



## Specific characteristics of essential oils of four *Artemisia* species from the Mongolian Trans-Altai Gobi

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**Abstract:** The essential oil compositions of four *Artemisia* species in Mongolian Trans-Altai Gobi were studied by gas chromatography (GC) and gas chromatography-mass spectrometry (GC-MS). The oil from *A. macrocephala* Jacq and *A. dracunculoides* Ledeb. were characterized by the presence of monoterpene hydrocarbons and oxygenated monoterpeneoids predominately. E-nerolidol (26.95%), methyleugenol (23.29%) and sabinene (13.21%) were found as main components in the essential oils of *A. dracunculoides*. *A. macrocephala* was characterized by the presence of chamazulene (13.8%), cineol (11.7%), myrcene (9.0%), germacrene-D (7.1%). *A. anethifolia* Web was characterized by the presence of fragrant compounds as camphor (26.05%),  $\alpha$ -thujone (10.1%), borneol (5.1%). Davanone and davanone derivatives were also detected in the sample in amount of 7.7% in total. *A. scoparia* Waldst differed by domination of monoterpene hydrocarbons (78.9%) with (Z)- $\beta$ -ocimene (29.24%),  $\alpha$ -pinene (15.19%), limonene (10.27%) and myrcene (9.61%).

**Keywords:** Wormwood, essential oil composition, chamazulene, 1.8-cineol, camphor,

### INTRODUCTION

The genus of *Artemisia* (family Asteraceae) which contains many useful aromatic and medicinal plants, comprises of about 400 species found in the northern hemisphere [1]. The genus *Artemisia* presents 103 species that are found wild all over the Mongolia [2, 3]. *Artemisia* popularly known as “sagebrush” or “wormwood” is a source of valuable drugs and essential oils. Because of medicinal importance and intricate chemical composition of several varieties and chemotypes, *Artemisia* continues to be subject of wide interest for chemists and taxonomists.

The genus *Artemisia* produces a great number of terpenoid compounds in glandular trichomes which have been found to be biologically active [4]. Currently, the pharmaceutical [5-8], food science [9, 10], fragrance [9, 11] and in perfumery [12], cosmetical industries [13] are intensively studying the terpenoids of *Artemisia* and their sesquiterpenoid lactones [14-16].

The *Artemisia* species are rich in volatile oils that exhibit a wide spectrum of biological activity as anti-inflammatory, antibacterial, antifungal, anti-oxidant, antiviral, allelopathic etc [17, 18].

*A. macrocephala*, *A. scoparia* are used as an antiseptic, anti-inflammatory, antihelmintic, tonic as well as for the treatment of stomachache and toothache in Mongolian traditional medicine [4, 5, 8].

A literature survey revealed only a few reports on essential oil composition of *A. macrocephala*, *A. scoparia* and many researches for *A. dracunculoides* is known Tarragon [19-22].

Tarragon possesses insecticide and radical-scavenging activities. Antifungal, antitumor and DNA-damaging effects were also reported for the essential oil of *A. dracunculoides* [23]. Worthy of mention is the use of the aromatic leaves of *A. dracunculoides* in perfumery and range of food applications which include soups, causes, salad dressing and in the Tarragon vinegar [9, 10, 23, 24].

Previously, reported constituents of *A. macrocephala* were flavonoids, alkaloids, saponins and terpenes including  $\alpha$ -pinene,  $\beta$ -pinene, limonene, p-cymene, borneol and 1,8-cineole in the essential oil of the plant. The oil also contains camphor propionic acid, acetic acid, enanthic acid and isovaleric acid. [21, 22, 25]. Mohammad Shoab et al., examined that the essential oil of *A. macrocephala* possesses acetylcholinesterase and butyrylcholinesterase inhibitory potential and revealed from the study beneficial applications of the oil in treatment of various neurodegenerative disorders including Alzheimer's disease, Parkinson's disease, ataxia and all other forms of dementia [25].

