Progress in Essential Oils

Brian M. Lawrence, Consultant

Laurus nobilis Oil

Laurus nobilis L. is a shrubby tree that is found growing throughout Europe and North Africa, consequently oil can be readily produced from the leaves as they are plentiful.

Leaves of *L. nobilis* (also known as bay) were collected in different onotogenetic stages in the grounds of the University of Tehran (Iran), air-dried and subjected to both steam and hydrodistillation for three hours by Amin et al. (2007). The resultant oils were subjected to analysis by GC-FID and GC/MS and their results are summarized in **T-1**. In addition, the authors averaged all of their analytical results on both hydrodistilled and steam distilled oils and additionally identified the following constituents (presumably all from the hydrodistilled oil):

α-thujene (0.1%)
δ-3-carene (0.2%)
α-terpinene (0.2%)
terpirnolene (0.2%)
borneol (0.6%)
trans-p-mentha-1(7),8-dien-2-ol (0.2%)
myrtenol (0.5%)
cis-p-mentha-1(7),8-dien-2-ol (0.3%)
β-elemene (0.2%)
β-caryophyllene (1.4%)
α-humulene (0.2%)
germacrene D (0.8%)
(E)-methyl isoeugenol (0.3%)
bicyclogermacrene (0.2%)
δ-cadinene (0.3%)
(Z)-α-bisabolene (0.8%)
germacrene D-4-ol (0.4%)
viridiflorol (0.2%)
caryophylla-4(14),8(15)-dienol* (1.2%)

*correct isomer not identified

In addition, trace amounts (<0.1%) were found in either the various hydrodistilled or steam distilled oils. They were hexanal, (E)-2-hexenol, (Z)-3-hexenol, (E)-2-hexenal, hexanol, tricyclene, dehydro-1,8-cineole, α-phellandrene, p-cymene, (E)-β-ocimene, *trans*-sabinene hydrate, α-campholenal, (Z)-p-mentha-2,8-dien-1-ol, *trans*-verbenol, nerol oxide, thuj-3-en-10-al, *trans*-piperitol, *trans*-carveol, nerol, *cis*-carveol, cuminaldehyde, carvone, geranial, phellandral, p-cymen-7-ol, carvacrol, neryl acetate, α-copaene, β-bourbonene, α-guaiene, aromadendrene, allo-aromadendrene, epi-cubebol, δ-amorphene,

Comparative percentage composition of the major components of the steam distilled oil of *Laurus nobilis* produced from leaves of different maturity **T-1**

Compound	Pre-flowering fresh leaf oil	Full-flowering fresh leaf oil	Full-flowering dried leaf oil	Fruit-bearing fresh leaf oil
α-pinene	5.6	4.0	5.3	4.4
camphene	t	t	t	0.5
sabinene + β-pinene	11.9	12.3	13.4	12.8
myrcene	0.7	0.1	t	0.7
1,8-cineole	33.4	51.6	53.9	51.0
γ-terpinene	0.3	0.6	0.9	0.7
cis-sabinene hydrate	0.2	0.4	0.4	0.5
linalool	4.0	2.6	2.3	3.7
cis-p-menth-2-en-1-ol	0.1	0.3	0.3	0.2
trans-pinocarveol	1.0	0.6	0.5	0.4
pinocarvone	t	0.3	0.5	0.4
δ-terpineol	t	0.3	0.3	0.3
terpinen-4-ol	1.0	3.1	2.8	2.3
α-terpineol	1.7	1.3	1.3	1.2
linalyl acetate	0.3	0.3	0.2	0.4
bornyl acetate	1.2	0.3	0.3	0.3
δ-terpinyl acetate	0.6	1.0	0.8	0.8
α-terpinyl acetate	10.0	10.7	9.6	10.8
eugenol	2.7	1.3	1.0	1.7
methyl eugenol	6.5	4.5	3.1	4.3
elemicin	t	0.1	0.1	t
caryophyllene oxide	2.0	1.1	0.6	1.0
β-eudesmol	1.9	0.5	0.3	0.5

t = trace (<0.1%)

γ-cadinene, 10-epi-cubebol, spathulenol, β-oplopenone, humulene oxide II, selin-11-en-4α-ol, α-eudesmol acetate and octadecane.

