Progress in Essential Oils

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Juniper Berry Oil

Kartnig et al. (1998) compared the range of composition between lab-distilled oils and commercial oils of juniper berries. The results of this comparative study are shown in **T-1**. It is interesting to note that because of a single adulterated juniper berry oil, the oxygenated (flavor-full constituents) terpenoid range is from zero to the more normally encountered levels.

Ranade (2002) reported that juniper berry oil contained the following components:

α-pinene (33.7%)
camphene (0.5%)
p-menthane‡ (0.1%)
β-pinene (1.1%)
sabinene (27.6%)
myrcene (5.5%)
α-phellandrene (1.3%)
α-terpinene (1.9%)
1,4-cineole (4.0%)
β-phellandrene (3.3%)
p-cymene (3.6%)
γ-terpinene† (3.0%)
terpinen-1-ol (4.6%)
bornyl acetate (0.4%)
α-terpineol (0.2%)
β-caryophyllene (0.6%)
neryl acetate (0.3%)
tricyclene† (0.1%)
δ-cadinene (0.2%)

† incorrect identification based on GC elution order; ‡ compound does not exist naturally

Oils produced from fresh, ripe (black) berries of *J. communis* obtained from plants growing in their natural habitat in northeastern Lithuania were analyzed by Butkiene et al. (2005). Using a combination of GC and GC/MS the authors determined that the oil compositions of five collections were found to range as follows:

xylene (0–1.8%)
tricyclene (0–0.3%)
α-pinene (21.0–46.3%)
camphene (0.3–0.8%)
verbenene (0–0.4%)
sabinene (0.5–2.5%)
β-pinene (0.4–1.1%)
myrcene (3.6–17.4%)
α-phellandrene (0–0.3%)
δ-3-carene (0–0.1%)
α-terpinene (0–0.5%)
p-cymene (0.3–0.5%)
β-phellandrene (0.2–1.2%)
limonene (1.1–5.3%)
γ-terpinene (0.1–1.9%)
fenchone (0–0.1%)
trans-linalool oxide[f] (0–0.3%)
terpinolene (0.5–1.6%)
p-cymenene (0.2–0.4%)
6-camphenone (0–0.5%)
linalool (0–1.3%)
perillene (0–0.2%)
α-fenchol (t–0.7%)
α-campholenal (0.1–4.1%)
trans-pinocarveol (t–2.1%)
cis-verbenol (0–0.6%)
trans-sabinol (0–0.5%)
camphor (0–1.5%)
cis-β-terpineol (0–2.5%)
trans-verbenol (0–1.6%)
p-mentha-1(7),2-di-en-8-ol(0–1.6%)
pinocamphone (0–0.2%)
pinocarvone (0–0.5%)
borneol (0.3–1.5%)
p-mentha-1,5-dien-8-ol (0.2–4.5%)
terpinen-4-ol (1.4–9.6%)
p-cymen-8-ol (0.1–0.7%)
α-terpineol (2.9–6.0%)
myrtenol (0.1–1.2%)
trans-dihydrocarvone (0–0.4%)
verbenone (0.4–3.9%)
trans-carveol (0–1.2%)
citronellol (0–1.3%)
cis-carveol (0–0.3%)
carvone (0–0.2%)
trans-myrtanol (0–0.2%)
methyl citronellate (0.1–1.5%)
bornyl acetate (0.3–1.3%)
2-undecanone (0–0.2%)
trans-pinocarvyl acetate (0–0.1%)
tridecane (0–t)
cis-pinocarvyl acetate (0–t)
δ-elemene (0–0.1%)
α-terpinyl acetate (0–0.1%)
α-cubebene (0–0.1%)
citronelly acetate (0–0.1%)
neryl acetate (0–0.1%)
α-copaene (0–0.1%)
trans-myrtanyl acetate (0–0.1%)
β-cubebene (0–0.1%)
β-elemene (0.1–0.8%)
longifolene (0–0.1%)
β-caryophyllene (0.2–0.6%)
β-gurjunene (0–0.2%)
γ-elemene (0.1–1.1%)
cis-muurola-3,5-diene (0–0.3%)
trans-muurola-3,5-diene (0–0.1%)
α-humulene (0.1–1.0%)
(E)-β-farnesene (t–0.4%)
cis-muurola-4(14),5-diene (0–0.2%)
isobornyl butyrate (0–0.1%)
trans-cadina-1(6),4-diene (0–0.2%)
γ-muurolene (0.1–0.5%)
germacrene D (0.1–3.1%)
citronellyl isobutyrate (0–0.5%)
(E)-β-ionone (0–0.5%)
β-selinene (0–0.3%)
epi-cubebol (0–0.4%)
trans-muurola-4(14),5-diene (0–0.1%)
cis-cadina-1,4-diene (0–0.2%)
bicyclogermacrene (0–0.6%)
α-muurolene (0.1–1.0%)
(E,E)-α-farnesene (0–0.1%)
γ-cadinene (0.2–1.4%)
endo-1-bourbananol (0–0.1%)
β-sesquiphellandrene (0–0.1%)
δ-cadinene (0.5–2.9%)
citronellyl butyrate (t–0.3%)
cadina-1(2),4-diene (0.1–0.2%)

