Progress in Essential Oils

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Basil oil: Part 2[a]

Dob et al. (2006) analyzed an oil produced from basil plants cultivated in Algeria. The composition of this oil was determined to be as follows:

sabinene (0.3%)
β-pinene (0.5%)
myrcene (0.6%)
1,8-cineole (9.7%)
(Z)-β-ocimene (0.2%)
γ-terpinene (0.2%)
terpinolene (0.1%)
linalool (43.8%)
trans-p-menth-2-en-1-ol (0.2%)
camphor (0.3%)
borneol (0.4%)
thujyl alcohol (0.4%)
α-terpineol (1.9%)
myrtenol (0.1%)
octyl acetate (0.3%)
eugenol (4.9%)
α-copaene (1.0%)
β-elemene (0.1%)
methyl eugenol (0.2%)
isocaryophyllene (0.1%)
trans-α-bergamotene (8.5%)
aromadendrene (0.7%)
(E)-β-farnesene (0.1%)
β-acoradiene (2.5%)
germacrene D (1.0%)
1-epi-bicyclosesquiphellandrene (0.7%)
bicyclogermacrene (2.7%)
(E,E)-α-farnesene (0.2%)
α-bulnesene[a] (0.5%)
γ-cadinene (0.1%)
δ-cadinene (0.1%)
trans-calamenene (0.1%)
humulene epoxide II (0.9%)
T-cadinol (5.8%)

[a]also known as δ-guaiene

In addition, trace amounts (<0.05%) of α-pinene, camphene, (E)-β-ocimene, *trans*-verbenol, borneol, terpinen-4-ol, nerol, geraniol, linalyl acetate, bornyl acetate, neryl acetate, β-bourbonene, β-cubebene, β-caryophyllene, α-humulene, (E)-nerolidol, spathulenol, α-muurolol, β-eudesmol, α-bisabolol, (Z,E)-farnesol, methyl hexadecanoate, isophytol, phytol and eicosane in the same oil. The authors also mistakenly characterized exo-norbornyl acetate in this oil in error.

Seeds of 18 selections of *O. basilicum* were collected from local farms and home gardens in Turkey by Telci et al. (2006). These seeds were raised into plants at the Gaziosmanpaşa University Experimental Research Station (Tokat, Turkey). Once mature, plants from each of their origins were harvested in full bloom, and 20 g of each were separately hydrodistilled for 2 hrs to yield oils ranging from 0.4–1.5%. The oils were analyzed by GC-FID and GC/MS to reveal a range in compositions. A summary of these compositional results can be seen in **T-12**. According to Telci et al., the 18 selections produced oils in which they proposed the existence of seven chemotypes (see 1–7 on **T-12**). These chemotypes were 1. linalool-rich, 2. methyl (E)-cinnamate-rich, 3. methyl (E)-cinnamate- and linalool-rich, 4. methyl eugenol-rich, 5. citral-rich, 6. methyl chavicol-rich, and 7. methyl chavicol- and citral-rich. As citral is not found as a component of *O. basilicum* oil and is a constituent of the oils of *O.* x *citriodorum* Vis., hence it is the belief of this reviewer that the oils grouped as chemotypes 5 and 7 are actually hybrids and not pure species. It is very difficult to differentiate between the two, so this type of misidentification is quite common.

An oil produced from the 'Opal' cultivar of purple basil, which was grown in Iran, was the subject of analysis by Omidbaigi et al. (2007). The oil was found to contain the following components:

α-pinene (0.5%)
sabinene (0.5%)
β-pinene (1.0%)
myrcene (1.1%)
1,8-cineole (13.7%)
(E)-β-ocimene (0.4%)
fenchone (0.7%)
linalool (49.4%)
camphor (0.5%)
α-terpineol (1.4%)
methyl chavicol (19.4%)
α-fenchyl acetate (0.6%)
eugenol (2.2%)
β-caryophyllene (0.7%)
trans-α-bergamotene (0.9%)
(E)-β-farnesene (0.6%)
germacrene D (1.1%)
bicyclogermacrene (0.7%)
γ-guaiene (0.8%)
α-muurolene (1.1%)
T-cadinol (2.6%)

According to D'Antuono et al. (2007) the so-called European, or sweet, basil exists in a number of forms. These morphotypes are sometimes given varietal status, e.g.:

1. *Ocimum basilicum* L. var. *majus* Alef. (smooth or slightly curled, medium-sized leaves, including the 'Genovese' types)
2. *O. basilicum* L. var. *bullatum* Alef. (curled leaves of large size, including 'Foglia di Lattuga'-types)
3. *O. basilicum* L. var. *minimum* (L.) Alef. (small fragrant leaves, ornamental plant with globoid shape)

Using GC/MS as their only method of analysis, Bunrathep et al. (2007) determined that an oil produced from endemic *O. basilicum* grown in the experimental garden of Rangsit University (Pathumthani, Thailand) possessed the following major components:

[a]Read Part 1 of this article in the May 2014 issue of *Perfumer & Flavorist* Magazine; *www.perfumerflavorist.com/magazin* .

T-12. Comparative percentage composition of basil oils produced from 18 selections of basil grown in Turkey

Compound	1	2	3	4	5	6	7
β-pinene	0.1–1.2	t–0.2	0.6	0.8	-	t–0.4	-
sabinene	t–0.2	-	0.3	0.4	-	t–0.2	-
α-phellandrene	t–0.2	-	-	-	-	-	-
myrcene	0.3–0.9	t– 0.1	0.4	0.5	-	t–0.3	-
limonene	0.2–0.3	-	0.1	0.2	-	t–4.0	-
1,8-cineole	0.2–14.5	0.4–1.8	6.1	10.3	t–0.2	0.4–5.0	-
(Z)-β-ocimene	0.2–1.8	0.3–0.4	0.5	1.2	-	t–2.0	-
γ-terpinene	t–0.2	-	-	-	-	-	-
terpinolene	t–0.2	-	-	0.1	-	-	-
6-methyl-5-hepten-2-one	-	-	-	-	1.1–1.3	-	0.7
fenchene	t–0.1	-	-	-	-	t–0.5	0.2
1-octen-3-ol	t–0.1	-	-	0.2	-	-	-
trans-sabinene hydrate	t–0.3	-	0.1	0.1	-	-	-
α-fenchyl acetate	t–0.1	-	-	-	-	-	-
α-cubebene	0.1–0.2	-	-	-	-	t–1.6	-
α-copaene	t–0.3	t–0.2	0.2	0.3	0.4–0.6	-	0.3
camphor	0.3–3.2	-	-	0.4	-	t–0.7	-
dill ether[†]	t–0.2	-	-	-	-	-	-
β-bourbonene	t–0.2	-	-	0.1	-	-	-
β-cubebene	0.1–0.3	t–0.1	-	0.3	0.4–0.5	t–0.2	0.3
linalool	37.7–60.2	17.3–27.3	23.2	12.3	3.2–5.3	1.7–8.4	2.7
linalyl acetate	-	-	0.2	-	t–0.6	-	-
octanol	t–0.2	t–0.1	-	-	-	-	0.2
isobornyl acetate	1.1–1.5	-	-	0.4	-	t–0.5	-
zingiberene	1.2–1.9	1.1–1.3	3.4	2.2	2.3–3.3	0.9–1.2	1.1
β-selinene[‡]	1.1–2.8	0.6–0.9	1.9	1.8	t–0.4	1.1–1.2	0.2
β-caryophyllene	0.3–3.1	t–0.1	0.7	-	2.5–4.2	0.5–1.9	2.5
methyl furan[†]	-	-	-	-	0.3–0.5	-	0.2
terpinen-4-ol	t–0.8	-	-	0.2	-	-	-
γ-cadinene[‡]	t–0.2	-	0.1	-	-	-	-
β-sesquiphellandrene[†]	0.1–0.2	-	0.1	0.1	t–0.3	-	-
α-humulene	0.9–1.2	0.3–0.5	1.6	1.1	0.7–1.5	-	0.7
methyl chavicol	t–0.9	t–0.8	-	0.8	-	60.3–76.3	41.8
(E)-β-farnesene	0.1–1.1	t–0.1	0.4	0.3	0.5–0.7	-	-
citral[a]	-	-	-	-	56.6–65.6	t–2.9	33.9
linalyl propionate	t–2.4	-	-	-	-	-	-
borneol	t–0.7	-	-	0.9	-	-	-
germacrene D	1.8–4.3	0.7–0.9	2.9	2.2	0.5–2.8	2.4–2.7	1.6
β-guaiene[†]	0.9–1.7	0.3–0.5	1.7	1.6	-	0.6–0.9	-
β-selinene	t–0.2	-	0.1	0.1	0.3–0.5	-	-
β-bisabolene	0.1–0.3	t–0.1	0.2	0.1	-	t–0.2	-
neryl acetate	-	-	-	-	-	-	0.3
bicyclogermacrene	0.9–2.0	0.3–0.5	1.3	1.1	-	-	-
carvone	-	-	-	0.5	-	-	-
γ-cadinene	1.3–5.0	1.2–1.6	3.6	2.6	0.4–0.8	0.8–2.6	0.6
β-elemene[†]	t–1.6	-	-	0.1	t–0.3	t–0.3	-
citronellol	-	-	-	-	t–0.2	-	-
β-sesquiphellandrene	0.1–0.4	-	0.2	-	-	-	-
α-bisabolene[*]	-	-	-	-	2.1–3.4	0.3–2.0	2.1
nerol	t–0.2	-	-	-	1.3–1.4	-	1.8
calamenene[*]	0.1–0.4	-	0.2	0.1	-	-	-
geraniol	0.2–1.1	t–0.3	0.5	-	1.0–3.9	-	1.4
(E)-β-ionone	t–0.1	-	0.2	-	t–0.2	-	-
caryophyllene oxide	0.2–0.3	-	-	0.1	1.8–2.0	t–0.2	0.6
methyl eugenol	0.5–2.6	-	0.3	34.2	0.8–3.3	1.3–3.4	1.1