Sangun et al. (2007) examined the composition produced from plants harvested in three regions of Turkey of the leaf and berry oils of *L. nobilis* using GC/MS. A summary of the findings of this study can be seen presented in **T-2**.

Kovacevic et al. (2007) compared the chemical composition of oils produced by hydrodistillation of the stems, shoots and leaves of *L. nobilis* collected from two regions of Montenegro (Budva and Bar). The oils were analyzed by GC-FID and GC/MS and the results of this study can be found summarized in **T-3**.

Yalcin et al. (2007) used GC/MS only to examine the composition of a lab-distilled oil of *L. nobilis* produced from leaves collected from shrubs growing in the mountains of Besparmak (northern Cyprus). The constituents found in this oil at levels of 0.5% or greater were as follows:

α-pinene (3.4%)
sabinene (3.3%)
β-pinene (3.3%)
α-terpinene (0.5%)
o-cymene (1.3%)
p-cymene (1.8%)
1,8-cineole (58.6%)
γ-terpinene (0.8%)
trans-pinocarveol (0.9%)
pinocarvone (0.6%)
lavandulol (0.5%)
terpinen-4-ol (4.3%)
α-terpineol (1.4%)
myrtenal (0.8%)
isothujyl acetate (1.1%)
α-terpinyl acetate (8.8%)

Numerous other trace to 0.5% levels of other constituents were purported to be characterized in the oil; however, as most of them were characterized by computer matching mass spectral fragment patterns, they will not be included in this review.

Flamini et al. (2007) analyzed an oil of *L. nobilis* produced by the traditional water distillation system used in the laboratory using both GC-FID and GC/MS. The components characterized in this oil were as follows:

α-thujene (0.4%)
α-pinene (3.2%)
camphene (0.3%)
sabinene (6.5%)
β-pinene (2.9%)
myrcene (1.1%)
δ-3-carene (0.5%)
α-terpinene (0.2%)
p-cymene (0.2%)
limonene (1.3%)
1,8-cineole (35.7%)
γ-terpinene (0.4%)
cis-sabinene hydrate (0.6%)
terpinolene (0.2%)
trans-sabinene hydrate (9.7%)
terpinen-4-ol (1.4%)
α-terpineol (2.8%)
nerol (0.2%)
linalyl acetate (0.3%)
isobornyl acetate (0.3%)
trans-sabinyl acetate (0.1%)
α-terpinyl acetate (9.3%)
eugenol (4.8%)
β-elemene (0.1%)
methyl eugenol (6.8%)
β-caryophyllene (0.6%)
valencene (0.3%)
β-bisabolene (0.2%)
elemicin (0.6%)
spathulenol (0.6%)
germacrene D-4-ol (1.2%)
caryophyllene oxide (0.2%)
viridiflorol (0.3%)
10-epi-γ-eudesmol (0.3%)
γ-eudesmol (0.2%)
caryophylla-4(14),8(15)-dien-5-ol (0.2%)
epi-α-bisabolol (0.5%)
α-eudesmol (1.2%)

Comparative percentage composition of oils of *Laurus nobilis* produced from the leaves and berries harvested from three different regions in Turkey **T-2**