Comparative percentage composition of juniper berry oils **T-1**

Compound	Lab-distilled oils	Commercial oils
tricyclene	0.7–2.2	t–2.9
α-pinene	18.1–38.3	26.5–57.8
camphene	0.2–0.3	0.2–1.6
sabinene	4.5–16.4	t–18.7
β-pinene	1.1–2.4	0.7–12.6
myrcene	3.2–21.2	0.3–22.5
α-phellandrene	0–0.3	0–1.1
δ-3-carene	0–0.3	0–1.8
α-terpinene	0–1.9	0–1.6
p-cymene	0.3–2.4	0.2–11.9
limonene	2.4–5.6	3.5–22.1
β-phellandrene	0.3–0.6	0.1–1.8
γ-terpinene	0.2–3.2	0–3.2
terpinolene	0.3–1.5	0–13.6
linalool	t–0.3	0–1.5
terpinen-4-ol	1.8–7.8	0–10.1
α-terpineol	0.3–0.8	0–4.9
verbenone	t–1.4	0–0.6
citronellol	0–0.3	0–0.3
carvone	0–0.3	0–0.9
bornyl acetate	0.2–0.4	t–2.0
α-terpinyl acetate + a-cubebene	0.5–1.2	0–1.1
α-copaene	0.2–0.7	t–1.8
β-elemene	0.4–1.6	0–1.4
β-caryophyllene	1.4–4.0	0–3.5
γ-elemene	0.5–1.2	0–0.7
germacrene D	2.8–8.0	0–4.6
α-muurolene	1.1–2.4	0–1.8
γ-cadinene	0.4–1.4	0–0.9
δ-cadinene	1.3–3.6	0–2.7
germacrene B	0.6–4.9	0–1.0
spathulenol	0.3–1.7	0–0.5
caryophyllene oxide	0.2–1.6	0–2.4

t = trace (< 0.1%)

α-cadinene (0.1–0.5%)
α-calacorene (0.1–0.2%)
elemol (0.2–0.5%)
germacrene B (0.2–0.5%)
germacrene D-4-ol (0–1.1%)
spathulenol (0.4–1.7%)
caryophyllene oxide (0–1.6%)
salvial-4(14)-en-1-one (0.1–0.4%)
β-oplopenone (0–0.2%)
β-atlantol (0–0.3%)
humulene epoxide II (0.3–2.1%)
1,10-di-epi-cubenol (0–0.3%)
l-epi-cubenol (0.2–0.8%)
γ-eudesmol (0.3–0.5%)
T-cadinol (0.5–2.5%)
T-muurolol (0.7–2.4%)
α-muurolol (0.5–1.2%)
β-eudesmol (0–0.2%)
α-eudesmol (0–0.1%)
α-cadinol (1.8–7.6%)
14-hydroxy-9-epi-β-caryophyllene (0.3–1.1%)
tetradecanol (0–1.5%)
eudesma-4(15),7-dien-β-ol (0.1–0.8%)
eudesm-7(11)-en-4-ol (0–0.6%)
14-hydroxy-α-humulene (0–0.4%)
oplopanone (0–0.2%)
14-hydroxy-α-muurolene (0–0.4%)
cyclopentadecanolide (0.1–0.2%)
abietatriene (t–0.1%)
abietadiene (t)
sandaracopimarinal (0–0.1%)
4-epi-abietal (0–0.1%)

