# Progress in Essential Oils

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## Rosemary Oil and Extract

Serrano et al. (2002) collected spontaneously growing rosemary plants from five different areas (Serpa, Portel, Sousel, Portalegre and Erora) of the inland region of Alentejo (Portugal). Each of these plants was grown from the vegetative material in an experimental garden, harvested when in full flower and subjected to water distillation in the laboratory. Analyses by GC and GC/MS of the oils that originated from the five areas revealed that they possessed similar compositions being rich in myrcene, 1,8-cineole and camphor (see **T-1**).

Rosemary oil was reported to contain a range of 1,8-cineole from 12.0–47.0% (Vincenzi et al. 2002).

Flamini et al. (2002) examined the composition of oils produced from different leaf and flower positions of two Italian ecotypes (Cevoli and Lungiana) of rosemary. The results of this study are summarized in **T-2**.

Kubeczka and Formacek (2002) analyzed two samples of Spanish rosemary oil using GC and $^{13}$C-NMR. The results of their study are presented in **T-3**. On examination of these results, Kubeczka and Formacek noted that sample B appeared to be adulterated with isoborneol and isobornyl acetate.

Rosemary oil produced from three locations in Lebanon was analyzed by Diab et al. (2002). The range in oil composition from the three locations was as follows:

α-pinene (18.8–39.0%)
camphene (2.1–6.5%)
β-pinene (1.8–6.5%)
sabinene (t–0.8%)
δ-3-carene (0–0.7%)
α-phellandrene (0–0.4%)
myrcene (1.1–2.1%)
α-terpinene (0.4–1.0%)
limonene (2.3–4.1%)
1,8-cineole (19.1–25.1%)
(Z)-β-ocimene (0–t)
γ-terpinene (0.9–2.2%)
p-cymene (0.4–1.4%)
terpinolene (0.7–1.5%)
camphor (1.6–5.0%)
isopinocamphone (0–0.7%)
linalool (1.4–4.9%)
linalyl acetate (0–0.3%)
bornyl acetate (1.1–4.7%)
β-caryophyllene (1.7–4.7%)
terpinen-4-ol (0.6–1.3%)
allo-aromadendrene (0–t)
α-humulene (0.3–1.2%)
δ-terpineol (0.2–1.4%)
borneol (0–4.8%)
α-terpineol (2.8–11.2%)
α-muurolene (0.2–0.7%)
δ-cadinene (t–0.6%)
geranyl acetate (0.2–0.9%)
verbenol* (0.1–0.7%)
geraniol (1.8–9.3%)
caryophyllene oxide (0.1–0.4%)

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

Because of the lack of information on the oil composition of 15 cultivars grown in Sardinia, Mulas et al. (2002) examined their compositions. They found that the oil compositions varied as follows:

α-pinene (13.9–56.9%)
camphene (4.5–11.8%)
β-pinene (1.5–3.3%)
myrcene (1.4–4.5%)
limonene (4.4–7.2%)
1,8-cineole (0.7–18.7%)
camphor (0.1–22.3%)
α-terpineol (1.0–2.7%)
borneol (0.7–15.9%)
verbenone (1.3–11.5%)
bornyl acetate (0.4–24.4%)

As can be seen, the rosemary oils varied considerably particularly in their α-pinene, 1,8-cineole, camphor, borneol, verbenone and bornyl acetate contents.

Pintore et al. (2002) compared the composition of two oils produced from plants collected from their natural habitats both in Corsica and Sardinia. The compositions of these oils can be found in **T-4**.