T-12. Comparative percentage composition of basil oils produced from 18 selections of basil grown in Turkey (Cont.)

Compound	1	2	3	4	5	6	7
humulene epoxide*	-	-	-	-	t–0.5	-	-
nerolidol*	0.2–0.3	t–0.1	0.2	0.5	-	0.2–0.7	-
methyl (E)-cinnamate	-	58.0–63.1	30.3	4.6	-	0.2–0.5	0.7
spathulenol	0.1–0.4	-	-	0.2	-	t–0.4	-
α-cadinol	0.1–0.4	2.4–2.9	0.6	0.1	1.4–1.7	-	1.0
eugenol	3.1–21.1	-	3.1	4.2	-	t–2.3	-
δ-cadinene†	7.4–8.7	t–2.4	5.5	3.9	-	t–5.4	-
β-bisabolol	0.1–0.3	-	0.2	0.2	0-	t–0.2	-
β-eudesmol	0.5–0.7	t–0.2	-	-	-	t–0.6	-
methyl jasmonate†	t—0.2	-	-	-	-	-	0.4
7-epi-amiteol†	t–0.2	-	0.2	0.2	-	-	-
hexadecanoic acid	0.3–0.4	t–0.1	0.7	0.1	0.4–0.5	0.1–0.4	0.2

t = trace (<0.1%)
*correct isomer not identifie
†incorrect identification based on GC retention indice
‡incorrectly listed twice
[a]citral is not a single component, it is a mixture of neral and geranial

myrcene (0.2%)
limonene (0.1%)
1,8-cineole (0.9%)
(E)-β-ocimene (2.3%)
fenchone (0.1%)
linalool (0.1%)
camphor (0.3%)
methyl chavicol (92.5%)
trans-α-bergamotene (2.1%)
α-bulnesene† (0.2%)
γ-cadinene (0.2%)
cubenol (0.5%)

†incorrect identificatio

Basil oil produced from plants harvested in Serbia was determined by Sokovic et al. (2007) to contain the following components:

α-pinene (0.1%)
camphene (0.1%)
myrcene (0.3%)
α-terpinene (0.1%)
limonene (0.9%)
1,8-cineole (0.8%)
(Z)-β-ocimene (0.1%)
(E)-β-ocimene (0.5%)
terpinolene (0.4%)
linalool (69.3%)
camphor (0.3%)
borneol (0.3%)
α-terpineol (0.6%)
methyl chavicol (2.4%)
nerol (0.4%)
carvone (0.1%)
geraniol (1.9%)
bornyl acetate (0.3%)
eugenol (1.4%)
α-copaene (0.4%)
β-elemene (0.8%)
β-caryophyllene (0.6%)
trans-α-bergamotene (1.0%)
α-guaiene (1.1%)
α-humulene (0.5%)
β-selinene (1.1%)
α-selinene (1.7%)
zingiberene (0.6%)
α-muurolene (0.1%)
trans-β-guaiene (2.1%)
γ-cadinene (2.5%)
δ-cadinene (1.1%)
(Z)-nerolidol (0.1%)
T-muurolol (0.4%)
α-cadinol (2.6%)
bisabolol oxide A† (0.2%)

†probably chamomile contaminant

Alves et al. (2007) compared the composition of oils produced from seven accessions of *O. basilicum* that were grown in an experimental garden in Brazil. The comparative composition of these oils, which were produced from dry leaves and flowers harvested from the plants in full bloom can be seen in **T-13**.

Nurzynska-Wierdak (2007) examined the morphological and developmental variability, and major oil composition of selected so-called basil cultivars (the term so-called was used as basil is used by this author to describe not only *O. basilicum* but the other *Ocimum* hybrids and species. It was found that the 'cinnamon' cultivar contained methyl (E)-cinnamate (29.9%), linalool (26.5%) and methyl chavicol (7.8%), the 'licorice' cultivar contained methyl (E)-cinnamate (53.8%) and linalool (18.95), and the 'Thai' cultivar contained methyl chavicol (68.6%) and 1,8-cineole (8.25%).

Chang et al. (2007) examined the effect of temperature on the essential oil composition in a growth chamber study. They found that basil plants produced higher amounts of essential oil at higher temperatures. Hence, commercial production of basil oil is favored in a tropical climate.

Basil oil and some of its constituents were screened against *Salmonella typhimurium* in the Ames test. The composition of the basil oil screened was determined (Stajkovic et al., 2007) by GC-FID and GC/MS to be as follows:

α-pinene (0.1%)
myrcene (0.3%)
limonene (0.9%)
1,8-cineole (0.8%)
(Z)-β-ocimene (0.4%)
(E)-β-ocimene (0.1%)
terpinolene (0.4%)
linalool (69.2%)
camphor (0.3%)
borneol (0.3%)
α-terpineol (0.7%)
methyl chavicol (2.4%)
bornyl acetate (0.3%)
eugenol (2.4%)
nerol (0.4%)
geraniol (1.9%)
thiogeraniol† (0.6%)
naphthalene† (0.3%)
α-copaene (0.4%)
β-bourbonene (0.1%)
β-elemene (0.8%)
β-caryophyllene (0.6%)
α-bergamotene* (1.0%)

T-13. Comparative percentage composition of the oils from seven *Ocimum basilicum* accessions

	Accessions						
Compound	**1**	**2**	**3**	**4**	**5**	**6**	**7**
β-pinene	0.5	-	-	-	-	-	-
6-methyl-5-hepten-2-one	-	-	-	-	-	-	0.2
myrcene	0.4	-	-	-	-	-	-
1,8-cineole	8.8	1.6	0.6	0.9	2.3	-	-
cis-linalool oxide[f]	0.6	-	0.7	-	-	-	-
fenchone	-	1.0	0.7	-	0.9	-	-
trans-linalool oxidef	0.5	-	-	-	-	-	-
linalool	72.2	13.7	26.7	49.3	10.2	17.3	19.7
camphor	-	0.4	-	0.5	1.1	1.1	0.2
nerol oxide	-	-	0.6	-	-	-	-
borneol	-	0.5	0.6	-	-	-	0.2
terpinen-4-ol	-	0.6	2.9	-	-	-	0.9
α-terpineol	0.8	-	1.4	-	-	0.9	-
methyl chavicol	3.0	35.9	1.4	15.0	19.7	3.8	21.4
octyl acetate	0.4	-	-	-	-	-	-
nerol	-	-	7.2	-	-	1.3	6.9
neral	-	-	4.9	-	-	0.5	4.5
geraniol	0.5	0.7	11.0	0.9	0.7	46.3	6.3
geranial	-	-	6.9	-	-	-	-
thujyl acetate	-	-	-	0.7	-	-	-
eugenol	1.2	-	-	-	0.7	0.4	0.3
neryl acetate	-	-	0.8	-	-	-	-
α-copaene	-	-	-	-	-	-	0.4
methyl (E)-cinnamate	-	-	0.8	0.7	-	1.9	0.6
geranyl acetate	-	-	-	-	-	1.9	0.4
β-bourbonene	-	-	-	-	-	-	0.2
β-elemene	0.9	1.6	0.6	1.3	1.6	1.1	-
methyl eugenol	-	4.4	0.9	0.9	16.8	1.4	1.8
β-caryophyllene	-	3.9	1.2	-	1.2	0.8	2.0
trans-α-bergamotene	2.4	3.7	4.1	0.9	3.6	4.0	3.7
α-guaiene	0.4	0.5	-	0.4	-	0.5	-
α-humulene	0.4	6.1	1.9	-	-	1.7	1.4
(E)-β-farnesene	-	-	-	-	2.0	-	-
germacrene D	1.1	3.9	1.5	1.7	2.1	1.7	2.0
β-selinene	-	1.6	-	0.6	0.9	1.9	1.0
α-selinene	-	2.2	1.9	-	-	-	1.2
germacrene A	-	-	-	1.7	2.3	-	-
α-bulnesene	0.9	1.5	0.9	1.4	2.1	1.7	1.0
γ-cadinene	1.0	2.1	1.3	2.0	3.5	1.2	1.0
δ-cadinene	-	2.5	1.7	0.6	-	0.8	0.7
(E)-nerolidol	-	-	1.1	0.4	1.1	-	0.4
ledol	-	0.5	-	-	-	-	0.3
spathulenol	0.4	0.7	1.2	1.0	3.3	2.0	0.3
caryophyllene oxide	-	0.7	3.7	0.4	1.9	0.6	-
humulene epoxide[*]	-	0.6	-	-	-	0.5	-
1,10-di-epi-cubenol	0.4	0.6	0.7	1.7	2.4	-	0.4
epi-α-cadinol	-	-	-	-	-	1.2	-
cubenol	-	2.6	-	-	-	-	-
α-muurolol	2.4	-	2.8	13.5	13.6	-	1.9
methyl (Z)-jasmonate	-	-	-	-	-	-	0.2
β-eudesmol	-	-	-	-	-	0.4	-
α-cadinol	-	0.5	-	-	1.1	-	-
α-bisabolol	-	-	-	0.5	-	-	-