Compound	Antalya		Yayaladagi		Samandagi	
	leaf oil	berry oil	leaf oil	berry oil	leaf oil	berry oil
α-thujene	0.4	t	t	0.4	t	0.4
α-pinene	3.7	16.6	2.2	11.3	2.6	6.8
camphene	0.2	2.1	t	0.8	t	0.8
sabinene	14.1	6.0	7.8	4.6	8.7	5.7
β-pinene	–	12.8	–	11.1	–	7.9
myrcene	0.6	0.9	t	0.5	t	0.6
α-phellandrene	t	15.9	t	10.6	t	13.3
p-cymenene	–	0.6	–	t	–	t
1,8-cineole	46.6	18.1	47.6	20.5	59.9	17.4
(E)-β-ocimene	t	11.9	0.3	19.9	t	28.4
γ-terpinene	0.4	–	0.8	–	0.8	–
trans-sabinene hydrate	1.3	–	0.8	–	0.5	–
cis-sabinene hydrate	0.6	–	0.4	–	t	–
terpinolene	t	–	0.3	–	0.3	–
linalool	0.6	1.4	0.4	t	0.4	t
terpinen-4-ol	1.8	–	2.2	–	2.1	–
α-terpineol	6.8	–	1.4	–	1.9	–
bornyl acetate	–	0.6	–	t	–	0.4
α-terpinyl acetate	11.9	4.1	25.7	4.9	16.3	3.7
β-elemene	0.2	3.1	0.2	4.5	0.2	2.7
eugenol	t	–	0.7	–	t	–
β-caryophyllene	t	t	t	1.5	0.2	0.7
methyl eugenol	2.0	–	3.4	–	0.4	–
α-humulene	t	–	t	–	t	–
germacrene D	–	0.9	–	1.7	–	0.9
germacrene A	–	2.8	–	4.4	–	3.2
α-farnesene*	–	0.6	–	1.8	–	1.7
(Z)-α-bisabolene	–	1.8	–	0.7	–	1.1
caryophyllene oxide	1.3	–	0.3	–	0.9	–
calamenene*	0.5	–	0.3	–	0.3	–
β-eudesmol	1.6	–	1.1	–	0.6	–
α-eudesmol	1.0	–	0.3	–	0.1	–

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

The authors compared this oil to oils produced by conventional microwave distillation (200 w and 300 w) and a pulsed microwave probe into a glass flask: containing leaf slices stirred in water. Analyses of these oils revealed that they were comparable to the hydrodistilled oil except that δ-terpineol and borneol were found exclusively in the microwave distilled oils, while β-elemene, spathulenol and 10-epi-γ-eudesmol were not found in the microwave distilled oils.

The volatile (essential oil-like concentrate) and the non-volatile fixed (or vegetable oil) oils were isolated from dried *L. nobilis* berries of Tunisian origin by Marzouki et al. (2008) using supercritical CO_2 extraction.

The volatile concentrate was produced at 40°C at a pressure of 90 bar using a 320 mL extraction vessel and two separator vessels (300 mL and 200 mL) connected in series. The extraction was performed by batch charging the dried berries and a continuous flow of supercritical CO_2 (SFE). The conditions of the two separators were 90 bar and -10°C for the first and 20 bar and 15°C for the second. The SFE was analyzed by GC/MS and it was compared with an oil produced by hydrodistillation (see **T-4**). The authors also isolated the fixed oil by extracting at 40°C and 250 bar.

A laboratory distilled oil of *L. nobilis* produced from berries collected in their natural habitat in Lebanon was analyzed by Loizzo et al. (2008) using GC/MS only. The oil was found to contain the following components:

α-thujene (0.1%)
α-pinene (3.7%)
camphene (1.7%)
sabinene (1.6%)
β-pinene (2.1%)
myrcene (0.6%)
α-phellandrene (0.1%)
α-terpinene (0.2%)
p-cymene (0.1%)
limonene (0.1%)
1,8-cineole (9.4%)
β-ocimene* (21.8%)
γ-terpinene (0.1%)
fenchone (0.1%)
camphor (0.4%)
α-terpineol (0.4%)
isoborneol† (0.3%)
bornyl acetate (0.2%)

Comparative percentage composition of oils produced from different plant parts of *Laurus nobilis* harvested in two regions of Montenegro **T-3**