In addition, one or both of the Corsican oils were also found to contain: α-thujene (0.1%), 1-octen-3-ol (0.1%), terpinolene (0.1%, 0.4%),

## Stay tuned

Brian M. Lawrence covers more compositional information on rosemary oil and extract in the December issue of *Perfumer & Flavorist* magazine!

p-cymenene (0.1%), *cis*-sabinene hydrate (< 0.1%), chrysanthenone (0.8%), *cis*-verbenol (0.1%, 0.6%), *trans*-verbenol (0.3%, 0.6%), pinocarvone (0.3%), lavandulol (0.3%), isopinocampheol (0.3%), methyl chavicol (0.3%), myrtenol (0.4%, 1.7%), α-campholenol (0.6%, 0.9%), *trans*-carveol (< 0.1%), citronellol (0.4%), neral (0.2%), geraniol (0.3%, 6.2%), geranial (0.2%), *trans*-pinocarvyl acetate (0.4%, 0.1%), neryl acetate (0.2%), geranyl acetate (0.6%), (Z)-jasmone (0.1%), methyl eugenol (0.4%), β-caryophyllene (2.0%, 0.6%), α-humulene (0.3%, 0.2%), ar-curcumene (< 0.1%) and spathulenol (0.2%).

**Percentage composition of rosemary oil produced from plants harvested from five distinct zones of Portugal** **T-1**

| Compound | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| α-thujene | 0.2 | 0.3 | 0.2 | 0.2 | 0.2 |
| α-pinene | 7.6 | 8.0 | 10.4 | 8.5 | 8.5 |
| camphene | 4.8 | 6.2 | 4.1 | 2.9 | 3.8 |
| β-pinene | 4.6 | 5.6 | 4.4 | 7.0 | 5.6 |
| sabinene | 0.2 | 0.2 | 0.2 | t | t |
| myrcene | 28.7 | 16.6 | 24.2 | 28.7 | 29.5 |
| β-phellandrene† | 2.0 | 1.2 | 3.0 | 2.3 | 1.7 |
| α-terpinene | 0.4 | 0.7 | 0.7 | 0.4 | 0.5 |
| limonene | 3.3 | 5.9 | 4.6 | 3.3 | 2.9 |
| 1,8-cineole | 8.3 | 13.3 | 13.8 | 14.5 | 14.4 |
| (Z)-β-ocimene | 3.3 | 0.2 | 0.3 | 0.4 | 0.8 |
| γ-terpinene | 1.0 | 1.7 | 2.3 | 1.0 | 1.5 |
| (E)-β-ocimene | 0.3 | t | 1.2 | t | 0.2 |
| p-cymene | 0.3 | 0.4 | 0.9 | 0.4 | 0.5 |
| terpinolene | 0.6 | 0.9 | 0.6 | 0.6 | 0.5 |
| α-cubebene | 0.2 | 0.2 | 0.3 | 0.2 | 0.5 |
| *trans*-sabinene hydrate | 0.5 | 1.0 | 0.7 | 0.6 | 0.6 |
| α-campholenal | t | – | 0.2 | 0.2 | t |
| 1-octen-3-ol | 0.3 | – | 0.3 | 0.3 | t |
| camphor | 23.1 | 21.4 | 15.3 | 19.4 | 17.9 |
| linalool | 1.7 | 2.3 | 2.0 | 1.9 | 1.9 |
| linalyl acetate | 0.2 | 0.2 | 0.3 | 0.3 | 0.2 |
| pinocarvone | 0.3 | 0.3 | 0.5 | 0.5 | 0.4 |
| bornyl acetate | 1.2 | 1.6 | 0.8 | 0.5 | 0.8 |
| β-gurjunene | 0.2 | t | 0.2 | 0.2 | 0.2 |
| β-caryophyllene | 0.9 | 1.2 | 1.8 | 1.2 | 1.1 |
| terpinen-4-ol | 0.7 | 1.2 | 0.9 | 0.6 | 0.7 |
| myrtenol | t | t | 0.2 | t | t |
| isopulegol | t | 0.2 | 0.2 | t | t |
| α-humulene | 0.2 | 0.6 | 0.5 | 0.3 | 0.4 |
| nopol | 0.4 | 0.3 | 0.3 | 0.3 | 0.3 |
| α-terpineol | 1.1 | 1.8 | 1.5 | 1.4 | 1.5 |
| borneol | 1.1 | 3.5 | 1.4 | 0.4 | 0.8 |
| verbenone | 1.0 | 0.7 | 1.1 | 1.5 | 1.0 |
| δ-cadinene | 0.2 | t | 0.3 | 0.3 | 0.3 |
| citronellol | t | 0.3 | 0.2 | 0.2 | 0.2 |
| geraniol | 0.2 | 0.2 | 0.2 | t | – |
| caryophyllene oxide | 0.6 | 1.1 | 1.4 | 1.2 | 1.2 |
| methyl eugenol | 0.3 | 0.4 | 0.3 | t | 0.3 |
| carvacrol | t | t | 0.2 | t | 0.3 |
| T-muurolol | t | – | 0.4 | 0.2 | 0.2 |