[*]correct isomer not identified; [f]furanoid form

α-guaiene (1.1%)
α-selinene (1.7%)
α-muurolene (0.1%)
α-bulnesene (2.1%)
γ-cadinene (2.5%)
δ–cadinene (1.1%)
nerolidol* (0.1%)
T-muurolol (0.4%)
α-cadinol (2.6%)
farnesol* (0.2%)

*correct isomer not identified; †incorrect identificatio

In addition, only a few normally encountered trace components were also characterized in this oil. Although the oil used in this screening was linalool-rich, the authors recommended that uncontrollable consumption of basil was not recommended, especially if accompanied by hydrocarbon-rich foods.

Beric et al. (2008) pursued the evaluation of the potential mutagenicity of the linalool-rich basil and determined that their screening results indicated that antigenotoxic potential of basil derivatives could most likely be attributed to its antioxidant properties.

Pant et al. (2008) and Malik et al. (2008) screened three Indian oils for their antimicrobial activity against specific infectious microbes. Using hydrodistillation of their oil isolation process and only GC/MS as their method of chemical analysis, the authors reported that an oil of *O. basilicum* obtained from plants cultivated in Selaqui (Uttarakhand, India) contained:

α-pinene (0.1%)
6-methyl-5-hepten-2-one (0.1%)
limonene (0.1%)
1,8-cineole (0.1%)
linalool oxide* (0.2%)
linalyl acetate‡ (22.5%)
methyl chavicol (70.0%)
neral (0.5%)
geranyl formate† (0.1%)
anisaldehyde (0.2%)
geranial (0.7%)
isocaryophyllene (0.2%)
α-bergamotene* (0.5%)
β-farnesene* (0.2%)
α-humulene (0.1%)
β-caryophyllene† (0.1%)
β-bisabolene (0.1%)
(E)-α-bisabolene (1.1%)
3-methoxycinnamaldehyde (1.0%)
aromadendrene† (0.2%)

*correct isomer not identifie
†incorrect identification based on GC elution orde
‡incorrect characterization—should be linalool, not linalyl acetate

Trace amounts (<0.05%) of camphene, sabinene (not β-terpinene as listed by the authors), β-pinene, an isomer of β-ocimene, dihydrotagetenone (a misidentification), cedrol (another misidentification) and δ-cadinene were also reported in this oil.

An oil produced from the fresh leaves of *O. basilicum* collected in Papua New guinea was analyzed using only GC/MS by Wossa et al. (2008). The composition of this oil was determined to be as follows:

linalool (6.0%)
octyl acetate (0.7%)
nerol (3.3%)
neral (36.1%)
(Z)-isocitral (0.7%)
geranial (44.5%)
(E)-isocitral (1.3%)
neryl acetate (0.7%)
β-caryophyllene (1.4%)
α-farnesene* (1.4%)
(Z)-α-bisabolene (3.8%)

*correct isomer not identifie

T-14. Comparative percentage composition of the oils of various cultivars of *Ocimum basilicum* grown in Egypt

Compound	'Egyptian Standard'		'Genova'		'Red Robin'		'Siam Queen'		'Purple Ruffles'	
	1	2	1	2	1	2	1	2	1	2
α-pinene	-	0.3	0.1	-	0.1	0.3	-	-	-	0.2
sabinene	1.0	1.5	1.0	0.5	0.5	1.1	0.6	0.9	0.5	0.5
myrcene	0.6	0.7	-	-	-	0.3	0.1	0.8	0.3	0.1
1,8-cineole	19.1	10.5	14.9	10.5	9.4	13.0	9.7	21.2	11.7	5.4
δ-3-carene†	-	0.1	1.4	-	-	0.9	-	-	-	-
α-terpinene†	-	-	-	-	-	-	0.6	1.4	-	-
trans-sabinene hydrate	-	-	-	-	-	-	-	1.4	-	-
linalool	19.9	40.4	4.2	18.9	10.9	43.4	46.2	27.5	42.6	32.7
camphor	0.3	0.2	0.1	-	0.1	0.2	0.3	0.8	-	-
terpinen-4-ol	1.2	0.8	0.3	-	-	-	3.6	7.0	0.1	-
methyl chavicol	15.6	28.9	46.5	22.5	58.4	25.2	-	-	11.4	35.9
geraniol	-	-	-	-	1.5	0.5	-	5.0	-	-
bornyl acetate	-	-	0.4	0.5	0.6	0.6	0.9	0.8	0.2	0.4
geranyl acetate	1.3	0.8	-	-	0.3	0.7	-	0.5	-	-
eugenol	4.1	-	-	7.0	-	-	-	-	-	-
γ-elemene	4.2	3.2	2.2	0.2	1.3	1.2	3.9	3.6	6.1	4.0
methyl eugenol	-	-	18.3	-	-	-	-	-	-	-
β-caryophyllene	-	-	-	-	1.4	1.4	1.3	1.3	1.2	-
trans-α-bergamotene	4.6	2.5	-	-	1.2	1.2	3.8	3.7	8.7	3.3
1-epi-bicyclosesquiphellandrene	0.7	0.1	0.1	-	0.5	0.3	1.1	-	0.4	0.5
α-humulene	1.5	0.3	0.4	0.7	0.5	0.2	0.5	0.5	1.1	0.5
α-cubebene†	-	1.4	0.2	3.9	1.8	1.4	0.1	-	0.1	0.1
germacrene D	4.0	-	1.6	3.1	0.1	-	5.1	4.7	2.0	1.4
bicyclogermacrene	1.1	-	-	-	-	-	-	1.3	-	-
α-guaiene	1.3	0.7	0.7	2.4	-	-	2.4	1.0	1.3	1.1
cadinene*	3.9	1.4	1.2	4.6	1.7	0.9	4.4	3.2	2.8	2.1
(Z)-α-bisabolene	-	-	-	-	0.4	0.5	-	-	0.3	-
nerolidol*	0.3	0.1	-	0.2	t	-	0.1	-	0.2	0.1
selinene†*	-	-	-	0.4	-	-	-	-	1.2	0.4
spathulenol	0.4	0.1	-	0.3	0.4	0.1	0.2	-	0.1	-
caryophyllene oxide	-	-	0.7	-	-	-	-	-	-	-
carotol†	-	-	0.4	1.6	0.8	0.5	-	-	0.7	0.8
isocubenol*	-	-	-	-	-	-	-	-	-	-
T-cadinol	10.9	4.2	4.0	16.9	7.3	5.4	11.9	8.4	7.0	8.4

1. 90-day plants; 2. 180-day plants; t = trace (<0.05%); *correct isomer not identified; †incorrect identificatio

It should be noted citral-rich chemotypes of basil are unknown. The authors probably analyzed an oil produced from a hybrid of *O. basilicum*.

