Progress in Essential Oils

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Armoise oil, *Artemisia herba-alba* oil: Part 2[b]

Dahmani-Hamzaoui and Baaliouamer (2010) collected *A. herba-alba* plants during their flowering stage from the Boussaada region in the northern Sahara desert region of Algeria. Oils were produced from air-dried and chopped plants using either hydrodistillation or microwave distillation. Analysis of the oils using GC-FID and retention indices only revealed that the main constituents of the oils that were similar in composition were as follows:

santalinatriene (0.8–0.9%)
tricyclene (0.2%)
α-thujene (0.5%)
camphene (4.5–4.9%)
sabinene (0.4%)
β-pinene (0.5-0.6%)
yomogi alcohol (0.1%)
1,2,3-trimethylbenzene (0-0.1%)
p-cymene (0.1%)
1,8-cineole (12.4–13.4%)
santolina alcohol (0.1%)
γ-terpinene (0.4%)
cis-sabinene hydrate (1.1%)
artemisia alcohol (1.1%)
α-thujone (1.0%)
β-thujone (1.9–2.1%)
chrysanthenone (3.2–3.3%)
camphor (48.1–49.3%)
pinocarvone (5.5–5.6%)
borneol (7.1–7.3%)
terpinen-4-ol (0.8–0.9%)
myrtenal (0.1%)
myrtenol (0.1%)
trans-piperitol (0.2%)
cis-carveol (0.1–0.2%)
cuminaldehyde (t–0.1%)
(E)-tagetenone (0.1%)
piperitone (0.1%)
cis-chrysanthenyl acetate (0.9–1.0%)
lyratyl acetate (0.1%)
lyratyl propionate (t–0.1%)
α-copaene (0.3%)
(Z)-jasmone (0.6%)
isocaryophyllene (0.1%)
β-chamigrene (t–0.1%)
γ-muurolene (2.0–2.1%)
α-muurolene (0.1%)
γ-cadinene (0.1%)
δ-cadinene (0.1%)
(E)-nerolidol (t–0.1%)
spathulenol (0.1%)
viridiflorol (t–0.1%)

Trace amounts (<0.05%) of α-thujene, thuja-2,4(10)-diene, 1-octem-3-ol, myrcene, 1,3,5-trimethylbenzene, α-phellandrene, o-isopropenyltoluene, α-terpinene, limonene, β-phellandrene, (E)-β-ocimene, terpinolene, *trans*-sabinene hydrate, filifolone, *trans*-pinocarveol, *trans*-verbenol, isothujyl alcohol, isoborneol, δ-terpineol, santalinyl acetate, thuj-3-en-10-al, p-cymen-8-ol, α-terpineol, *cis*-piperitol, verbenone, *trans*-piperitol, *trans*-carveol, (E)-tagetenone isobornyl acetate, bornyl acetate, cumin alcohol, sabinyl acetate isomer, filfolide, α-terpinyl acetate, eugenol, β-elemene, β-cubebene, (E)-jasmone, methyl eugenol, β-caryophyllene, aromadendrene, α-guaiene, allo-aromadendrene, ethyl (E)-cinnamate, β-selinene, γ-cadinene, cadina-1,4-diene, ledol, caryophyllene oxide, globulol, β-copaen-4α-ol and davanone were also characterized in this oil.

Imelouane et al. (2010) analyzed a lab-distilled oil that was produced in 1.0% yield of *A. herba-alba* plants collected from an undisclosed region of Morocco using GC-FID and GC/MS. The constituents that were collectively characterized in this oil were:

T-4. Comparative percentage composition of the four chemotypes of *Artemisia herba-alba* of Tunisian origin

Compound	Type 1	Type 2	Type 3	Type 4
α-pinene	1.1	0.8	1.4	2.2
camphene	1.6	1.0	1.1	1.4
sabinene	0.3	0.5	0.4	1.5
α-terpinene	0.8	0.9	1.0	1.2
p-cymene	1.0	0.9	1.8	1.7
1,8-cineole	5.0	4.5	12.3	18.4
γ-terpinene	0.6	0.6	0.8	2.0
α-thujone	5.5	49.3	24.1	10.7
β-thujone	58.0	15.0	24.3	14.1
chrysanthenone	2.1	1.4	1.8	1.4
camphor	5.4	3.9	7.5	10.8
trans-pinocarveol	1.7	1.4	2.2	3.5
borneol	1.7	1.4	2.6	2.5
bornyl acetate	0.5	0.3	0.6	1.2
trans-sabinyl acetate	3.4	7.6	3.8	7.8
(E)-jasmone	0.2	0.3	0.2	1.2
germacrene D	0.8	0.8	1.1	1.3