*A. scoparia* has medicinal properties like anti-cholesterolemic, antipyretic, antiseptic, antibacterial, diuretic, cholagogue, vasodilator [19]. The seeds and young flowering stem of the plant, yield an essential oil that also finds extensive use in medicine. Essential oil of this plant has strong antioxidant and insecticidal activity against stored-product insects [6, 20, 21].

In 1976, Shatar et al., examined the chemical composition of *A. scoparia* oil produced from plants grown in Mongolian Gobi. The compounds identified in the GC were as follows:  $\alpha$ -pinene (15.0%), camphene (12.0%),  $\beta$ -pinene (1.2%), sabinene

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(6.0%), 3- $\delta$ -carene (2.4%), myrcene (2.5%), terpinene (4.3%),  $\alpha$ -phellandrene (3.5%),  $\beta$ -phellandrene (3.0%), p-cymene (5.0%), longicyclene (2.5%), longifolene (0.3%),  $\beta$ -bisabolene (0.6%),  $\beta$ -santalene (0.2%),  $\alpha$ -himachalene (2.5%),  $\gamma$ -bisabolene (0.4%),  $\delta$ -cadinene (1.8%) and curcumene (0.2%) [21]. We reported the chemical composition of the essential oil of Mongolian twenty two *Artemisia* species previously [24, 26-29].

The essential oil composition of *Artemisia anethifolia* has not been investigated so far.

As a part of our studies on *Artemisia* species in Mongolian Trans-Altai Gobi, we have now investigated the essential oil composition of *A. dracuncululus*, *A. macrocephala*, *A. anethifolia* and *A. scoparia*.

## EXPERIMENTAL

**Plant material:** Aerial parts of *A. scoparia*, *A. anethifolia*, *A. macrocephala* and *A. dracuncululus* were collected from wild growing plants in Mongolian Trans-Altai Gobi at full flowering and fruiting stage in July-September 2011-2013. The exact dates of each harvesting are showed in Table 1.

A voucher specimen has been deposited in the Herbarium fund of the Institute of Botany of the Mongolian Academy of Sciences, Ulaanbaatar, Mongolia.

**Isolation of oil:** Air-dried aerial parts (70-80 g) were subjected to a hydro distillation in Clevenger type apparatus for 3 h. The samples were yielded 0.43% (w/w) of *A. scoparia* oil, 0.75% of *A. anethifolia* oil, 0.23% of *A. macrocephala* oil and 0.56% of *A. dracuncululus* oil. The oils were dried over anhydrous calcium chloride and stored in sealed vials at 4°C before analysis.

**Gas chromatography (GC) and gas chromatography and mass spectrometry (GC/MS):** GC analysis was carried out on Hewlett Packard HP 5890II Gas Chromatograph fitted with an fused silica DB-Wax column (30m $\times$ 0.25mm $\times$ 0.25 $\mu$ m); carrier gas nitrogen, linear velocity 38 ml/min, split ratio 30:1. The injector and detector temperature was 250°C, column temperature was programmed from 80 to 200°C at a rate 2°C/min, 0.5  $\mu$ l solutions of essential oil samples in dichloromethane (1%) were subjected to the injector. Quantitative data were obtained from an electronic integration of the flame ionization detector (FID) peak area. GC-MS analysis was performed on HP 5971A instrument with MS detector 5890II of the same company which was operated in EI mode (70eV). GC-MS fitted with a Supelcowax 10 column (60m $\times$ 0.25mm $\times$ 0.25 $\mu$ m); carrier gas helium, linear velocity 10 ml/min, split ratio 30:1. The injector and detector temperature was 250°C and 280°C, column temperature was programmed from 80 to 120°C at a rate 3°C/min. All GC condition and capillary column used were as described above but a carrier gas was helium.

**Identification of components:** The separated components were identified by matching with mass-spectral library data and by comparison of Kovat's indices with those of authentic components and with published data [30-34].