Wood et al. (2008) determined that the sesquiterpene ketone rotundone was present in basil leaves an amount of 4 µg/kg. Aerial parts of *O. basilicum* grown in the Botanic Garden of University of Agriculture Faisalbad (Pakistan) were harvested during summer (June), autumn (September), winter (December) and spring (March) by Hussain et al. (2008). The compositions of the oils produced by hydrodistillation, which were analyzed by GC-FID and GC/MS, ranged as follows:

limonene (t–0.3%)
1,8-cineole (0.2–1.2%)
(Z)-β-ocimene (0–0.8%)
fenchone (t–1.0%)
linalool oxide* (t–1.1%)
linalool (56.7–60.6%)
camphor (1.1–3.1%)
α-terpineol (0.7–1.0%)
nerol (0.5–1.3%)
linalyl acetate (0–0.5%)
bornyl acetate (t–0.5%)
α-copaene (0–0.4%)
β-cubebene (t–0.5%)
β-caryophyllene (1.2–1.9%)
α-bergamotene* (7.4–9.2%)
α-humulene (t–0.4%)
γ-muurolene (0.5–0.9%)
germacrene D (1.1–3.3%)
β-selinene (0.4–0.8%)
bicyclogermacrene (0.6–1.1%)
γ-cadinene (3.2–5.4%)
calamenene* (0.6–1.0%)
spathulenol (t–0.5%)
caryophyllene oxide (t–0.7%)
viridiflorol (1.3–1.8%
T-cadinol (8.6–12.4%)
β-eudesmol (t–0.3%)
α-cadinol (0.2–0.5%)
α-bisabolol (t–0.4%)

*correct isomer not identified; t = trace (<0.05%

Omer et al. (2008) grew five basil cultivars ('Egyptian Standard,' 'Genova,' 'Red Robin,' 'Siam Queen' and 'Purple Ruffles') at the Egyptian National

T-15. The comparative composition of the oils of 10 cultivars of basil grown in Poland

	1	2	3	4	5	6	7	8	9	10
α-pinene	0.9	1.0	0.9	0.8	0.4	0.7	0.3	0.7	0.2	0.2
camphene	0.2	0.1	0.3	-	0.2	-	-	0.1	t	-
sabinene	0.2	0.1	0.1	0.1	0.1	0.1	1.3	0.1	0.1	0.1
β-pinene	1.7	1.9	1.6	1.5	0.2	1.6	0.3	1.4	0.5	0.5
myrcene	1.4	1.4	0.4	1.2	0.1	1.3	-	1.0	0.4	0.3
α-terpinene	1.5	1.4	1.6	1.2	0.4	1.5	1.3	1.3	0.7	0.6
limonene	0.5	0.5	0.6	0.6	1.8	0.4	1.3	0.4	0.3	0.1
1,8-cineole	15.4	16.2	15.1	13.2	-	13.5	-	12.9	7.1	5.8
linalool	44.0	52.5	37.1	57.2	76.2	60.7	14.3	53.0	61.4	75.2
camphor	1.2	-	2.7	0.1	0.5	-	0.5	0.1	0.7	-
methyl chavicol	-	-	0.6	0.5	0.4	0.3	0.2	0.7	0.4	0.3
nerol	t	-	t	-	-	t	2.9	-	0.2	0.1
geraniol	0.1	0.1	0.1	0.5	0.1	0.2	0.8	0.2	12.8	9.8
carvacrol	t	0.7	0.2	0.5	0.1	0.3	t	t	t	t
eugenol	3.9	2.5	8.2	3.9	1.1	3.1	0.1	5.6	3.4	2.5
geranyl acetate	t	-	t	0.2	-	-	0.6	-	0.9	0.5

t = trace (<0.05%)
1. 'Genovese,' 2. 'Martina,' 3. 'Piccolino,' 4. 'Robin,' 5. 'Minette,' 6. Red Robin,' 7. 'Lemonette,' 8. 'Large Green Leaf,' 9. 'Kasia' and 10. 'Wala'

Research Centre (Shalakan, Kalubia Governorate, Egypt). The plants, which were irrigated with saline water, were harvested 90 days and 180 days after transplanting. Oils produced separately from the aerial plants were subjected to analysis by GC/MS only. The results of this study can be seen in **T-14**.

Karaman et al. (2008) used various levels of three polyamines (spermine, spermidine and putrescene) on the seeds of a basil cultivar whose oil was rich in linalool, 1,8-cineole and methyl (E)-cinnamate. They concluded that the use of exogenous polyamines can promote oil yield and can have an effect on the quantitative levels of the oil components.

Seidler-Lozykowska and Krol (2008) examined the composition of basil oil produced in Poznan (Poland) from 10 cultivars ('Genovese,' 'Martina,' 'Piccolino,' 'Robin,' 'Minette,' 'Red Robin,' 'Lemonette,' 'large green leaf,' 'Kasia' and 'Wala') using GC-FID and retention times only. The results of this study are shown in **T-15**. As can be seen, the oils were not thoroughly characterized, although more than 69% were identified in all of the oils, except that from the 'Lemonette' cultivar. As the authors only characterized 23.9% of this oil, it is quite likely that it is a lemon basil (hence the name) rich in neral and geranial.

Danesi et al. (2008) used GC-FID and GC/MS to analyzed oils obtained from the 'Genovese,' 'lettuce leaf' and 'purple' cultivars of basil grown in Italy. The compositions of these oils can be seen in **T-16**.

Zheljazkov et al. (2008) produced oils from 38 accessions of basil (obtained from the U.S. Department of Agriculture's ARS National Plant Germplasm System) that were grown in Verona (Mississippi). These oils, which were screened for their major constituents, were grouped as follows:

Group 1 (16 accessions): linalool (1.9–73%)
Group 2 (six accessions): linalool (28–66%) and eugenol (5–29%)
Group 3 (six accessions): methyl chavicol (20–72%)
Group 4 (six accessions): methyl chavicol (8–29%) and linalool (8–53%)
Group 5 (two accessions): methyl eugenol (37–91%) and linalool (15–60%)
Group 6 (one accession): methyl cinnamate (9.7%) and linalool (31%)
Group 7 (one accession): bergamotene isomer (major but not quantified

The effect of fertilizers on the growth and yield of the 'Genovese' basil cultivar grown in Egypt was studied by Kandil et al. (2009). Although it was found that increasing fertilizer amounts increased the basil biomass and the oil yield, the oil composition only varied quantitatively as can be seen as follows:

α-pinene (0.1–0.8%)
β-pinene (0.2–1.9%)
myrcene (0.6–1.9%)
1,8-cineole (12.6–13.8%)
α-terpinene† (0.1–0.2%)
β-terpinene† (0.7%)
linalool (55.8–60.6%)
linalyl acetate (0.8–1.1%)
methyl chavicol (3.3–6.2%)
α-terpineol (0.1–0.2%)
β-terpineol† (0.4–0.5%)
methyl eugenol (1.2–1.9%)
eugenol (2.8–3.3%)
isoeugenol† (1.3–1.6%)
farnesol* (2.6–3.4%)

†incorrect identificatio
*correct isomer not identifie

Javanmardi (2009) screened the major components found in 23 Iranian basil cultivars using SPME-GC/MS headspace analysis. He found that six cultivars were rich in methyl chavicol and linalool and two were rich in methyl chavicol. The other cultivars had citral (neral + geranial) (five cultivars); methyl chavicol and citral (eight cultivars); or methyl chavicol, linalool and citral (two cultivars); however, it is very likely that these cultivars were *O. basilicum* hybrids.

Nine basil cultivars ('Verde fino,' 'large leaves,' 'Genovese,' 'Gecon,' 'large leaves 2,' Toscana folho al face,' 'Greco a Palla,' 'Roxo runin' and 'Roxo osmin'), whose oils were all linalool-rich, were examined for potential commercial cultivation in Brazil by Atti Serafini et al.

(2009). It was found that the yield of oil per hectare varied from 6.21–42.51 L/ha (for 'Genovese') and the linalool content per cultivar ranged from 66.4% (for 'Roxo runin') to 83.6% (for 'Toscano folho al face,' also known as 'Toscano lettuce leaf'). The other oil components characterized were 1,8-cineole (2.5–9.2%), *trans*-α-bergamotene (1.4–5.7%) and eugenol (2.4–8.0%).

Raseetha Vani et al. (2009) showed that there was a large season variation in the oil composition of basil collected from a housing area in Petaling Jaya (Malaysia). Using GC/MS as their only method of analysis, the following range of components were characterized in oils produced from fresh leaves harvested in April, June, July, August and September:

1,8-cineole (0–1.0%)
β-ocimene* (0.9–2.7%)
linalool (0–1.0%)
camphor (0.3–1.1%)
methyl chavicol (51.1–81.0%)
eugenol (0–12.8%)
β-elemene (0–3.1%)
methyl eugenol (0–0.7%)
β-caryophyllene (0–1.9%)
α-humulene (0–2.2%)
germacrene D (0–0.7%)
bicyclogermacrene (0–2.2%)
γ-cadinene (0–0.7%)
α-amorphene† (0–3.5%)
β-cubebene† (0–2.4%)

*correct isomer not identifie
†incorrect identification based on GC elution orde

Finally, it would appear to this reviewer that the range in oil composition could easily be the result of a non-homogenous *O. basilicum* gene pool.