Compound	Stem oil		Shoot oil		Leaf oil	
	A	B	A	B	A	B
α-thujene	0.2	0.2	0.4	0.4	0.5	0.5
α-pinene	2.5	1.9	5.6	4.8	6.2	5.2
camphene	0.4	0.1	0.5	0.2	0.5	0.2
sabinene	4.2	4.1	9.6	10.0	10.0	9.8
β-pinene	2.5	2.0	4.3	4.0	4.7	4.1
myrcene	0.5	0.6	0.7	1.0	0.5	1.1
α-phellandrene	0.2	0.2	0.2	0.3	0.2	0.3
α-terpinene	0.1	0.2	0.2	0.3	0.3	0.3
p-cymene	1.0	0.5	0.4	0.4	0.5	0.5
limonene	1.5	1.1	1.9	1.6	2.0	1.7
1,8-cineole	18.8	28.3	36.2	46.0	39.0	40.9
γ-terpinene	0.4	0.4	0.5	0.6	0.6	0.6
cis-sabinene hydrate	0.2	0.4	0.4	0.4	0.3	0.2
p-mentha-2,4(8)-diene	0.1	0.2	0.2	0.2	0.2	0.3
linalool	5.8	7.7	4.3	6.7	4.1	6.1
borneol	0.2	0.1	0.1	0.1	–	0.1
terpinen-4-ol	1.7	1.7	1.4	1.8	1.7	1.8
α-terpineol	1.4	2.9	1.6	2.3	1.6	2.3
bornyl acetate	0.1	0.3	0.1	0.1	–	0.1
carvacrol	–	0.2	–	0.2	–	0.2
ocimenyl acetate*	–	0.3	–	0.2	–	–
(Z)-isosafrole	0.2	0.2	0.1	0.1	0.1	–
δ-elemene	0.7	0.4	0.1	0.2	0.3	–
α-terpinyl acetate	12.5	10.3	9.6	9.8	9.3	9.7
α-cubebene	–	0.2	–	0.7	–	–
eugenol	1.4	3.6	1.5	–	1.3	1.1
α-copaene	0.2	–	0.1	–	0.8	–
β-cubebene	–	0.2	–	–	–	0.1
β-elemene	–	1.2	0.6	–	–	0.5

α-ylangene (0.2%)
α-copaene (0.2%)
α bergamotene* (0.1%)
β-elemene (1.0%)
β-caryophyllene (0.3%)
(E)-β-farnesene (0.1%)
α humulene (0.1%)
γ-cadinene (0.4%)
δ-cadinene (0.1%)
eremanthin (3.7%)
dehydrocostus lactone (7.6%)

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

It was surprising that eremanthin and dehydrocostus lactone (uncommon sesquiterpene lactones) were found in this oil. As a result, their identity requires corroboration.

A commercial oil of *Laurus nobilis* which was screened for its anti-fungal activity, was determined by Simic et al. (2009) to possess the following composition:

α-thujene (0.9%)
α-pinene (7.2%)
camphene (0.7%)
sabinene (9.1%)
β-pinene (5.2%)
myrcene (0.9%)
p-cymene (2.5%)
limonene (1.9%)
1,8-cineole (41.9%)
linalool (7.0%)
terpinen-4-ol (1.6%)
α-terpineol (1.7%)
3-hexenyl butyrate* (0.6%)
linalyl acetate (1.4%)
bornyl acetate (1.2%)
α-terpinyl acetate (5.5%)
eugenol (1.4%)
β-elemene (0.9%)
methyl eugenol (2.5%)

*correct isomer not identified

Comparative percentage composition of oils produced from different plant parts of *Laurus nobilis* harvested in two regions of Montenegro **T-3 (cont.)**

Compound	Stem oil		Shoot oil		Leaf oil	
	A	B	A	B	A	B
methyl eugenol	10.6	7.3	5.7	2.4	3.4	3.0
α-gurjunene	0.3	0.1	0.3	0.1	0.4	0.2
β-caryophyllene	1.8	2.5	1.5	1.1	1.5	1.0
α-guaiene	0.2	0.3	0.1	0.2	–	0.3
α-humulene	–	0.2	–	–	–	0.1
γ-muurolene	0.7	0.8	0.6	0.2	0.5	0.3
α-muurolene	0.5	0.5	0.3	0.2	0.3	0.3
α-bulnesene	1.0	1.0	–	0.2	0.7	0.6
(E,E)-α-farnesene	0.2	0.3	0.2	0.1	–	0.3
γ-cadinene	0.9	1.0	0.3	0.2	–	0.2
δ-cadinene	0.4	0.5	0.3	–	0.3	0.4
trans-cadina-1(2), 4-diene	0.9	0.2	–	–	0.5	–
α-copaen-8-ol	0.4	0.4	0.3	0.1	0.2	0.1
elemicin	–	0.4	–	0.1	0.9	0.3
germacrene D-4-ol	–	–	–	0.1	0.6	0.2
spathulenol	4.2	1.6	1.4	0.1	–	0.2
caryophyllene oxide	4.8	2.7	1.1	0.3	–	0.3
globulol	1.5	0.2	0.4	0.1	0.4	0.1
viridiflorol	1.1	0.2	0.3	–	0.3	–
humulene epoxide II	1.1	0.4	0.1	–	–	–
10-epi-γ-eudesmol	0.3	1.0	0.3	–	0.2	0.2
γ-eudesmol	–	1.0	0.3	–	0.2	0.2
T-muurolol	0.8	–	–	–	–	–
α-muurolol	2.6	1.6	0.5	0.1	0.5	0.3
α-cadinol	0.4	0.4	0.2	–	–	–
khusinol	0.9	0.5	0.3	–	–	–
(E)-nerolidol acetate	0.2	–	0.1	–	–	–
α-bisabolol	0.8	0.2	0.3	–	–	–