Type 1. β-thujone-rich; Type 2. α-thujone-rich; Type 3. α- and β-thujone-rich; Type 4. 1,8 cineole, camphor; α-thujone and β-thujone-rich

[b]Part 1 of this article appeared on pages 48–52 of the March 2015 edition of this magazine; *www.perfumerflavorist.com/magazine*

tricyclene (0.4%)
α-pinene (0.6%)
camphene (7.2%)
sabinene (1.0%)
1-octen-3-ol (0.3%)
α-phellandrene (0.4%)
α-terpinene (0.3%)
p-cymene (0.5%)
1,8-cineole (7.1%)
γ-terpinene (0.3%)
terpinolene (0.3%)
β-thujone (7.0%)
chrysanthenone (0.4%)
camphor (43.1%)
sabina ketone (1.1%)
borneol (4.9%)
terpinen-4-ol (1.1%)
verbenone (0.2%)
cis-carveol (0.3%)
carvone (0.2%)
bornyl acetate (3.8%)
thymol (1.0%)
γ-elemene (0.1%)
bicycloelemene (0.2%)
eugenol (0.2%)
α-copaene (0.3%)
verbenone (0.5%)
β-cubebene (0.2%)
α-amorphene (0.2%)
germacrene D (1.4%)
α-patchoulene (0.2%)
germacrene B (0.6%)
bicyclogermacrene (0.1%)
δ-cadinene (0.2%)

Trace amounts (<0.09%) of cuminyl alcohol, spathulenol, viridiflorol and kaurene were also characterized in the oil.

Mighri et al. (2010) examined the composition of the oils of four chemical types of *A. herba-alba* using GC-FID and GC/MS. The plants, which were harvested from an experimental garden at the Institut des Region Arides (Medenine, Tunisia) during their flowering stage, were initially air-dried before the leaves and flowers, minus the large stems, were subjected to hydrodistillation for 4 hr. The comparative composition of the four oil types can be seen in **T-4**.

Boukrich et al. (2010) collected *A. herba-alba* plants from the semi-arid and arid regions of Tunisia. They collected 10 individual plants from Msaken (Sahel central Tunisia), an inferior semi-arid region (300–400 mm rainfall annually), eight individual plants from El Kef (northwestern Tunisia), a superior semi-arid region (400–600 mm rainfall annually), and eight individual plants from Samâaliat and Kirchaou (southeastern Tunisia), an inferior arid climate (100–200 mm rainfall annually). Each accession was weighted and air-dried in the shade for 20 days, after which they were subjected to separate hydrodistillation for 4 hr. The oil yields were 1.55–4.12% (central Tunisia), 1.98–4.86% (southeastern Tunisia) and 1.65–2.82% (northwestern Tunisia).

Each of the oils was analyzed using GC-FID, ^{13}C-NMR, retention indices and, in a few situations, GC/MS. As one might expect the major constituents varied drastically. For example, α-thujone (trace–79.9%), chrysanthenone (trace–64.8%), camphor (trace–47.9%) and *trans*-sabinyl acetate (trace–43.8%). A number of other constituents were found in amounts exceeding 10%, including 1,8-cineole (23.5%), davanone (20.7%), β-thujone (19.0%), pinocarvone (14.8%) and camphene (10.2%).

As armoise oil of commercial value is α-thujone-rich, it is of interest to note that all but one of the central Tunisian oil and one oil sample from the Southeastern Tunisia samples possessed the following range in composition:

α-pinene (0–0.7%)
camphene (0–1.1%)
sabinene (0.3–6.5%)
myrcene (0–3.3%)
p-cymene (0.2–1.0%)
1,8-cineole (0.4–2.8%)
α-thujone (48.7–79.9%)
β-thujone (7.2–18.2%)
chrysanthenone (0–2.9%)
camphor (0–17.1%)
trans-pinocarveol (0.2–1.9%)
pinocarvone (0.2–3.2%)
borneol (0–3.9%)
terpinen-4-ol (0.2–1.0%)
cis-chrysanthenyl acetate (0–1.9%)
bornyl acetate (0–1.0%)
trans-sabinyl acetate (0–0.9%)
(Z)-jasmone (0–1.1%)
germacrene D (0.6–5.1%)
bicyclogermacrene (0.1–1.0%)
spathulenol (0.1–1.1%)

The other oil samples contained varying amounts of the other dominant constituents. This shows that collections of *A. herba-alba* from its natural environment can result in the production of oils that are totally dissimilar to the named commercial oil of the specific botanical origin.