Three commercial selections and fiv so-called landraces (plants grown in local farms or home gardens) of *O. basilicum* were grown in an herb garden of Gazi Osmanpasa University (Bursa, Turkey). Oils were produced by Kaçar et al. (2009) from flowering plants harvested over two seasons using hydrodistillation. The compositions of the oils were determined by GC-FID and retention times. The oils were found to be linalool-rich, linalool- and methyl eugenol-rich, linalool-, eugenol- and 1,8-cineole-rich, and linalool- and methyl chavicol-rich. The average main components characterized in these oils from two seasons are shown in **T-17**.

Oils produced from *O. basilicum* plants harvested during full flowerin

T-16. Percentage composition of the oils of three basil cultivars grown in Italy

Compound	'Genovese' oil	'Lettuce leaf' oil	'Purple' oil
(E)-2-hexenal	0.9	0.6	0.3
(Z)-3-hexenol	0.2	0.4	0.2
α-pinene	0.4	0.4	0.5
camphene	0.1	t	0.1
sabinene	0.4	0.3	0.4
β-pinene	1.3	1.1	1.7
myrcene	1.0	0.6	1.2
α-terpinene	t	t	0.1
limonene	0.4	0.3	0.6
1,8-cineole	8.1	6.6	7.9
(Z)-β-ocimene	0.1	t	-
(E)-β-ocimene	1.6	1.1	0.1
γ-terpinene	0.1	0.1	0.1
cis-sabinene hydrate	0.1	-	0.1
linalool	38.3	36.0	47.5
camphor	0.2	0.3	1.1
α-fenchyl alcohol	0.5	0.2	0.3
terpinen-4-ol	0.2	0.3	0.2
α-terpineol	1.1	0.8	1.2
methyl chavicol	-	33.1	-
α-fenchyl acetate	-	-	0.2
chavicol	t	0.4	-
geraniol	0.1	-	1.0
bornyl acetate	0.4	0.2	t
eugenol	35.0	9.4	23.3
β-elemene	0.2	0.2	0.4
methyl eugenol	0.1	0.1	0.2
β-caryophyllene	-	-	0.7
α-bergamotene[a]	2.5	1.3	0.3
α-guaiene	0.1	-	0.2
δ-cadinene†	0.1	0.1	0.2
α-humulene	0.1	0.2	0.2
β-farnesene*	0.1	-	0.2
epi-bicyclosesquiphellandrene	0.2	0.2	0.3
germacrene D	0.9	0.8	0.8
bicyclogermacrene	0.4	0.5	0.4
α-cubebene†	0.3	0.3	0.4
α-cadinol	2.2	1.9	3.1

t = trace (<0.05%)
[a]*trans*-isomer
†incorrect identification based on GC elution orde
*correct isomer not identifie

from three locations (Papara, Punaauia and Mahina) in Tahiti were hydrodistilled for six to eight hrs to produce oils ranging from 0.2–0.6%. Analysis of these oils by Adam et al. (2009) revealed that the oils were all rich in methyl (E)-cinnamate. The range in composition of these three oils was found to be:

α-thujene (t–0.1%)
α-pinene (0.2–0.6%)
benzaldehyde (0.1%)
sabinene (0.2–0.4%)
β-pinene (0.5–1.1%)
myrcene (0.2–0.4%)
p-cymene (0.1–0.3%)
1,8-cineole (2.8–10.3%)
(E)-β-ocimene (0.1–1.6%)
γ-terpinene (0.1–0.5%)
linalool (4.6–21.9%)
δ-terpineol (0.1–0.2%)
terpinen-4-ol (0.9–2.2%)
α-terpineol (0.5–1.1%)
methyl (Z)-cinnamate (8.1–8.6%)
methyl (E)-cinnamate (43.4–62.3%)

T-17. Comparative percentage composition of some oils of *Ocimum basilicum* of Turkish origin

Compound	1	2	3	4	5	6	7	8
α-pinene	-	-	0.5	-	-	-	-	-
β-pinene	1.4	1.1	0.8	0.5	-	0.3	0.2	0.9
1,8-cineole	11.4	8.0	9.1	2.1	1.0	3.1	1.8	7.7
linalool	65.6	82.7	55.6	78.3	45.6	80.4	75.3	32.1
camphor	0.6	0.6	0.8	0.3	0.6	-	0.1	1.1
methyl chavicol	1.5	1.4	23.8	1.6	1.3	5.0	1.6	52.0
geraniol	1.5	1.0	1.1	1.1	-	0.7	1.0	1.2
eugenol	12.6	1.9	2.6	5.1	2.1	7.5	6.6	3.7
methyl eugenol	1.5	2.0	0.7	9.5	46.1	4.9	11.4	1.4

β-elemene (0.1–0.3%)
β-caryophyllene (t–0.1%)
trans-α-bergamotene (0.3–1.9%)
α-guaiene (0.1–0.2%)
α-humulene (0.1–0.3%)
cis-muurola-4(14),5-diene (0.1%)
germacrene D (0.1–0.4%)
α-bulnesene (0.1–0.2%)
1-epi-cubenol (0.2–0.6%)
α-muurolol (1.3–3.6%)

t = trace (<0.05%)

Using colchicine treatment of some *O. basilicum* seeds, Omidbaigi et al. (2010) produced some putative tetraploids from the diploid basil of Hungarian origin. Plants of both the diploid and tetraploid basils were harvested and oils produced separately by hydrodistillation from 100 g lots (three replicates) were analyzed by GC-FID and GC/MS. The results of this study are presented in **T-18**.

T-18. Comparative percentage composition of oils of diploid and tetraploid clones of *Ocimum basilicum*

Compound	Diploid oil	Tetraploid oil
myrcene	0.2	0.6
1,8-cineole	3.2	5.6
(Z)-β-ocimene	0.8	1.2
linalool	64.9	73.8
epoxy-(Z)-β-ocimene	0.4	0.4
nerol	12.6	0.9
eugenol	-	5.6
neryl acetate	0.7	0.7
α-copaene	0.2	0.3
β-elemene	3.7	4.3
β-caryophyllene	0.2	0.2
cis-α-bergamotene[a]	5.8	7.1
aromadendrene	1.3	1.8
α-humulene	0.9	1.6
germacrene D	5.7	4.5
β-selinene	1.1	0.2
bicyclogermacrene	3.1	2.7
γ-guaiene	2.1	3.0
γ-cadinene	3.3	5.9
cis-calamenene	0.4	0.3
α-cadinene	-	4.4
viridifloro	-	0.2
spathulenol	0.2	1.3
cubenol	0.8	1.4
T-cadinol	6.5	11.2
α-cadinol	0.3	0.6

[a]probably *trans*-isomer

Kumar Anand et al. (2011) collected *O. basilicum* plants at their full flowerin stage from the Central Nursery of the Forest Research Institute (Dehradun, Uttarakhand, India) from which they obtained an oil on 0.53%. Analysis of this oil using GC-FID and GC/MS revealed that it contained the following components:

α-pinene (0.1%)
β-pinene (0.1%)
limonene (0.1%)
1,8-cineole (0.1%)
(Z)-β-ocimene (0.1%)
linalool (0.2%)
methyl chavicol (70.0%)
neral (0.5%)
linalyl acetate (22.5%)
geranial (0.7%)
β-caryophyllene (0.2%)
α-humulene (0.1%)
β-farnesene* (0.2%)
β-selinene (0.3%)
β-bisabolene (0.1%)

*correct isomer not identifie

Trace amounts (<0.05%) of camphene and (E)-β-ocimene have also been characterized in this oil. Furthermore, it should be noted that the occurrence of neral and geranial and linalyl acetate is extremely unusual in *O. basilicum* oils. It would appear to this reviewer that this oil could have originated from interspecifi hybridization or, less likely, an example of a new basil chemotype.

Oils produced separately from the leaves and flowers of two unnamed cultivars is of basil grown at Bucaramanga (Colombia) by Munoz-Aceveda et al. (2011) were analyzed by GC-FID and GC/MS. The results of the analyses are shown in **T-19**.