## RESULTS AND DISCUSSION

The essential oils were isolated from the aerial parts of four *Artemisia* species at full flowering and fruiting stage were obtained in 3 replications and taken means of the oil yields as shown in Table 1. Additionally the place and time of collection of the plant materials are given in Table 1.

Table 1. Essential oil yields of four *Artemisia* species

Plant name	Date of collection	Vegetation period	Oil yield, %
<i>A. scoparia</i> Waldst	August 2012	in full bloom	0.43
<i>A. anethifolia</i> Web	August 2012	In full bloom	0.75
<i>A. macrocephala</i> Jacq	September 2013	ripe fruits	0.23
<i>A. dracuncululus</i> L	July 2011	in full bloom	0.56

The essential oils were obtained from aerial parts of wild growing *A. dracuncululus*, *A. anethifolia*, *A. macrocephala* and *A. scoparia* in Mongolian Trans-Altai Gobi. GC and GC-MS analyses led to detection of 88 constituents accounting 88.30-94.03% of the oils (Table 2). The compounds were identified on the basis of their mass spectral characteristics and retention indices on non polar HP-5MS column.

*A. dracuncululus* essential oil contained 44 compound, accounting 88.30% of the oil. As it seen in Table 2, the oil was rich oxygenated terpenoids: Monoterpenoids 33.66% and sesquiterpenoids 28.66%. Methyl Eugenol (23.29%), E-nerolidol (26.95%), sabinene (13.21%) were dominating in the investigated sample. The different observers revealed from previous studies which are noted to be principle chemotype of methylchavicol (35.7-60.46%), sabinene (0.11-46.78%), ocimene (0.3-13.54%),  $\gamma$ -terpinene (2.43-17.01%) for essential oil of *A. dracuncululus* from South Sibiria, USA, Russia and Italia [10, 29] while the investigated sample has specific chemotype that including considerable amounts of methyleugenol and aromatic alcohols. It can be shown that the *A. dracuncululus* from Mongolian Trans-Altai Gobi can be used for raw material in the medicines, perfumes, cosmetic and food producing.

The oil of *A. anethifolia* contained 47 compounds, accounting 88.17% of the oil (Table 2). The sample differed from the described by domination of monoterpenoids (56.94%), among which are camphor (26.05%),  $\alpha$ - $\beta$ -thujone (14.35%). In addition, borneol (5.11%), hexadien-2.4-1-phenyl (4.51%), caryophyllene oxide (2.53%), germacrene-D (2.53%), caryophyllene (2.07%), spathulenol (2.17%) were detected as prominent monoterpenoids. A literature survey showed any reports concerning essential oil composition of *A. anethifolia*. Also the oil differed from the described above by the presence of davanone type compounds (7.73%) davanone-1, davanone-2, davanone-3, davanone-4 and davanyl ether. Literature survey showed that they accompanied davana type compounds in essential oils and could be described as