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

Raina et al. (2005) analyzed a commercial sample of juniper berry oil that was procured in India. They found that the oil possessed the following composition:

tricyclene (0.1%)
α-pinene (36.9%)
camphene (0.2%)
β-pinene (2.0%)
sabinene (1.1%)
δ-3-carene (1.1%)
myrcene (30.9%)
limonene (11.1%)
β-ocimene* (0.3%)
γ-terpinene (1.0%)
p-cymene (0.6%)
α-terpinene[†] (1.3%)
terpinolene (0.1%)
bornyl acetate (0.3%)
β-caryophyllene (1.5%)
trans-sabinene hydrate[†] (0.8%)
γ-elemene (0.8%)
α-humulene (0.3%)
cis-α-bergamotene (0.3%)
α-cadinene (0.4%)
germacrene D (0.7%)
α-terpineol (0.3%)
δ-terpineol (1.1%)
thymol (0.7%)

*correct isomer not identified; [†] incorrect identification based GC elution order

Damjanovic et al. (2006) compared the composition of an oil and a supercritical fluid CO_2 extract of juniper berries collected from the northern part of Montenegro. The composition of the CO_2 extracts produced under different conditions can be seen in **T-2**.

Three oils were produced from the juniper berries based on the mesh size of the ground dried berries. The compositions of these oils can be seen summarized as follows:

α-thujene (t–0.2%)
α-pinene (28.6–32.8%)
camphene (0–0.2%)
β-pinene + sabinene (15.7–20.5%)
myrcene (7.2–18.2%)
δ-3-carene (0–1.0%)
α-phellandrene (0–0.1%)
p-cymene (0.7–1.0%)
limonene (0.9–5.2%)
γ-terpinene (0.3–1.8%)
terpinolene (1.4–3.1%)
linalool (t–1.1%)
trans-β-terpineol (t–0.4%)
terpinen-4-ol (1.2–2.6%)
bornyl acetate (0–0.2%)
α-cubebene (0–0.4%)
α-copaene (0–0.2%)
β-elemene (0–0.6%)
β-caryophyllene (1.0–9.2%)
α-humulene (0–0.7%)
(E)-β-farnesene (0.2–2.2%)
germacrene D (3.8–12.1%)
eudesma-4(14),11-diene (0–0.4%)
α-muurolene (0–0.2%)
γ-cadinene (0–0.2%)
δ-cadinene (0.7–4.4%)
α-cadinol (1.2–1.7%)

t = trace (< 0.1%)

In addition, trace amounts (< 0.1%) of cyclofenchene, α-terpineol and *trans*-pinocarvyl acetate were also characterized as components of one or more oils.

Butkiene et al. (2006) analyzed the composition of oils of five accessions of both unripe and ripe juniper berries obtained from the Vilnius district of Lithuania. The composition of oils produced from unripe juniper berries was determined to be as follows:

xylene (t–0.8%)
tricyclene (t–0.1%)