†incorrect identity based on GC elution order; t = trace (< 0.1%); zones of Portugal: 1 = Serpa; 2 = Portel; 3 = Sousel; 4 = Portalegre; 5 = Évora

Similarly, one or both of the Sardinian oils also contained: α-fenchone (0.1%), 1-octen-3-one (0.1%, 0.1%), 1-octen-3-ol (0.2%, 0.3%), fenchone (< 0.1%), *trans*-linalool oxide furanoid (< 0.1%, 0.1%), α-campholenal (0.1%, 0.2%), an allo-ocimene isomer (< 0.1%), *trans*-pinocarvyl acetate (0.1%) and (Z)-jasmone (0.1%, 0.1%).

A lab-prepared supercritical fluid $CO_2$ extract of crushed dried rosemary leaves of Egyptian origin was analyzed by El-Ghorab (2003). The constituents identified in this extract are as follows:

α-pinene (6.54%)
camphene (2.38%)
β-pinene (1.85%)
myrcene (0.86%)
α-phellandrene (0.46%)
o-cymene† (0.81%)
p-cymene (0.05%)
1,8-cineole (52.31%)
(Z)-β-ocimene (0.19%)
isoterpinolene† (0.29%)
p-mentha-1,3,8-triene† (0.15%)
terpineol* (0.01%)
camphor (13.52%)
pinocarvone (0.25%)
borneol (6.17%)
terpineol* (0.66%)
α-terpineol (3.00%)
isobornyl formate† (0.29%)
(E)-tagetenone† (0.07%)
bornyl acetate (0.48%)
eugenol† (0.75%)
α-copaene (0.08%)
methyl eugenol (0.22%)
α-humulene (0.68%)
isocaryophyllene† (5.48%)
γ-elemene (0.08%)
spathulenol (0.46%)
7-epi-α-eudesmol† (0.44%)
1-epi-cubenol (0.27%)
(Z)-α-santalol† (0.56%)
(Z)-α-santalyl acetate† (0.12%)
phytol (0.06%)

*correct isomer not identified; †incorrect identification

Lahlou and Berrada (2003) analyzed rosemary oils produced from three collections of rosemary from Morocco. Two of the oils were found to be similar with the third oil being different, as can be seen in **T-5**.

Rosemary oils produced from plants collected in four different regions of Southern Spain over a full year were found to vary only slightly. Salido et al. (2003) found the four

**Percentage composition of the oils obtained from the leaves and flowers of two rosemary ecotypes (Cevoli and Lungiana) collected from different positions on the plant** **T-2**