Artemisia herba-alba plants were collected from Mount Bir Elhfay (Sidi Bouzid, Tunisia) and subjected to hydrodistillation by Kadri et al. (2011). Using GC/MS and GC-FID as the method of analysis, the oil was found to contain the following correctly identified constituents:

α-pinene (2.8%)
camphene (1.7%)
1,8-cineole (8.9%)
α-thujone (24.9%)
β-thujone (8.3%)
chrysanthenone (4.7%)
camphor (10.8%)
borneol (3.1%)
chrysanthenyl acetate* (3.3%)
bornyl acetate (1.0%)
sabinyl acetate* (5.3%)
α-copaene (0.9%)
β-caryophyllene (0.9%)
germacrene D (14.5%)
δ-cadinene (1.3%)

*correct isomer not identified

Behtari et al. (2012) collected *A. herba-alba* plants at their vegetative and flowering stages from four different altitudes (1,100, 1,200, 1,280 and 1,380 m) in the North Rangeland of Gorgan Province (Iran). Air-dried vegetative and flowering stage plants (100 g of each) from each altitude were subjected to hydrodistillation to produce oils of 0.59–0.80% and 0.43–0.92% yields, respectively. The oil compositions from the plants collected from different altitudes were found to be very similar. As a result, the authors only subjected the oils produced from vegetative and flowering plants to analysis using both GC-FID and GC/MS. The components characterized in the two oils can be found in **T-5**.

An oil produced from *A. herba-alba* plants collected from Makther Seliana (Tunisia) were separated into leaves and stems. The leaves were dried and subjected to hydrodistillation for 3 hr. Analysis of the oil by Amri et al. (2013) using GC-FID and GC/MS revealed the following composition:

1,8-cineole (0.7%)
α-thujone (7.8%)
β-thujone (2.2%)
chrysanthenone (15.0%)
trans-pinocarveol (1.3%)
camphor (39.1%)
trans-sabinol (1.7%)
trans-verbenol (0.3%)
eucarvone (0.8%)
isoborneol (4.0%)
cis-chrysanthenol (2.6%)
viridene (0.5%)
terpinen-4-ol (0.8%)
dihydrocarveol (0.3%)
myrtenol (0.4%)

T-5. Comparative percentage composition of the vegetative and flowering plant oils of *Artemisia herba-alba* of Iranian origin

Compound	Vegetative plant oil	Flowering plant oil
sabinene	0.5	–
myrcene	4.5	–
1,8-cineole	8.0	–
artemisia ketone	13.0	21.3
trans-sabinene hydrate	8.5	0.8
trans-sabinene hydrate acetate	0.6	–
chrysanthenone	0.7	0.5
α-terpineol	–	1.3
camphor	–	1.9
p-menth-3-en-8-ol	2.9	–
isoborneol	2.8	–
borneol	1.0	–
cis-pinocarveol	7.5	29.6
trans-carveol	4.1	2.2
davanone	2.1	–
isobornyl acetate	2.1	–
tridecane	–	3.0
neoisodihydrocarvyl acetate	2.0	2.3
β-caryophyllene	2.5	1.5
aromadendrene	4.7	1.9
germacrene A	1.7	–
trans-calamenene	1.0	0.3
α-calacorene	0.4	–
caryophyllene alcohol	1.1	1.1
caryophyllene oxide	2.2	0.8
γ-eudesmol	–	0.6
α-eudesmol	4.6	1.2
tetradecane	–	0.8
(E,E)-farnesol	–	1.7
(E,Z)-farnesol	2.9	0.7
cedryl acetate	0.9	0.9
isopropyl tetradecanoate	0.7	–
nonadecane	2.8	9.3
eicosene*	0.3	0.5
octadecanol	0.5	2.0
heneicosane	1.7	6.0
tricosane	–	1.2

*correct isomer not identified

verbenone (0.4%)
cis-chrysanthenyl acetate (0.9%)
trans-linalool oxide acetate* (0.3%)
α-terpinen-7-al† (0.4%)
γ-terpinen-7-al† (0.5%)
(Z)-patchenol† (3.1%)
(E)-patchenol† (9.5%)
spathulenol (0.8%)
ar-turmerone (0.5%)

*correct isomer not identified
†questionable identification

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