α-pinene (45.6–64.9%)
camphene (0.4–0.8%)
verbenene (0–0.1%)
sabinene (1.5–1.9%)
β-pinene (1.2–2.5%)
myrcene (4.3–12.8%)
α-phellandrene (t–0.4%)
δ-3-carene (0–0.5%)
α-terpinene (t–0.1%)
β-phellandrene (0.7–2.5%)
limonene (1.4–2.0%)
γ-terpinene (t–0.3%)
terpinolene (0.1–1.5%)
linalool (0–0.2%)
camphor (0–0.1%)
terpinen-4-ol (0.1–2.1%)
p-cymen-8-ol (0–0.1%)
α-terpineol (0.1–1.2%)
citronellol (0–0.3%)
methyl citronellate (0.2–1.1%)
bornyl acetate (1.1–2.2%)
2-undecanone (0–0.2%)
trans-pinocarvyl acetate (0–0.3%)
α-terpinyl acetate (0–0.2%)
citronellyl acetate (0–0.1%)
α-copaene (t–0.1%)
trans-myrtanyl acetate (t–0.1%)
β-cubebene (t–0.1%)
β-elemene (0.4–0.9%)
longifolene (0–0.3%)
β-caryophyllene (0.1–0.2%)
γ-elemene (t–0.3%)
cis-muurola-3,5-diene (t–0.1%)
trans-muurola-3,5-diene (t–0.1%)
α-humulene (0.2–0.3%)
(E)-β-farnesene (t–0.1%)
cis-muurola-4(14),5-diene (0.1–0.2%)
trans-cadina-1(6),4-diene (t–0.1%)
γ-muurolene (0.1–0.3%)
germacrene D (0.7–1.3%)
citronellyl isobutyrate (0–0.1%)
trans-muurola-4(14),5-diene (0–0.2%)
bicyclogermacrene (0.2–0.6%)
α-muurolene (0.3–0.6%)
β-bisabolene (0–0.2%)
γ-cadinene (0.2–0.7%)
cubebol (0–0.2%)

Percentage composition of supercritical fluid CO_2 extracts of Montenegro juniper berries produced under different conditions **T-2**

Compound	1	2	3
α-thujene	1.3	0.3	–
α-pinene	30.3	24.9	7.8
sabinene	2.2	7.6	2.4
β-pinene	2.2	2.0	0.1
myrcene	20.5	17.5	4.6
δ-3-carene	0.7	0.6	t
p-cymene	3.1	1.3	t
limonene	5.6	3.7	0.2
γ-terpinene	1.0	0.3	t
terpinolene	1.0	0.3	0.1
linalool	3.3	1.9	0.1
trans-β-terpineol	1.1	0.9	t
α-terpineol	1.5	1.7	0.4
trans-pinocarvyl acetate	1.3	1.4	0.4
α-cubebene	–	0.6	–
β-elemene	2.6	1.9	0.5
β-caryophyllene	1.7	2.1	2.1
α-humulene	1.5	1.8	2.7
(E)-β-farnesene	1.0	1.5	2.3
germacrene D	2.7	3.8	3.3
γ-cadinene	0.7	–	1.0
δ-cadinene	1.8	1.2	0.9
germacrene B	3.7	2.7	2.6
α-cadinol	–	0.6	0.9
methyl *trans*-communate	–	3.3	2.6
10-nonadecanol	2.7	4.6	10.1
tetracosanol	–	3.7	31.1
triacontane	–	2.3	7.7
nonadecanol	–	–	2.8
eicosanol	t	0.9	12.4
unidentified compounds	3.7	14.8	66.7

t = trace (< 0.1%); SFE conditions (using 1.8 mm ground juniper berries): 1 = 40°C/90 bar, 2 = 40°C/120 bar, 3 = 40°C/200 bar

endo-1-bourbananol (0.2%)
β-sesquiphellandrene (0.3–0.8%)
δ-cadinene (1.2–2.4%)
citronellyl butyrate (0.1–0.7%)
cadina-1(2),4-diene (t–0.2%)
α-cadinene (0.1–0.3%)
α-calacorene (0–0.1%)
elemol (0.6–1.8%)
germacrene B (0–0.3%)
germacrene D-4-ol (0.5–2.0%)
spathulenol (t–0.4%)
caryophyllene oxide (0–0.2%)
longiborneol (0–0.2%)
β-oplopenone (0–0.1%)
humulene epoxide II (0–0.1%)
1,10-di-epi-cubenol (t–0.3%)
1-epi-cubenol (0.1–0.4%)
γ-eudesmol (t–0.1%)
T-cadinol (1.3–3.2%)
T-muurolol (0.3–2.3%)
α-muurolol (0.1–0.6%)
α-cadinol (2.8–8.2%)
selin-11-en-4α-ol (0–0.3%)
14-hydroxy-9-epi-β-caryophyllene (t–0.2%)
epi-α-bisabolol (0–0.3%)
eudesma-4(15),7-dien-1β-ol (0.1%)
eudesm-7(11)-en-4-ol (0.1–0.3%)
14-hydroxy-α-humulene (0–0.1%)
(E)-α-atlantone (0–0.5%)
14-hydroxy-α-muurolene (0–0.5%)
cyclopentadecanolide (t–0.2%)
nonadecane (0–0.2%)
abietatriene (t–0.3%)
abietadiene (t–0.5%)

t = trace (< 0.1%)