| Compound | Cevoli | | | Lungiana | | | Cevoli | | | Lungiana | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | AL | IL | LL | AL | IL | LL | AF | IF | LF | AF | IF |
| α-pinene | 28.6 | 26.1 | 30.3 | 18.6 | 11.5 | 23.1 | 21.8 | 15.1 | 6.6 | 10.2 | 12.9 |
| camphene | 7.4 | 5.6 | 6.7 | 2.7 | 2.6 | 3.5 | 10.6 | 6.6 | 3.0 | 2.1 | 2.3 |
| sabinene | 0.9 | 1.0 | 1.0 | – | – | – | – | – | – | – | – |
| β-pinene | 1.4 | 0.4 | 0.5 | 6.8 | 6.5 | 4.2 | 2.8 | 1.6 | 1.0 | 11.5 | 10.6 |
| myrcene | 3.2 | 3.1 | 3.6 | 1.6 | 1.7 | 1.2 | 2.3 | 1.8 | 1.3 | 1.3 | 2.0 |
| α-terpinene | 0.5 | 0.4 | 0.4 | 0.6 | 0.6 | 0.7 | – | – | – | 0.6 | – |
| p-cymene | 0.7 | 1.2 | 1.2 | 0.6 | 0.9 | 1.5 | – | – | – | 0.3 | – |
| limonene | 3.8 | 4.6 | 4.2 | – | – | – | 3.5 | 2.7 | 2.3 | – | – |
| β-phellandrene | – | – | – | 2.2 | 2.2 | 2.3 | – | – | – | 1.6 | 2.8 |
| 1,8-cineole | 8.5 | 7.3 | 8.7 | 43.3 | 55.3 | 42.5 | 7.7 | 6.0 | 5.9 | 46.4 | 31.5 |
| γ-terpinene | 0.8 | – | – | 1.0 | 1.0 | 0.9 | 0.7 | 0.6 | 0.7 | 1.1 | – |
| linalool | 1.8 | 2.8 | 1.6 | 0.9 | 0.4 | 0.5 | 0.7 | 1.1 | 0.6 | 0.5 | – |
| camphor | 9.3 | 10.1 | 9.5 | 4.6 | 8.1 | 9.1 | 10.1 | 10.6 | 11.5 | 2.5 | 4.8 |
| borneol | 6.0 | 8.2 | 6.7 | 9.0 | 3.0 | 4.2 | 14.7 | 17.0 | 18.8 | 9.3 | 10.3 |
| terpinen-4-ol | – | – | – | – | – | – | – | 1.2 | 1.4 | – | – |
| α-terpineol | – | 1.7 | 1.6 | 3.6 | 3.3 | 3.2 | – | 1.4 | 1.9 | 3.3 | 5.3 |
| verbenone | 6.0 | 8.2 | 6.7 | – | – | – | 14.6 | 17.0 | 18.8 | – | – |
| thymol | 0.9 | 0.4 | 0.9 | – | – | – | 0.9 | – | – | – | – |
| geraniol | 1.4 | 1.0 | 1.4 | – | – | – | – | – | – | – | – |
| bornyl acetate | 4.7 | – | – | 1.2 | – | – | 6.8 | 9.6 | 9.0 | – | 2.8 |
| α-cedrene | – | 0.9 | 0.6 | – | – | – | 1.1 | – | – | – | – |
| β-caryophyllene | – | – | – | 0.9 | 0.2 | 0.6 | – | – | – | 3.3 | 6.9 |
| α-humulene | – | – | – | 0.4 | – | 0.3 | – | – | – | 0.4 | – |

AL = apical leaves; AF = apical flowers; IL = intermediate leaves; IF = intermediate flowers; LL = lower leaves; LF = lower flowers

**Comparative percentage composition of two samples of Spanish rosemary oil** **T-3**

| Compound | Oil A | Oil B | Compound | Oil A | Oil B |
|---|---|---|---|---|---|
| tricyclene | 0.34 | 0.49 | p-cymene | 2.61 | 2.40 |
| α-thujene + α-pinene† | 24.50 | 17.74 | terpinolene | t | 0.97 |
| camphene | 7.80 | 7.67 | camphor | 22.79 | 18.54 |
| β-pinene | 2.96 | 4.39 | linalool | 0.47 | 1.32 |
| sabinene | t | 0.11 | linalyl acetate | 0.02 | 0.16 |
| δ-3-carene | 0.19 | 0.07 | bornyl acetate | 1.34 | 1.02 |
| myrcene | 1.71 | 2.48 | isobornyl acetate | 0.04 | 1.50 |
| α-phellandrene | – | 0.39 | terpinen-4-ol + β-caryophyllene | 1.01 | 1.74 |
| α-terpinene | – | 0.43 | isoborneol | 0.06 | 0.68 |
| limonene | 4.70 | 5.81 | α-humulene | 0.02 | 0.18 |
| 1,8-cineole† + β-phellandrene | 22.59 | 22.97 | α-terpineol | 1.93 | 1.74 |
| γ-terpinene | – | 0.73 | borneol | 1.77 | 2.10 |
| 3-octanone | 0.67 | 0.72 | verbenone | 0.80 | 1.72 |