Oils produced by hydrodistillation from the fresh aerial parts of the

'Vikarsudha' and 'CIM Soumya' cultivars of *O. basilicum* grown in Pantnagar (Uttarakhand, India) in yields of 0.46% and 0.35%, respectively, were analyzed using GC-FID and GC/MS by Padalia and Verma (2011). The oil compositions, which were quite similar, were found to be as follows:

myrcene (t–0.2%)
limonene (t–0.3%)
trans-linalool oxide[f] (t–0.2%)
linalool (21.9–25.6%)
cis-p-menth-2-en-1-ol (0.1–0.2%)
terpinen-4-ol (t–0.1%)
α-terpineol (0.1–1.2%)
geraniol (0.1–0.2%)
methyl chavicol (64.9–68.0%)
eugenol (0.1–0.4%)
methyl eugenol (0.2–0.4%)
β-elemene (t–0.5%)
β-caryophyllene (0.3–0.7%)
γ-muurolene (t–0.6%)
germacrene D (0.7%)
bicyclogermacrene (0.7–2.0%)
caryophyllene oxide (0.2–0.3%)
β-eudesmol (0.2%)

[f]furanoid form
t = trace (<0.1%)

Trace amounts (<0.1%) of α-thujene, α-pinene, camphene, β-pinene, α-terpinene, (E)-β-ocimene, γ-terpinene, terpinolene, 1,8-cineole, *cis*-sabinene hydrate, methyl (E)-cinnamate, α-copaene, β-bourbonene, β-gurjunene, α-humulene, β-selinene and α-selinene were also found in the oils of one or both of these basil cultivars.

Nine accessions of *O. basilicum* were subjected separately to hydrodistillation to produce oils that were analyzed for their major components by Carovic-Stanko et al. (2011). Based on these main components, the oils could be grouped into five types. Three oils were rich in methyl chavicol, three were oils rich in linalool, one oil was rich in both methyl chavicol and linalool, one oil was rich in linalool, eugenol and α-farnesene, and one oil was rich in linalool and methyl cinnamate, as can be seen in **T-20**.

Hanif et al. (2011) collected seeds of *O. basilicum* from various cultivated and wild sites in Oman. Plants raised from these seeds that were harvested during their full-flowering stage from the agricultural experimental station of Sultan Qaboos University (Muscat, Oman) were subjected to hydrodistillation to yield an oil in 0.171% yield. Analysis of this oil using GC/MS only revealed that the following components were identified

α-pinene (0.1%)
sabinene (0.2%)
β-pinene (0.4%)
1-octen-3-ol (0.1%)
myrcene (0.5%)
limonene (0.3%)
1,8-cineole (6.4%)
(E)-β-ocimene (0.3%)
octanol (0.2%)
linalool (69.9%)
camphor (0.7%)

T-19. Comparative percentage composition of the leaf and flower oils of two basil cultivars

Compound	Cultivar 1		Cultivar 2	
	Leaf oil	Flower oil	Leaf oil	Flower oil
(E)-3-hexenol[a]	-	-	0.5	1.2
1-octen-3-ol	-	-	-	0.5
β-pinene	-	-	0.6	1.3
myrcene	-	-	-	1.7
1,8-cineole	4.8	2.8	5.4	13.3
(E)-β-ocimene	-	0.4	-	-
fenchone	-	-	-	1.1
linalool	44.7	37.1	45.0	24.4
camphor	0.9	0.6	-	-
α-terpineol	1.0	0.6	0.6	2.1
methyl chavicol	0.5	0.2	0.4	-
eugenol	30.8	19.7	10.5	29.7
β-elemene	1.1	2.3	3.5	1.3
β-caryophyllene	-	-	1.8	0.8
trans-α-bergamotene	4.3	5.2	7.1	6.6
α-guaiene	0.7	1.8	2.2	0.7
α-humulene	-	0.9	0.8	-
germacrene D	2.2	5.3	4.3	1.4
bicyclogermacrene	0.7	1.0	1.4	0.8
α-bulnesene	0.7	2.1	2.5	0.8
δ-cadinene	1.7	2.5	0.9	1.4
β-sesquiphellandren e	-	-	0.5	0.5
1,10-di-epi-cubenol	-	0.7	-	-
T-cadinol	1.9	5.6	3.3	2.9
β-eudesmol	-	0.6	0.9	-

T-20. Comparative percentage composition of the oils of five chemical forms of *Ocimum basilicum*

Compound	1	2	3	4	5
p-cymene	-	-	0.2	0.6	0.2
1,8-cineole	0–2.5	2.7–7.4	6.2	7.7	2.0
linalool	0–0.4	58.8–66.4	20.8	30.5	46.2
camphor	0–3.5	0.5–1.2	0.6	1.3	0.6
methyl chavicol	78.2–94.6	0–1.9	47.5	0.6	5.5
eugenol	0–0.4	6.3–12.3	-	19.6	7.3
β-elemene	-	0–1.0	-	-	-
β-caryophyllene	-	0–2.0	-	-	-
α-farnesene*	-	0–2.8	0.3	16.4	-
β-bisabolene	0–0.5	-	-	-	-
methyl (Z)-cinnamate	-	0–0.9	1.2	-	18.8
caryophyllene oxide	0–0.5	0–0.4	-	-	-

The cultivars of the five chemical forms were: 1. 'Purpurascens,' 'Erevanski' and 'Thai Basil' 2. 'Sweet,' 'Genovese' and 'Dark Opal'; 3. 'Blistered Lettuce Leaf'; 4. 'Green Globe' and 5. 'Thai Queenette'; *correct isomer not identifie

terpinen-4-ol (0.1%)
α-terpineol (0.8%)
myrtenol (0.1%)
p-allyl anisole† (0.7%)
α-fenchyl acetate (0.1%)
nerol (0.3%)
neral (0.3%)
geraniol (10.9%)
carvone (0.1%)
geranial (0.5%)
bornyl acetate (0.1%)
myrtenyl acetate (0.1%)
eugenol (0.1%)
geranic acid (0.1%)
geranyl acetate (1.4%)
β-elemene (0.1%)
methyl eugenol (0.1%)
α-bergamotene* (1.6%)
1-epi-bicyclosesquiphellandrene (0.1%)
germacrene D (0.1%)
(E)-β-farnesene (0.1%)
bicyclogermacrene (0.3%)
germacrene A (0.4%)
δ-guaiene (0.4%)
α-amorphene† (0.3%)
β-sesquiphellandrene (0.1%)
cubenol (0.1%)
T-cadinol (0.9%)

*correct isomer not identifie
†incorrect identification based on GC elution orde

The authors also reported the identification of a number of trace (<0.05%) constituents of this oil such as an isomer of 3-hexenol, camphene, 3-octanol, (Z)-3-hexenyl acetate, α-terpinene, o-cymene, (Z)-β-ocimene, γ-terpinene, *cis*-sabinene hydrate, an octenyl acetate isomer, α-fenchyl alcohol, 2-cyclohexen-1-ol, *trans*-chrysanthemaldehyde, isoborneol, a limonene oxide isomer, decyl acetate, pulegone, tridecane, α-cubebene, *trans*-α-bergamotene, β-caryophyllene, β-bisabolene, α-muurolol, α-cadinene, a sesquisabinene hydrate isomer, aromadendrene, (E)-nerolidol, spathulenol, β-eudesmol, α-cadinol and α-bisabolol.

The flowering above-ground plants of an endemic *O. basilicum* collected from Maragheh district (northwestern Iran). Oil produced from these plants by hydrodistillation in 0.7% yield was analyzed by Hassanpouraghdam et al. (2011) using GC/MS only. The oil composition was characterized as follows:

α-pinene (0.1%)
sabinene (0.1%)
β-pinene (0.3%)
myrcene (0.1%)
3-octanol (0.1%)
α-phellandrene (0.1%)
p-cymene (0.1%)
limonene (1.5%)
1,8-cineole (0.2%)
(Z)-β-ocimene (0.1%)
γ-terpinene (0.2%)
fenchone (0.3%)
linalool (1.7%)
cis-rose oxide (0.2%)
camphor (0.3%)
menthone (33.1%)
menthol (6.1%)
neoisomenthol (7.5%)
methyl chavicol (21.5%)
pulegone (3.7%)
chavicol (0.1%)
piperitone (0.3%)
isopulegyl acetate (0.3%)
menthyl acetate (5.6%)
carvacrol (0.2%)
α-cubebene (0.1%)
eugenol (0.1%)
α-copaene (0.5%)
β-bourbonene (0.1%)
β-cubebene (0.3%)
β-elemene (0.5%)
methyl eugenol (1.0%)
β-caryophyllene (2.2%)
trans-α-bergamotene (0.7%)
α-guaiene (0.1%)
(E)-β-farnesene (1.1%)
germacrene D (1.4%)
α-amorphene (1.1%)
(E)-β-ionone (0.1%)
bicyclogermacrene (0.5%)
cis-calamenene (0.2%)
spathulenol (0.4%)
caryophyllene oxide (0.4%)
muurolol* (0.1%)
β-eudesmol (0.2%)
α-cadinol (2.9%)
phytol (0.1%)

*correct isomer not identifie

It should be noted that this is the firs time that compounds such as menthone, menthol, menthyl acetate, neoisomenthol, isopulegyl acetate and pulegone normally found in oils of *Mentha* species have been found as constituents of any oils of *O. basilicum*. Consequently, this analysis is highly questionable, or the oil was produced from contaminated plant material.