A = vicinity Budva, B = vicinity Bar
*correct isomer not identified

Marzouki et al. (2009) analyzed fruit oils of *L. nobilis* collected from seven different regions of Tunisia using GC/MS. The range in composition of these oils was found to be as follows:

α-pinene (2.1–7.8%)
camphene (0.7–1.4%)
sabinene (0.7–1.7%)
β-pinene (1.1–3.5%)
myrcene (t–0.4%)
1,8-cineole (7.4–35.0%)
(Z)-β-ocimene (t–5.2%)
(E)-β-ocimene (23.6–54.5%)
terpinolene (t–1.0%)
linalool (0.4–0.9%)
trans-pinocarveol (t–1.5%)
borneol (t–0.5%)
terpinen-4-ol (t–1.0%)
α-terpineol (t–1.5%)
cis-sabinene hydrate acetate (t–1.2%)
bornyl acetate (1.1–4.0%)
α-terpinyl acetate (0.5–3.8%)
α-ylangene (t–3.7%)
β-cubebene (t–1.0%)
β-longipinene (1.9–2.6%)
methyl eugenol (t–1.4%)
α-gurjunene (t–0.5%)
β-caryophyllene (t–1.2%)
α-guaiene (t–0.6%)
germacrene D (t–1.2%)
cis-β-guaiene (t–1.0%)
bicyclogermacrene (0.3–4.7%)
α-bulnesene (0.5–1.2%)
γ-cadinene (0.6–1.6%)
δ-cadinene (0.9–1.9%)
germacrene D-4-ol (t–1.3%)
spathulenol (0.6–1.8%)
caryophyllene oxide (t–0.8%)
globulol (t–0.9%)

α-cadinol (t–1.3%)
(Z)-nerolidol acetate (t–0.4%)
5-isocedranol (t–1.4%)

t = trace (<0.1%)

In addition trace amounts (<0.1%) of δ-3-carene, linalyl acetate, α-humulene and elemicin were also found in these oils. Furthermore, the major components (compounds found in amounts greater than 5.0%) found in the seed oils of *L. nobilis* were:

α-pinene (4.5–11.1%)
sabinene (1.8–5.4%)
β-pinene (2.7–6.0%)
1,8-cineole (7.7–19.1%)
bornyl acetate (1.6–5.0%)
α-terpinyl acetate (t–8.7%)
β-longipinene (6.2–9.7%)
α-bulnesene (4.0–6.7%)
δ-cadinene (4.6–5.4%)

t = trace (<0.1%)

Nabiha et al. (2009) determined that the floral bud oil of Tunisian *L. nobilis* contained the following constituents:

α-pinene (0.1%)
sabinene (0.1%)
myrcene (0.4%)
δ-3-carene (0.2%)
1,8-cineole (0.4%)
cis-sabinene hydrate (0.4%)
linalool (1.3%)
terpinen-4-ol (6.4%)
α-terpineol (3.2%)
myrtenol (0.8%)
α-undecanone (0.8%)
α-terpinyl acetate (28.4%)
eugenol (7.4%)
neryl acetate (0.4%)
methyl eugenol (19.6%)
β-caryophyllene (2.3%)
germacrene D (1.3%)
bicyclogermacrene (1.0%)
δ-cadinene (1.2%)
elemicin (4.4%)
spathulenol (1.5%)
caryophyllene oxide (3.2%)
β-eudesmol (1.2%)

Bayramoglu et al. (2009) compared the effects of microwave power and time on the microwave distillation of leaves of *L. nobilis* of Turkish origin. The compositions of the oils were compared with a lab-distilled oil by hydrodistillation from the same batch of leaves. The so-called solvent-free microwave distillation (SFMD) was carried out at either 249 w or 622 w of microwave power. Although the authors analyzed oils produced from hydrodistillation durations of 60 min, 75 min and 195 min, and the 249 w and 622 w microwave distillations at 10 min, 25 min and 130 min, and 7 min, 15 min and 85 min, respectively, only the 195 min hydrodistillation and the 25 min and 15 min microwave distillations are included in the results shown in **T-5**.