†major component of mixture; t = trace (< 0.1%)

selections to contain the following range of components:

tricyclene (0.2–0.3%)
α-thujene (t–0.3%)
α-pinene (10.2–21.6%)
camphene (5.2–8.6%)
thuja-2,4(10)-diene (0.1–0.3%)
sabinene (t–0.1%)
β-pinene (2.3–7.5%)
1-octen-3-ol (t–0.3%)
3-octanone (0.5–3.2%)
myrcene (0.9–4.5%)
3-octanol (t–0.2%)
α-phellandrene (0.2–1.1%)
δ-3-carene (0–1.4%)
α-terpinene (0.3–0.7%)
p-cymene (0.2–1.7%)
limonene (2.0–3.8%)
1,8-cineole (12.1–14.4%)
(Z)-β-ocimene (t–0.4%)
phenylacetaldehyde (t–0.3%)
(E)-β-ocimene (t)
γ-terpinene (0.5–1.3%)
*cis*-sabinene hydrate (t–0.4%)
terpinolene (0.5–1.3%)
*trans*-sabinene hydrate (t–0.6%)
linalool (0.3–1.0%)
chrysanthenone (0.3–0.7%)
camphor (17.2–34.7%)
iso(iso)pulegol (0–0.1%)
pinocamphone (0–0.1%)
pinocarvone (0.1%)
borneol (3.2–7.7%)
isopinocamphone (0.1–0.3%)
terpinen-4-ol (0.4–0.9%)
p-cymen-8-ol (t–0.2%)
α-terpineol (1.2–2.5%)
myrtenol (0.1–0.2%)
verbenone (2.2–5.8%)
bornyl acetate (0.2–2.3%)
eugenol (0–0.1%)
α-ylangene (t–0.2%)
α-copaene (0–0.1%)
methyl eugenol (t–0.2%)
β-caryophyllene (1.8–4.6%)
α-guaiene (0–0.1%)
α-humulene (0.5–2.1%)
γ-muurolene (t–0.1%)
germacrene D (t–0.1%)
β-bisabolene (t–0.2%)
γ-cadinene (0–0.2%)
δ-cadinene (t–0.3%)
α-calacorene (0–0.6%)
caryophyllene oxide (0.2–0.8%)
humulene epoxide II (t–0.2%)

t = trace (< 0.1%)

**Comparative percentage composition of rosemary oils produced from plants of Corsican and Sardinian origin** **T-4**

| Compound | Corsican oils | | Sardinian oils | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| tricyclene | 0.3 | 0.1 | 0.2 | 0.2 |
| α-pinene | 24.6 | 13.7 | 20.2 | 14.7 |
| camphene | 6.6 | 2.4 | 3.5 | 3.0 |
| verbenene | 0.8 | 1.2 | 0.4 | 0.4 |
| β-pinene | 1.9 | 1.1 | 0.5 | 0.4 |
| myrcene | 3.0 | 0.7 | 0.9 | 0.9 |
| α-phellandrene | 0.3 | 0.1 | 0.3 | 0.1 |
| p-cymene | 3.0 | 1.5 | 1.2 | 1.1 |
| limonene | 4.6 | 2.0 | 3.2 | 1.4 |
| 1,8-cineole | 3.5 | 3.4 | 11.3 | 4.9 |
| β-phellandrene | 1.2 | 0.3 | 0.2 | 0.1 |
| (Z)-β-ocimene | 0.2 | 0.1 | 0.3 | 0.1 |
| γ-terpinene | 0.4 | 0.4 | 0.3 | 0.2 |
| linalool | 4.6 | 1.8 | 1.0 | 1.0 |
| camphor | 8.7 | 2.9 | 11.5 | 14.1 |
| *trans*-pinocarveol | 0.1 | 0.1 | 0.3 | 0.3 |
| isopinocamphone | 0.5 | 0.5 | 0.5 | 0.6 |
| borneol | 6.2 | 6.7 | 7.1 | 7.3 |
| terpinen-4-ol | 0.9 | 1.3 | 1.0 | 1.1 |
| α-terpineol | 0.8 | 2.4 | 2.3 | 2.9 |
| verbenone | 4.4 | 20.3 | 15.7 | 24.9 |
| bornyl acetate | 13.6 | 17.0 | 11.3 | 12.0 |