An oil produced from wild-growing *O. basilicum* collected in the vicinity of Kehmis-Miliana (Ain-Defla region northern Algeria) was analyzed by Brada et al. (2011) using GC-FID and GC/MS. The components identified in this oil were:

α-pinene (0.2%)
β-pinene (0.8%)
myrcene (5.6%)
p-cymene (0.3%)
1,8-cineole (6.7%)
(Z)-β-ocimene (0.4%)
(E)-β-ocimene (2.8%)
γ-terpinene (0.5%)
terpinolene (0.3%)
linalool (44.7%)
1-octen-3-yl acetate (0.1%)
3-octyl acetate (0.2%)
allo-ocimene* (2.4%)
(E,E)-allo-ocimene (0.3%)
terpinen-4-ol (0.1%)
α-terpineol (5.1%)
nerol (0.9%)
linalyl acetate† (14.0%)
lavandulyl acetate† (0.8%)
myrtenyl acetate (0.2%)
neryl acetate (2.4%)
geranyl acetate (4.0%)
β-elemene (0.2%)
(Z)-jasmone (0.2%)
β-caryophyllene (1.3%)
α-bergamotene[a] (0.2%)
α-guaiene (0.2%)
germacrene D (0.4%)
α-amorphene (0.2%)
δ-cadinene (0.2%)
elemol (2.1%)
spathulenol (0.4%)
viridiflorol (0.5%
γ-eudesmol (0.4%)
β-eudesmol (0.4%)
α-eudesmol (0.1%)

*correct isomer not identifie
[a]*trans*-isomer
†questionable basil oil constituents

Trace amounts (<0.1%) of camphene, α-terpinene, α-phellandrene, limonene, carvone, bornyl acetate, carvacrol, α-terpinyl acetate and α-gurjunene were also found in this oil.

A linalool-rich clone of *O. basilicum* grown in Poland by Nurznska-Wierdak and Borowski (2011) under different nitrogen treatments was found to range in oil content from 0.49% to 1.04% and range in oil composition as follows:

α-pinene (0.4–0.6%)
sabinene (0.4–0.8%)
β-pinene (0.8–1.6%)
myrcene (0.8–1.7%)
limonene (0.4–0.6%)
1,8-cineole (7.5–14.7%)
(E)-β-ocimene (t–0.7%)
cis-sabinene hydrate (t–0.5%)
fenchone (t–0.3%)
linalool (47.2–60.5%)
(Z)-myroxide[a] (t–0.3%)
camphor (0.5–1.5%)
pinocarvone (0–t)
borneol (0.3–0.8%)

terpinen-4-ol (t–0.4%)
α-terpineol (0–1.7%)
methyl chavicol (0–19.2%)
octyl acetate (0–0.4%)
α-fenchyl acetate (0–0.3%)
nerol (0–t)
neral (0–t)
geraniol (0–5.8%)
bornyl acetate (0.7–2.4%)
trans-pinocarvyl acetate (0–t)
carvacrol (0–t)
myrtenyl acetate (0–t)
α-terpinyl acetate (0–t)
eugenol (4.1–8.2%)
geranyl acetate (t–0.6%)
β-elemene (0.8–1.5%)
methyl eugenol (t–3.6%)
β-caryophyllene (t–0.3%)
trans-α-bergamotene (2.4–7.0%)
α-guaiene (t–0.9%)
(E)-β-farnesene (0.3–0.7%)
α-humulene (t–0.6%)
cis-muurola-4(14),5-diene (t–0.5%)
germacrene D (1.3–2.2%)
bicyclogermacrene (0.3–0.5%)
α-bulnesene (0.6–1.2%)
γ-cadinene (1.0–1.6%)
trans-calamenene (t–0.3%)
β-sesquiphellandrene (t–0.3%)
spathulenol (t–0.6%)
1,10-di-epi-cubenol (t–0.5%)
T-cadinol (1.5–3.7%)
α-cadinol (t–0.3%)

t = trace (<0.1%)
[a]also known as (Z)-β-ocimene epoxide

Trace amounts (<0.1%) of α-thujene, camphene, α-phellandrene, α-terpinene, γ-terpinene, terpinolene, *cis*-linalool oxide (furanoid form), δ-terpineol, δ-elemene, β-cubebene, β-cedrene, aromadendrene, *cis*-muurola-3,5-diene, β-acoradiene, β-selinene, germacrene A, 10-epi-cubebol, α-cadinene, longipinanol, caryophyllene oxide, globulol, viridiflorol, 1-epi-cubenol, neointermedeol, intermedeol and α-bisabolol were also found in these oils.

The composition of oils produced from green and purple types of *O. basilicum*, which were collected from Karj (north of Tehran, Iran), were analyzed by GC-FID and GC/MS by Yavari et al. (2011). They found that the green basil oil contained:

α-pinene (0.1%)
6-methyl-5-hepten-2-one (1.6%)
p-cymene (0.6%)
limonene (0.5%)
fenchone (1.8%)
trans-verbenol (0.8%)
methyl chavicol (62.5%)
neral (10.0%)
geraniol (12.5%)
(E)-anethole (1.5%)
methyl eugenol (1.3%)
β–caryophyllene (1.6%)
trans-α-bergamotene (0.3%)
α-humulene (0.8%)
germacrene D (0.2%)
β-selinene (0.6%)
(Z)-α-bisabolene (0.7%)
trans-calamenene (0.5%)
α-cadinene (0.3%)

It should be pointed out that this is a very unusual chemical composition because of the existence of neral (not normally found in *O. basilicum* oils) without being accompanied by geranial. Normally, when the two aldehydes exist in an oil, geranial is always found in higher levels than neral, and they are usually found in lemon basil, not *O. basilicum*. In contrast to the green basil oil, the purple basil oil contained:

α-pinene (1.2%)
sabinene (0.5%)
β-pinene (1.0%)
myrcene (1.0%)
1,8-cineole (10.0%)
(E)-β-ocimene (0.7%)
fenchone (7.0%)
linalool (17.0%)
camphor (2.5%)
α-copaene (1.5%)
β-bourbonene (0.6%)
β-elemene (3.5%)
β-caryophyllene (7.5%)
trans-α-bergamotene (17.5%)
α-humulene (3.0%)
(E)-β-farnesene (4.1%)
germacrene D (6.0%)
bicyclogermacrene (4.0%)
trans-β-guaiene (2.5%)
δ-cadinene (0.5%)
caryophyllene oxide (0.5%)

This is only one of the few times that an oil of *O. basilicum* has been found

T-21. Percentage composition of the oils of three basil cultivars grown in Poland

Compound	1	2	3
β-pinene	-	0.1	-
1-octen-3-ol	0.1–0.3	-	0–0.1
myrcene	-	0.1–0.3	-
1,8-cineole	2.4–3.0	7.2–10.2	7.7–12.6
cis-β-terpineol[†]	-	0.1–0.2	0.2
cis-linalool oxide[f]	0.2–0.8	0.6–1.0	0.5–0.7
trans-linalool oxide[f]	0.4–0.7	0.6–0.9	0.5–0.7
linalool	24.6–36.6	41.1–47.8	37.5–48.7
2-phenethyl alcohol[†]	0–0.3	-	-
1-methyl-4-acetyl cyclohexene[*†]	0.2–0.4	0.3–0.7	0.3–1.1
camphor	0.6–0.7	0.8–1.0	0.8
lilac aldehyde C[†]	0.1–0.3	-	-
borneol	0.3–0.4	-	-
terpinen-4-ol	1.1–2.0	0.2–0.3	0.3–2.0
α-terpineol	0.8–0.9	0.7–0.9	0.8–1.0
methyl chavicol	5.6–14.3	14.3–20.2	13.4–18.6
anethole[*†]	0.4	-	-
α-fenchyl acetate	0.2	-	-
2-hydroxy-1,8-cineole[†]	0.1–0.4	-	-
nerol	0.2	-	-
chavicol	0–2.0	-	-
bornyl acetate	0.3–0.9	0.6–0.8	0.4–0.6
methyl (Z)-cinnamate	2.7–5.5	-	-
2-acetoxy-1,8-cineole[†]	-	0.1	-
α-cubebene	0.1	0.1	0.1
eugenol	2.4–2.8	2.4–4.8	1.6–2.3
β-elemene	0.2–0.3	0.4–0.6	0.4–0.5
methyl (E)-cinnamate	18.7–21.9	-	-
methyl eugenol	0–0.6	0.3–0.7	-
β-caryophyllene	0.2–0.4	0.1–0.2	0–0.3
α-bergamotene[a]	0.7–1.2	1.6–2.3	1.1–6.5

with such a richness of sesquiterpene hydrocarbons.