Comparative percentage composition of an SFE and oil of *Laurus nobilis* berries of Tunisian origin **T-4**

Compound	SFE volatile concentrate	Hydrodistilled oil
α-pinene	8.0	10.3
camphene	2.6	3.8
sabinene	1.8	2.6
β-pinene	4.2	5.8
1,8-cineole	8.8	8.1
(Z)-β-ocimene	2.0	3.0
(E)-β-ocimene	20.9	23.7
linalool	2.2	4.2
p-mentha-1,5-dien-8-ol	1.5	1.5
linalyl acetate	4.5	1.3
bornyl acetate	2.9	2.1
α-terpinyl acetate	3.8	3.0
β-cubebene	2.2	1.9
β-longipinene	7.1	6.8
methyl eugenol	1.4	1.0
β-caryophyllene	2.5	1.9
germacrene D	2.7	1.8
viridiflorene	1.5	1.0
α-bulnesene	3.5	2.7
γ-cadinene	2.7	2.1
δ-cadinene	4.7	3.9
spathulenol	2.3	1.4
α-cadinol	2.0	1.1
δ-isocedranol†	2.1	1.1

†doubtful correct identification

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Comparative concentration of components characterized in laurel leaf oil produced by different methods **T-5**

Compound	Hydrodistilled oil	Microwave distilled	
		622 w oil	249 w oil
α-thujene	3.5[a]	1.8	2.6
α-pinene	39.0	0.0	20.0
camphene	2.9	1.9	1.9
sabinene	47.0	41.6	41.0
β-pinene	32.4	20.3	20.9
α-phellandrene	1.6	–	1.3
α-terpinene	4.9	2.2	2.2
p-cymene	12.8	9.5	10.3
1,8-cineole	630.2	878.8	874.1
γ-terpinene	8.9	4.0	4.5
terpinolene	2.9	1.1	1.2
linalool	2.4	3.0	3.0
trans-pinocarveol	9.8	13.5	13.0
camphor	0.9	1.3	1.2
sabina ketone	3.7	6.0	5.5
pinocarvone	6.3	9.5	9.5
borneol	8.8	11.6	8.0
terpinen-4-ol	36.8	36.8	36.4
α-terpineol	2.2	2.8	2.5
myrtenal	10.1	12.3	11.6
cuminaldehyde	3.1	3.8	3.5
carvone	2.8	2.0	2.6
bornyl acetate	4.5	4.3	4.1
cuminaldehyde	1.6	1.5	1.2
pseudo limonene[†]	7.1	5.7	5.8
α-terpinyl acetate	90.3	68.2	66.7
eugenol	12.2	11.1	8.5
methyl eugenol	12.1	10.1	8.1
β-eudesmol	4.0	–	–

a = mg/mL
622 w oil: Oil produced using 622 w of microwave power for 15 min
249 w oil: Oil produced using 249 w of microwave power for 25 min
Hydrodistilled oil: 195 min distillation duration
*correct isomer not identified
[†]incorrect identification based on GC elution order

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Palmarosa Oil

The major constituents of a sample of Nepalese palmarosa oil were found by Yonzon et al. (2005) to be as follows:

(E)-β-ocimene (2.5%)
linalool (4.9%)
β-caryophyllene (3.4%)
geranyl acetate (22.6%)
geraniol (61.4%)
geranyl hexanoate (1.9%)
farnesol* (1.2%)

*correct isomer not identified

The main aroma-bearing constituents of a commercial sample of palmarosa oil were found by Jirovetz et al. (2006) to be as follows:

nerol (0.2%)
neral (0.2%)
geraniol (79.3%)
geranial (0.5%)
geranyl formate (0.2%)
geranyl acetate (6.2%)
neryl propionate (0.5%)
geranyl butyrate (0.3%)

Trace amounts (<0.1%) of citronellol and neryl acetate were also found in this oil.

