | 5.3 | 0.4 |
| sabinene | 8.8 | 0.6 |
| δ-3-carene | 8.8 | 4.7 |
| myrcene | 1.7 | 0.6 |
| α-phellandrene | 10.2 | 0.7 |
| α-terpinene | 0.8 | 0.1 |
| limonene | 16.3 | 7.1 |
| β-phellandrene | 3.0 | 2.3 |
| γ-terpinene | 0.8 | t |
| p-cymene | 1.7 | 10.9 |
| terpinolene | 0.7 | 0.1 |
| α-cubebene | 0.2 | 0.6 |
| α-copaene | 0.1 | 0.1 |
| α-gurjunene | 0.1 | 1.5 |
| linalool | 0.2 | 1.4 |
| β-elemene | 0.1 | 0.1 |
| terpinen-4-ol | 1.5 | 0.3 |
| β-caryophyllene | 1.3 | 1.8 |
| α-humulene | 0.2 | 0.6 |
| γ-muurolene | 0.1 | 0.1 |
| α-terpineol | 0.2 | 0.3 |
| germacrene D | 5.1 | 1.8 |
| piperitone | 0.2 | 0.1 |
| γ-elemene | 0.6 | 0.1 |
| δ-cadinene | 0.6 | 1.0 |
| γ-cadinene | 0.1 | 0.2 |
| α-cadinene | 0.3 | 1.6 |
| calamenene* | t | 0.3 |
| palustrol | t | 0.1 |
| caryophyllene oxide | t | 0.3 |
| α-calacorene | 0.4 | 0.2 |
| elemol | 1.4 | 3.8 |
| spathulenol | 0.9 | 0.5 |
| γ-eudesmol | 0.1 | 5.7 |
| T-cadinol | 0.1 | 1.7 |
| α-muurolol | 0.2 | 2.6 |
| thymol | t | 0.3 |
| α-eudesmol | 0.5 | 1.1 |
| β-eudesmol | 0.8 | 0.9 |
| α-cadinol | 0.2 | 1.2 |

t = trace (<0.1%)
[a]commercial source
*correct isomer not identified

El-Massry et al. (2009) analyzed an oil of *S. terebinthifolius* obtained from fresh and dried leaves obtained from trees harvested in Egypt. The results of the comparative analysis of fresh and dried leaf oil can be seen in **T-6**. It is of interest to note that the compositions of the fresh and dried leaf oils were very different to all published data on these oils. As a result, the taxonomic identity of the leaves distilled and analyzed in this study is definitely in question.

Gundidza et al. (2009) screened an oil produced from the fresh leaves of *S. terebinthifolius* collected in Zimbabwe for its biological activities. The main components of this oil were determined by GC/MS to be as follows:

α-pinene (30.3%)
camphene (0.6%)
myrcene (6.6%)
β-pinene (8.0%)
myrcene (1.6%)
α-phellandrene (9.9%)
α-terpinene (0.8%)
sabinene (40.7%)
(E)-β-ocimene (0.3%)
γ-terpinene (0.8%)
3-cyclohexenol (0.6%)

The above list of compounds is shown in the published elution order from a non-polar column. As a result, the report is of little value, as myrcene, sabinene and 3-cyclohexenol were incorrectly characterized.

**Comparative percentage composition of oils obtained from ripe fruit of *Schinus terebinthifolius* collected at different distillation intervals** **T-5**