In addition, trace amounts (< 0.1%) of α-terpinene, p-cymene, α-campholenal, *trans*-pinocarveol, *trans*-verbenol, verbenone, citronellol, carvone, myrtenyl acetate, δ-elemene, α-cubebene, β-bourbonene, β-gurjunene, β-selinene and octadecane were pres-

Comparative composition of juniper berry oils produced from locations in Serbia **T-3**

Compound	1	2
α-pinene	36.6	40.5
sabinene	16.2	18.0
myrcene	10.9	13.5
p-cymene	2.2	2.3
limonene	3.9	5.1
α-terpinene	1.4	2.2
terpinolene	1.2	1.2
terpinen-4-ol	2.4	2.5
α-cubebene	1.1	1.0
α-copaene	1.1	1.4
β-elemene	0.9	1.0
β-caryophyllene	5.3	0.6
α-humulene	1.2	0.6
germacrene D	1.1	0.1
bicyclogermacrene	3.2	1.3
γ-cadinene	0.6	0.6
δ-cadinene	0.6	0.6

1 = oil produced from berries collected from Zubin Patok (Serbia); 2 = oil produced from berries collected from Leposavic (Serbia)

ent in the unripe juniper berry oils.

For comparison purposes, juniper berry oils produced from ripe berries were found to possess the following components:

xylene (t–0.8%)
tricyclene (0–0.1%)
α-pinene (27.7–51.9%)
camphene (0.2–0.5%)
verbenene (0–0.3%)
sabinene (0.4–1.1%)
β-pinene (0.3–2.1%)
myrcene (6.3–19.6%)
α-phellandrene (t–0.5%)
δ-3-carene (0–1.2%)
α-terpinene (t–0.2%)
p-cymene (t–0.5%)
β-phellandrene (0.2–1.8%)
limonene (1.6–2.9%)
α-terpinene (t–0.4%)
terpinolene (0.1–1.4%)
p-cymenene (t–0.2%)
linalool (0–0.5%)
α-campholenal (0–1.5%)
trans-pinocarveol (0–0.6%)
camphor (t–0.9%)
trans-verbenol (0–0.9%)
pinocarvone (0–0.1%)
borneol (0.1–1.1%)
p-mentha-1,5-dien-8-ol (0–1.8%)
terpinen-4-ol (0.4–6.1%)
m-cymen-8-ol (0–0.1%)
p-cymen-8-ol (t–0.8%)
α-terpineol (0.5–4.6%)
myrtenol (0–0.7%)
verbenone (0–1.1%)
trans-carveol (0–0.2%)
citronellol (0–0.2%)
carvone (0–0.2%)
cis-myrtanol (0–0.2%)
trans-myrtanol (0–0.3%)
methyl citronellate (0.1–1.5%)
bornyl acetate (0.7–1.3%)
thymol (0–0.6%)
2-undecanone (0–0.1%)
trans-pinocarvyl acetate (0–0.3%)
tridecane (0–0.1%)
α-terpinyl acetate (0–0.2%)
α-cubebene (0–0.1%)
citronellyl acetate (0–0.1%)
α-copaene (t–0.1%)
trans-myrtanyl acetate (t–0.1%)
β-cubebene (t–0.1%)
β-elemene (0.2–0.6%)
longifolene (0–0.2%)
β-caryophyllene (0.1–0.4%)
γ-elemene (t–0.3%)
α-humulene (0.1–0.6%)
(E)-β-farnesene (0–0.2%)
cis-muurola-4(14),5-diene (t–0.1%)
trans-cadina-1(6),4-diene (t–0.1%)
α-muurolene (0.1–0.5%)
germacrene D (0.2–0.8%)
citronellyl isobutyrate (0–0.3%)
(E)-β-ionone (0–0.3%)
β-selinene (0–0.2%)
trans-muurola-4(14),5-diene (0–0.2%)
bicyclogermacrene (0–0.4%)
α-muurolene (0.3–0.8%)
β-bisabolene (0–0.2%)
γ-cadinene (0.5–1.1%)
endo-1-bourbonanol (0.1–0.2%)
β-sesquiphellandrene (0.1–0.4%)
δ-cadinene (1.4–2.5%)
citronellyl butyrate (0.1–0.2%)
cadina-1(2),4-diene (t–0.2%)
α-cadinene (0.1–0.4%)
α-calacorene (t–0.2%)
elemol (0.3–0.8%)
germacrene B (0.1–0.3%)
germacrene D-4-ol (0.2–1.1%)
spathulenol (t–3.2%)
caryophyllene oxide (0.3–1.4%)
salvial-4(14)-en-1-one (0–0.5%)
longiborneol (0–0.3%)
β-oplopenone (0–0.4%)
humulene epoxide II (0.3–2.0%)
1,10-di-epi-cubenol (t–0.3%)
l-epi-cubenol (0.2–0.8%)
γ-eudesmol (t–0.5%)
T-cadinol (1.1–3.5%)
T-muurolol (1.0–2.5%)
α-muurolol (0.2–1.0%)
α-cadinol (2.7–8.6%)
selin-ll-en-4α-ol (0–0.4%)
14-hydroxy-9-epi-β-caryophyllene (0.3–1.8%)
epi-α-bisabolol (0–0.5%)
eudesma-4(15),7-diene-1β-ol (0.3–1.1%)
eudesm-7(11)-en-4-ol (0.2–0.8%)
14-hydroxy-α-humulene (0–0.3%)
(E)-α-atlantone (0–0.3%)
14-hydroxy-α-muurolene (0.1–0.3%)
octadecane (0–0.4%)
cyclopentadecanolide (t–0.3%)
nonadecane (0–0.4%)
abietatriene (t–0.1%)
abietadiene (t–0.2%)