The effect of combinations of weed biomass (0–30%) and palmarosa biomass prior to hydrodistillation was examined by Rajeswara Rao et al. (2007). The main components of the oils were found to range as follows:

myrcene (1.5–2.0%)
(Z)-β-ocimene (1.0–1.1%)
(E)-β-ocimene (1.4–2.0%)
linalool (2.2–3.0%)
geraniol (69.8–75.4%)
geranyl acetate (12.4–17.9%)

The authors did find that the weed biomass affected the quality of oil produced by causing it to have an off-odor.

Ranade (2007) reported that a typical palmarosa oil produced in India contained the following major components:

monoterpene hydrocarbons (2.9%)
linalool (1.2%)
β-caryophyllene (0.8%)
α-humulene (0.6%)
α-selinene (0.3%)
neral (0.6%)
cadinene* (0.1%)
geranyl acetate (5.1%)
α-farnesene* (0.3%)
geranyl butyrate + geranyl isovalerate (0.4%)
geraniol (82.8%)
calacorene* (0.3%)
caryophyllene oxide (0.1%)
farnesol* (1.6%)

*correct isomer not identified

Palmarosa is a perennial aromatic grass whose leaves can be differentiated into two parts, the leaf sheath and the leaf blade. Morphologically the leaf sheath is attached around the stem, enclosing part of it while the leaf blade (often called lamina) extends from the top of the leaf sheath. Rajeswara Rao et al. examined the composition of oils produced from various plant parts such as the leaf lamina, the leaf sheath, the inflorescence and compared them with the oil produced from the whole grass. The results of this study are reported in **T-6**.

Comparative percentage composition of various plant parts of palmarosa grass **T-6**

Compound	Leaf lamina oil	Leaf sheath oil	Inflorescence oil	Whole grass oil
α-pinene	0.4	0.4	0.7	0.4
camphene	t	t	t	t
6-methyl-5-hepten-2-one	t	t	0.2	0.1
myrcene	0.2	0.3	0.4	0.3
limonene	0.5	0.3	0.5	0.4
(E)-β-ocimene	1.2	1.2	4.3	2.1
linalool	1.1	0.8	1.3	2.0
α-terpineol	0.1	0.1	0.1	0.1
geraniol	85.3	79.4	70.1	74.2
neryl acetate	0.2	0.4	0.4	0.4
geranyl acetate	4.3	9.4	14.8	10.7
β-caryophyllene	0.5	0.7	0.9	1.6
geranyl isobutyrate	0.1	0.1	0.3	0.3
geranyl butyrate	0.2	0.2	0.1	0.1
(Z,Z)-farnesol	0.3	0.3	0.1	0.3
(E,Z)-farnesol	1.6	1.7	1.7	34
geranyl hexanoate	0.6	0.3	0.7	0.8
oil yield (%)	1.40	0.33	2.00	0.75

t = trace (<0.1%)

An oil of palmarosa was reported (Anon 2009) to possess the following composition:

myrcene (0.2%)
limonene (0.1%)
α-ocimene† (0.4%)
β-ocimene* (1.8%)
linalool (2.9%)
nerol (0.2%)
neral (0.2%)
geraniol (80.5%)
geranyl formate (0.1%)
geranyl acetate (8.5%)
β-elemene (0.1%)
β-caryophyllene (1.7%)
α-humulene (0.1%)
β-selinene (0.1%)
geranyl butyrate (0.2%)
caryophyllene oxide (0.1%)
geranyl hexanoate (0.6%)
farnesyl acetate* (0.1%)

*correct isomer not identified

Trace amounts (<0.05%) of isovaleraldehyde, isoamyl formate, isoamyl acetate, 2-heptanone, 6-methyl-5-hepten-2-one, p-cymene, a dimethyl heptenal isomer, octanol, a linalool oxide isomer, terpinolene, hotrienol, (E,E)-allo-ocimene, citronellal, α-terpineol, amyl hexanoate, lavandulyl acetate, citronellyl acetate, α-selinene, valencene, α-parnasinene, geranyl valerate, (E,E)-farnesol and neophytadiene. It should be noted that as the originators of this study used GC/MS and computer matching of MS spectral patterns, the components listed as trace constituents require corroboration before they can be considered as true constituents of the oil.

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