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**Percentage composition of rosemary oil from Morocco** **T-5**

| Compound | Oil A | Oil B and C | Compound | Oil A | Oil B and C |
|---|---|---|---|---|---|
| α-pinene | 34.0 | 18.7–23.5 | γ-terpinene | 0.9 | 0.1–1.5 |
| camphene | 1.5 | 0.2–3.7 | linalool | 4.0 | 0.6–0.9 |
| myrcene† | 0.2 | 0.5 | camphor | 11.7 | 12.6–13.2 |
| β-pinene | 0.3 | 0.2–0.8 | borneol | 16.9 | 4.6–7.1 |
| limonene | 2.3 | 1.7–2.2 | terpinolene† | 1.5 | 0.3–0.4 |
| 1,8-cineole | 8.7 | 40.0–49.8 | α-terpineol | 2.3 | 0.9–2.0 |
| p-cymene | 2.1 | 0.6–1.3 | β-caryophyllene | 1.9 | 3.1–3.7 |
| α-terpinene† | 0.2 | t–0.1 | terpinen-4-ol | 0.9 | t |
| α-phellandrene† | 0.5 | 0.3–0.5 | bornyl acetate | 5.5 | 0.1–0.3 |
| | | | verbenone | 0.5 | t |

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

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## Arrayan Oil

Limited quantities of the leaf oil of arrayan [ex. *Luma chequen* (Molina) A. Gray] are available commercially in Peru. Analysis of this oil by Gonçalves et al. (2006) revealed that it possessed the following composition:

butyl isobutyrate (2.1%)
α-pinene (57.1%)
camphene (0.9%)
β-pinene (6.0%)
p-cymene (1.4%)
1,8-cineole (12.1%)
limonene (2.9%)
linalool (5.5%)
α-fenchyl alcohol (0.3%)
α-campholenal (0.2%)
*trans*-pinocarveol (0.3%)
*cis*-verbenol (0.5%)
borneol (0.4%)
terpinen-4-ol (0.3%)
α-terpineol (1.7%)
verbenone (0.3%)
geraniol (0.1%)
thymol (0.1%)
β-caryophyllene (0.3%)
aromadendrene (0.2%)
allo-aromadendrene (0.1%)
β-selinene (1.0%)
α-selinene (0.8%)
α-muurolene (0.1%)
δ-cadinene (0.2%)
caryophyllene oxide (0.3%)
globulol (0.1%)

A lab-distilled oil of *L. chequen* was analyzed by GC, GC/MS and $^{13}$C-NMR by Vallverdu et al. (2006). The oil that was produced from both leaves and twigs was found to contain the following components:

ethyl 2-methylbutyrate (0.1%)
isobutyl isobutyrate (1.1%)
α-thujene (0.3%)
α-pinene (57.3%)
camphene (0.2%)
β-pinene (6.2%)
2-methylbutyl isobutyrate (1.7%)
p-cymene (0.9%)
1,8-cineole (7.5%)
limonene (3.8%)
*cis*-linalool oxide[f] (0.2%)
*trans*-linalool oxide[f] (0.2%)
linalool (3.7%)
α-fenchyl alcohol (0.2%)
α-campholenal (0.4%)
*trans*-pinocarveol (0.7%)
*trans*-verbenol (2.2%)
pinocarvone (0.4%)
borneol (0.3%)
terpinen-4-ol (0.2%)
myrtenal (0.4%)
p-cymen-8-ol (0.1%)
α-terpineol (0.6%)
myrtenol (0.6%)
verbenone (0.9%)
*trans*-carveol (0.3%)
allo-aromadendrene (0.1%)
benzyl isobutyrate (0.1%)
β-selinene (1.3%)
α-selinene (0.4%)
caryophyllene oxide (0.9%)
viridiflorol (0.1%)
cubenol (0.1%)

[f] = furanoid form

Trace amounts (< 0.05%) of myrcene, (Z)-3-hexenyl isobutyrate, p-cymenene, menthone, pulegone, geraniol and β-elemene were also found in this oil.

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