t = trace (< 0.1%)

Trace amounts (< 0.1%) of α-fenchol, myrtenyl acetate, β-bourbonene, (E)-α-ionone, β-gurjunene, *cis*-muurola-3,5-diene and *trans*-muurola-3,5-diene were present in the ripe juniper berry oils.

Chatzpoulou and Katsiotis (2006) determined the main constituents of juniper berry oil produced in the laboratory by hydrodistillation of berries collected above 1000 m during the summer on Mt. Olympus (Greece). They were as follows:

α-thujene (0.3%)
α-pinene (40.3%)
camphene (0.3%)
sabinene (3.8%)
β-pinene (2.8%)
myrcene (10.6%)
α-terpinene (0.1%)
limonene (1.9%)
γ-terpinene (0.1%)
terpinolene (0.8%)
linalool (0.1%)
terpinen-4-ol (0.3%)
α-cubebene (0.9%)
α-copaene (0.8%)
β-caryophyllene (2.6%)
α-humulene (2.1%)
germacrene D (10.4%)
δ-cadinene (1.9%)

Trace amounts of (< 0.1%) of p-cymene and borneol were also found in this oil.

As part of a screening study for the antioxidant activity of some commercially available oils, Wei and Shibamoto (2007) determined that the composition of juniper berry oil was as follows:

α-pinene (33.7%)
camphene (1.9%)
β-pinene (1.4%)
sabinene (10.8%)
myrcene (12.4%)
α-terpinene (1.3%)
limonene (4.5%)
γ-terpinene (2.4%)
p-cymene (1.4%)
terpinolene (1.4%)
β-elemene (2.6%)
β-caryophyllene (1.8%)
terpinen-4-ol (1.7%)
γ-elemene (2.6%)
α-humulene (1.8%)
germacrene* (2.0%)
γ-cadinene (2.0%)

*correct isomer not identified

The range in composition of the main components found in juniper berry oils produced from plants collected in three different locations in Serbia was the subject of analysis by Glisic et al. (2007). The results of this study are presented in **T-3**.

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