Table 1. Essential oil yields of four Artemisia species, %

Compounds	<i>A.dracunculus</i>	<i>A.anethifolia</i>	<i>A.macrocephala</i>	<i>A.scoparia</i>
$\alpha$ -thujene	-	-	-	0.14
<b><math>\alpha</math>-pinene</b>	-	0.61	1.4	<b>15.19</b>
camphene	-	2.71	1.2	0.18
<b>sabinene</b>	<b>13.21</b>	<b>0.24</b>	<b>0.6</b>	<b>3.85</b>
<b><math>\beta</math>-pinene</b>	<b>1.10</b>	0.31	0.4	<b>5.55</b>
<b>myrcene</b>	<b>0.88</b>	-	<b>9.0</b>	<b>9.61</b>
$\alpha$ -phellandrene	-	-	3.6	-
$\alpha$ -terpinene	0.26	-	0.4	0.26
p-cymol	0.58	0.19	1.4	-
<b>limonene</b>	<b>1.60</b>	-	<b>1.2</b>	<b>10.27</b>
(E)- $\beta$ -ocimene	0.80	-	-	1.02
<b>(Z)-<math>\beta</math>-ocimene</b>	<b>1.24</b>	-	-	<b>29.47</b>
$\gamma$ -terpinene	0.71	-	0.7	-
terpinolene	0.45	-	0.5	-
<b>Monoterpene hydrocarbones</b>	<b>22.55</b>	<b>4.06</b>	<b>20.4</b>	<b>78.94</b>
<b>1.8-cineol</b>	1.10	1.21	<b>11.7</b>	2.61
lavandulacton	-	0.33	-	-
artemisia keton	-	0.75	-	-
(E)-sabinenehydrate	0.20	0.25	-	-
(Z)-sabinenehydrate	0.33	0.27	1.6	0.09
linalool	0.31	0.21	1.2	-
<b><math>\alpha</math>-thujone</b>	<b>0.23</b>	<b>9.95</b>	-	-
<b><math>\beta</math>-thujone</b>	-	<b>4.40</b>	-	0.07
(E)-p-ment-2-en-1-ol	-	0.93	-	-
chryzanthenon	-	0.24	-	-
pinocarveol	-	0.79	-	-
<b>camphor</b>	-	<b>26.05</b>	1.4	-
(E)-chryzanthenol	-	0.47	0.2	-
<b>borneol</b>	-	<b>5.11</b>	0.9	0.45
terpin-4-ol	4.38	0.76	0.5	0.19
isogeraniol	-	-	1.2	-
<b><math>\alpha</math>-terpineol</b>	<b>2.68</b>	0.38	1.9	0.08
gernaylacetate	-	-	-	0.36
methylchavicol	0.46	-	-	-
myrtenol	-	1.06	-	-
(Z)-piperitol	-	1.25	-	-
(Z)-carveol	-	0.14	-	-
bornylformat	-	0,19	-	-
carvon	-	0,20	-	-
methylsalicilate	-	-	-	-
bornylacetate	0.21	1.03	-	-
(Z)-piperitolacetate	0.59	-	-	-
<b>methyleugenol</b>	<b>23.39</b>	-	-	-
<b>Monoterpenoids</b>	<b>33.66</b>	<b>56.94</b>	<b>20.6</b>	<b>1.26</b>
$\alpha$ -santalene	-	-	-	1.12
copaene	-	0.5	-	-
$\beta$ -bourbonene	-	-	0.5	-
$\beta$ -elemene	-	-	0.7	-
caryophyllene	1.00	2.07	2.0	1.60
humulene	-	-	0.2	0.12
$\beta$ -farnesene	0.29	-	2.0	0.45
selina-4,11-dien	-	-	1.3	-
<b>germacrene-D</b>	<b>0.29</b>	<b>2.53</b>	<b>7.1</b>	-
<b><math>\beta</math>-selinene</b>	-	-	<b>4.0</b>	+
$\gamma$ -muurolene	0.19	-	-	-
bicyclogermacrene	0.86	-	1.0	2,27
(E-E)- $\alpha$ -farnesene	-	-	-	0.44
$\gamma$ -cadinene	-	-	-	0.33
$\delta$ -cadinene	0.40	0.49	-	-
selin-3,7(11)-dien	-	-	2.6	0.90
<b>Chamazulen</b>	-	-	<b>13.8</b>	-
<b>Sesquiterpene hydrocarbones</b>	<b>3.43</b>	<b>6.89</b>	<b>35.2</b>	<b>11.75</b>