A commercially available oil of *O. basilicum* was screened for its lavicidal activity of the cotton cutleaf worm by Pavela (2012). The oil was reported to possess the following composition:

linalool (4.2%)
methyl chavicol (93.7%)

It would appear to this reviewer that this was a man-made oil, not one produced from *O. basilicum* plants.

Blank et al. (2012) examined the effect of hybridizing selected basil cultivars on their oil compositions. The four cultivars used in this study that was performed in Brazil were 'Cinnamon,' 'Genovese,' 'Sweet Dani' and 'Maria Bonita.' Analysis of the lab hydrodistilled oils using GC-FID and GC/MS revealed that the oil of the 'Cinnamon' cultivar contained the following major components:

1,8-cineole (3.5%)
linalool (27.3%)
methyl chavicol (1.1%)
methyl (Z)-cinnamate (5.8%)
methyl (E)-cinnamate (51.9%)
α-cadinol (3.4%)

In contrast, the main components of the oils of the linalool-rich 'Genovese' and 'Maria Bonita' cultivars were:

1,8-cineole (5.2–10.4%)
linalool (67.3–75.4%)
geraniol (0–14.7%)
geranial (0–0.2%)
trans-α-bergamotene (1.4–5.2%)
α-cadinol (0.8–3.7%)

Although the oil yields of the 'cinnamon,' 'Genovese' and 'Maria Bonita' cultivars were 1.88%, 1.45% and 3.81%, respectively, the 'Sweet Dani' cultivar had only 1.22% oil. The main components of the oil of the 'Sweet Dani' cultivar were:

nerol (4.0%)
neral (31.7%)
geraniol (1.9%)
geranial (41.4%)
β-caryophyllene (2.0%)

Based on these above results, it would appear that the 'Sweet Dani' cultivar is not an *O. basilicum*, but a cultivar of *O.* x *citriodorum* (lemon basil) or a hybrid.

Wesolowska et al. (2012) used GC/MS only to examine the lab-distilled oils produced in yields of 0.38–0.55% that were obtained from the basil cultivars 'Thai Siam,' 'Bolloso Napolitano' and 'Foglia di Lattuga' (lettuce leaf) that were harvested at their commencement of flowering from an experimental garden in Szczecin (Poland) over two seasons. The compositions of these cultivar oils that were examined by GC/MS only are shown in **T-21**.

Nurzynska-Wierdak (2012) produced oils from four Polish basil cultivars 'Kasia,' 'Wala,' 'Genua Star' and 'Opal' that were harvested from pots at their full flowering stage. The oils, which were produced from plants that had been fertilized by either foliar feeding or non-foliar feeding, were analyzed by GC-FID and GC/MS. The results of this study can be seen in **T-22**.

No unusual trace compounds were identified in the oils of the four cultivars.

Goncearius et al. (2012) examined the oil composition of some Romanian basil cultivars that differed in their leaf and flower colors. Although the authors analyzed the oils using GC/MS only, numerous components listed for basil in their analyses were in error because the oils of two of the cultivars were definitely hybrids and not pure species. The oils of the other cultivars were found to contain either linalool as the major component or linalool and methyl chavicol.

Tarakmeh and Abutalebi (2012) compared sun-drying, oven-drying (45°C) and shade-drying of fresh basil plants prior to flowering. They found that shade-drying gave an oil yield of 0.43% versus 0.33% for oven-drying and 0.20% for sun-drying.

T-21. Percentage composition of the oils of three basil cultivars grown in Poland (Cont.)

Compound	1	2	3
α-guaiene	0.4	0.4–0.6	0.3–0.7
(Z)-β-farnesene	0.5–0.7	0.4–0.5	0.2–0.4
α-humulene	0.3–0.4	0.4–0.6	0.3–0.5
1-epi-bicyclosesquiphellandrene	0.3–0.6	0.3–0.4	0.3–0.4
γ-muurolene	0.2	-	-
β-cubebene†	1.1–1.2	1.0	0.9–1.5
β-selinene	0.2–0.4	0.1–0.2	-
bicyclogermacrene	0.7–0.9	0.4	0.3–0.4
α-bulnesene	0.4–0.8	0.4–0.5	0.4–0.5
γ-cadinene	1.1–2.2	1.2–1.7	1.2–1.8
calamenene*	0.3–0.5	0.4–0.5	0.3–0.7
ledol†	-	-	0–0.2
nerolidol*	0.4–0.6	-	-
spathulenol	0.3–0.9	0.4–0.8	0.4–0.6
caryophyllene oxide	0.2–0.3	0.1–0.2	0.2
viridifloro	0.3	1.2–1.3	0.2–0.3
cadina-1,4-diene†	-	0.7–0.9	0.1–0.4
cubenol†	0.9–1.3	-	0.8–0.9
β-cadinene†	5.8–7.0	3.9–5.7	4.6–6.3
α-cadinol†	1.1–1.2	0.9–1.1	1.1–1.2
spathulenol‡	0–0.2	0–0.3	-
α-bisabolol	0.2–0.5	0.2–0.4	0–0.1
tetradecanal†	0–0.1	0–0.1	-
7,10,13-hexcatrienal†	0–3.0	-	-
phytol	0.3–0.8	0.1–0.5	0.2

1. 'Thai Siam' oil; 2. 'Bolloso Napoletano' oil; 3. 'Foglia di Lattuga' oil
*correct isomer not identifie
†incorrect identificatio
‡cannot occur twice
a*trans*-isomer
ffuranoid form

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T-22. Comparative percentage composition of the oils of four Polish basil cultivars

Compound	'Kasia' oil	'Wala' oil	'Geneva Star' oil	'Opal' oil
α-pinene	t	t	t–0.2	0.3
sabinene	t	t	t–0.1	t–0.2
β-pinene	t	0.3–0.5	0.7–0.9	0.9–1.0
myrcene	0.5	0.3	0.7–0.8	1.0
limonene	t	t	t–0.1	0.5–0.7
1,8-cineole	0.4–2.4	3.2–4.3	6.9–7.6	7.4–7.8
(E)-β-ocimene	0.2–0.4	0.2–0.3	t	-
trans-linalool oxide[f]	0.2–0.3	t	-	-
cis-linalool oxide[f]	0.2–0.4	0–t	-	-
fenchone	t	0.2–0.3	-	0.9
linalool	74.2–75.9	64.1–67.3	60.6–62.9	65.3–66.1
camphor	0.1–0.3	t	0.1–0.3	0.7–1.0
borneol	t	t–0.4	0.7	t–0.2
terpinen-4-ol	0.2–0.4	0.2–0.5	t	t
α-terpineol	t–0.2	0.1–0.3	0.8–0.9	0.2–0.8
methyl chavicol	-	t–2.4	-	-
α-fenchyl acetate	t	t–0.3	-	1.6–1.8
geraniol	8.8–9.6	11.8–13.4	-	0.3–0.4
bornyl acetate	t–0.1	t	-	0.2
eugenol	-	-	4.2–4.4	0.7–1.1
α-copaene	t–0.2	t–0.2	t–0.4	t
methyl eugenol	-	-	-	1.8–2.3
geranyl acetate	t–0.2	0.5–0.7	0–t	t–0.4
β-elemene	0.7–1.4	0.5–1.0	1.7	2.0–2.7
β-caryophyllene	0.3–0.4	t	t	1.3–1.6
trans-α-bergamotene	0.4	t	7.5	0.4–0.6
α-guaiene	0.4	t–0.2	0.7	1.0–1.4
α-humulene	t	t	0.2–0.4	0.2–0.4
cis-muurola-4(14),5-diene	0.4	0.5–0.6	t	t
viridifloren	t	0.2–0.4	t	t
β-selinene	t	0.2–0.4	t	t
germacrene D	1.3–1.5	2.0–2.4	2.3	1.4–1.8
bicyclogermacrene	0.5–0.8	0.4–0.7	0.2–0.4	1.0–1.2
α-bulnesene	0.6–0.8	0.5	1.3–1.4	1.7–2.0
δ-amorphene	t	t	t	t–0.1
trans-calamenene	t	t–0.3	0.3–0.5	t
γ-cadinene	1.7	2.0–2.2	1.7	1.3–1.5
spathulenol	t	t	t	t–0.4
1,10-di-epi-cubenol	0.7	0.7–0.8	0.5–0.6	t–0.2
T-cadinol	4.7–4.8	4.7–6.7	4.0–4.1	2.7–3.0
α-cadinol	t	0.2–0.3	0.1–0.2	0–0.1

t = trace (<0.05%)

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