| Compound | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| α-thujene | 0.2 | 0.1 | 0.2 | 0.1 | 0.1 | 0.1 |
| α-pinene | 14.3 | 8.3 | 6.5 | 5.5 | 3.1 | 1.8 |
| sabinene | 3.5 | 1.3 | 0.9 | 1.3 | 0.6 | 0.3 |
| β-pinene | 3.5 | 2.1 | 1.7 | 1.8 | 1.0 | 0.7 |
| myrcene | 5.7 | 3.6 | 2.8 | 3.8 | 1.6 | 1.0 |
| α-phellandrene | 12.9 | 9.2 | 7.5 | 9.1 | 4.6 | 2.9 |
| δ-3-carene | 30.1 | 21.7 | 17.2 | 14.3 | 10.2 | 5.8 |
| p-cymene | 1.3 | 1.0 | 0.9 | 0.8 | 0.7 | 0.6 |
| β-phellandrene | 18.5 | 13.9 | 11.2 | 7.7 | 7.1 | 4.5 |
| terpinolene | 1.1 | 1.0 | 0.9 | 0.8 | 0.6 | 0.4 |
| terpinen-4-ol | 0.2 | 0.9 | 1.1 | 1.2 | 1.6 | 2.2 |
| δ-elemene | 0.2 | 0.6 | 0.6 | 0.4 | 0.4 | 0.3 |
| α-copaene | 0.1 | 0.3 | 0.4 | 0.3 | 0.3 | 0.3 |
| β-elemene | 0.5 | 0.9 | 1.0 | 0.9 | 0.9 | 0.7 |
| β-caryophyllene | 1.2 | 3.8 | 3.8 | 1.9 | 3.3 | 2.5 |
| α-humulene | 0.1 | 0.4 | 0.5 | 4.3 | 1.1 | 0.9 |
| germacrene D | 2.2 | 8.7 | 8.7 | 5.5 | 7.4 | 4.4 |
| α-muurolene | 0.3 | 1.7 | 1.8 | 3.6 | 2.6 | 1.6 |
| γ-cadinene | 0.1 | 0.4 | 0.7 | 0.8 | 1.0 | 1.0 |
| δ-cadinene | 0.3 | 2.9 | 4.9 | 6.3 | 6.9 | 6.3 |
| elemol | 0.3 | 3.4 | 6.3 | 5.6 | 11.3 | 13.6 |
| germacrene B | 0.1 | 0.6 | 0.8 | 0.8 | 0.9 | 0.7 |
| caryophyllene oxide | 0.1 | 0.4 | 0.6 | 0.7 | 0.9 | 0.8 |
| germacrene D-4-ol | 0.1 | 0.6 | 1.4 | 1.9 | 3.2 | 5.3 |
| T-cadinol | 0.1 | 0.5 | 1.3 | 3.2 | 3.0 | 4.6 |
| α-cadinol | 0.1 | 1.5 | 3.8 | 4.7 | 9.4 | 16.3 |
| α-bisabolol | 0.1 | 0.7 | 0.9 | 0.8 | 0.9 | 0.4 |

Distillation times: 1). 20 min; 2). 40 min; 3). 60 min; 4). 80 min; 5). 100 min; 6). 180 min

## Comparative percentage composition of fresh and dried leaf oils of *Schinus terebinthifolius* of Egyptian origin — T-6

| Compound | Fresh leaf | Dry leaf |
|---|---|---|
| valeraldehyde | t | 0.3 |
| ethyl propionate | - | 0.7 |
| 1-octene | - | 1.9 |
| 5-methylenenorbonene* | - | 0.5 |
| santolinatriene | - | 5.8 |
| α-pinene | 1.0 | - |
| α-fenchene | 0.8 | - |
| verbenene | 0.5 | - |
| sabinene | 1.2 | 7.6 |
| m-cymenene* | 0.4 | - |
| terpinolene | 1.0 | - |
| β-thujone | 1.5 | 0.6 |
| camphor | 0.7 | 1.8 |
| *cis*-β-terpineol** | 17.9 | 3.6 |
| neothujanol | 2.7 | - |
| citronellol | 7.0 | 1.2 |
| (Z)-tagetenone | 0.6 | - |
| (E)-tagetenone | 1.0 | - |
| methyl citronellate | 0.9 | - |
| neothujyl acetate | 0.4 | - |
| dehydroelsholtzia ketone | 0.4 | - |
| α-cubebene | 0.6 | - |
| cyclosativene | 0.8 | - |
| α-copaene | 1.9 | - |
| patchoulene** | 2.5 | 1.0 |
| β-bourbonene | 2.7 | 0.3 |
| isolongifolene | 3.5 | 0.3 |
| β-elemene | 0.7 | - |
| cyperene | 1.3 | 0.6 |
| α-gurjunene | 1.8 | 7.2 |
| α-cedrene | 1.3 | 4.5 |
| β-cedrene | 9.8 | 7.2 |
| β-caryophyllene | 17.6 | 1.6 |
| dehydroaromadendrane | 0.7 | 1.4 |
| γ-cadinene | 3.4 | 1.6 |
| 7-epi-α-selinene | 1.5 | 1.0 |
| δ-cadinene | 3.7 | 1.5 |
| β-sesquiphellandrene | 3.2 | 8.6 |
| (E)-γ-bisabolene | 1.2 | 1.3 |
| selina-3,7-diene | 0.4 | 1.2 |
| sesquisabinene hydrate** | - | 0.6 |
| 6,11-oxidoacor-4-ene | 2.0 | 1.3 |
| α-agarofuran | - | 0.7 |
| geranyl butyrate | 0.5 | 12.2 |
| ledol | - | 3.0 |
| caryophyllene alcohol | 0.8 | 13.1 |
| spathulenol | - | 3.5 |
| globulol | - | 2.0 |
| dihydro-ar-turmerone | - | 0.3 |

*doubtful correct identification
**correct isomer not identified


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