lavandulylisobutanoate	-	-	1.0	-
lavandulyl-3- methylbutanoate	-	-	2.2	-
<b>E-nerolidol</b>	<b>26.95</b>	-	0.3	1.58
<b>hexadien-2,4,1-phenyl</b>	-	<b>4.51</b>	-	-
<b>neryl-2-methylbutanoate</b>	-	-	<b>4.0</b>	-
E,E- $\alpha$ -fernezelin	-	0.45	-	-
davanyl ether	-	2.21	-	-
neryl-3-methylbutanoate	-	-	2.2	-
geranyl-2-methylbutanoate	-	-	1.4	-
copaborneol	-	-	2.2	-
geranyl-3-methylbutanoate	-	-	0.4	-
davanon-1	-	1.47	-	-
davanon-2	-	2.19	-	-
davanon-3	-	1.10	-	-
spathulenol	1.39	-	0.9	-
caryophyllene oxide	0.32	2.17	0.4	0.13
epi- $\alpha$ -cadinol	-	2.53	-	0.11
davanon-4	-	0.76	-	-
$\beta$ -bisabolol oxide	-	0.81	-	0.26
$\gamma$ -eudesmol	-	-	0.3	-
bisabolol	-	2.08	-	-
T-cadinol	-	-	0.4	-
caryophyll-4-en-13-ol	-	-	0.5	-
<b>Sesquiterpenoids</b>	<b>28.66</b>	<b>20.28</b>	<b>16.2</b>	<b>2.08</b>
<b>Total identified compounds</b>	<b>88.30</b>	<b>88.17</b>	<b>92.4</b>	<b>94.03</b>

biogenetically connected with them or their degradation products [1, 10, 17].

Further, 32 compounds were identified in the *A.scoparia* essential oil, representing 94.03% of the studied oil. (*Z*)- $\beta$ -ocimene (29.47%),  $\alpha$ -pinene (15.19%) and limonene (10.27%) were found to be the main terpenoids in analyzed sample. Myrcene (9.51%),  $\beta$ -pinene (5.55%), sabinene (3.85%) were detected in the relatively low concentrations in the investigated sample. Spathulenol, nerolidol, caryophyllene oxide,  $\alpha$ -cadinol and epi- $\alpha$ -bisabolol were the only five sesquiterpenoids detected in amounts of 2.08% in total. It should be noted a high percentage of  $\beta$ -ocimene (29.47%) in the oil. This compound has not been detected previously in a plant originated from Khangai region, Mongolia. Instead,  $\alpha$ -pinene, camphene are reported as principle components in the plant [21]. Comparison of the obtained results with those published so far showed similar essential oil profile which was characterized by high percentage of monoterpene hydrocarbons and aromatic compounds. The observed differences were significant and could be due to the effect of ecological conditions or stage of the plant development [29].

Finally, in *A.macrocephala* oil were detected 44 compounds, representing 92.4% of the oil. The obtained results have considerably enlarged data for *A.macrocephala* essential oil. So far, monoterpenoids were known as main components of the oil with borneol (10.8), cineol (10.7%), isoborneol (8.3%), camphor (6.3%) and chamazulene without any quantitative data [21], camphene, limonene, *p*-cymol,  $\alpha$ -thujone [7], caryophyllene,  $\beta$ -selinene [1], 1.8-cineol,  $\gamma$ -terpinene, sabinene, limonene [29]. These components were presented in the investigated sample, but the oil was characterized by high contents of chamazulene

(13.8%), 1.8-cineol (11.7%). Other prominent compounds were myrcene (9.0%) and germacrene (7.1%). *A.macrocephala* in Mongolian Trans-Altai Gobi could be more anti-inflammatory activity than others which are growing in different areas of Mongolia because of chamazulene content according to the studies by researchers at Siberian State Medical University showed high anti-inflammatory activities for azulene (derivative product is chamazulene) containing essential oils of wormwood [35].

## CONCLUSION

According to the results, specific chemotypes in the essential oils from *A.scoparia*, *A.dracunculus*, *A.macrocephala* in Mongolian Trans-Altai Gobi are revealed comparing with previous researches of the three *Artemisia* species are wild growing in different regions of the Mongolia. Furthermore chemical compositions of the essential oil from *A.anethifolia* in the Gobi were investigated firstly [1, 3, 7, 10], which are dominated by monoterpenoids. Determining components as main from the *Artemisia* species are methyleugenol in *A.dracunculus*, aromatic alcohols and ketones in *A.anethifolia*, chamazulene in *A.macrocephala* possess high bioactivity properties and the essential oils could be effective supplements for medicine, food, perfumer industries.

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