NATURAL PRODUCT COMMUNICATIONS

An International Journal for Communications and Reviews Covering all Aspects of Natural Products Research
Composition of the Essential Oil of Wild Growing Artemisia vulgaris from Erie, Pennsylvania

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Received: January 15th, 2012; Accepted: February 22nd, 2012

Essential Oil from wild growing Artemisia vulgaris L. originating in Erie, Pennsylvania was obtained by hydrodistillation of the aerial parts of the plant. Gas chromatographic-mass spectral analysis was used to identify the major volatiles present. Up to 22 components were detected in the essential oils. Germacrene D (25%), Caryophyllene (20%), α-Zingiberene (15%) and Borneol (11%) represent the major components of leaf oil, while the buds were rich in 1,8-Cineole (32%), Camphor (16%), Borneol (9%), and Caryophyllene (5%). trans-2-Hexenal was also detected in the aerial parts of the plant. α-Zingiberene and trans-2-Hexenal have not been previously reported for Artemisia vulgaris L. The major analytes are compared to those from Artemisia vulgaris L., originating outside of the United States.

Keywords: Artemisia vulgaris L., Vulgarole, α-Zingiberene, GC-MS, Mass Spectroscopy, Hydrodistillation, Essential Oil.

Table 1: Essential oil composition of Artemisia vulgaris.

<table>
<thead>
<tr>
<th>Compound</th>
<th>ID°</th>
<th>RI°</th>
<th>AVBO (%)</th>
<th>AVLO (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>trans-2-Hexenal</td>
<td>A</td>
<td>850</td>
<td>nd</td>
<td>1.0</td>
</tr>
<tr>
<td>Santolinalactone</td>
<td>B</td>
<td>917</td>
<td>2.2</td>
<td>nd</td>
</tr>
<tr>
<td>α-Pinene</td>
<td>A</td>
<td>933</td>
<td>0.8</td>
<td>0.7</td>
</tr>
<tr>
<td>Camphene</td>
<td>A</td>
<td>948</td>
<td>0.7</td>
<td>0.2</td>
</tr>
<tr>
<td>β-Pinene</td>
<td>A</td>
<td>976</td>
<td>0.4</td>
<td>0.3</td>
</tr>
<tr>
<td>1-Octen-3-ol</td>
<td>A</td>
<td>979</td>
<td>1.8</td>
<td>0.1</td>
</tr>
<tr>
<td>p-Cymene</td>
<td>A</td>
<td>1025</td>
<td>2.4</td>
<td>0.2</td>
</tr>
<tr>
<td>1,8-Cineole</td>
<td>A</td>
<td>1031</td>
<td>32.2</td>
<td>1.8</td>
</tr>
<tr>
<td>γ-Terpinene</td>
<td>A</td>
<td>1059</td>
<td>tr</td>
<td>tr</td>
</tr>
<tr>
<td>Camphor</td>
<td>A</td>
<td>1147</td>
<td>16.3</td>
<td>tr</td>
</tr>
<tr>
<td>Borneol</td>
<td>A</td>
<td>1167</td>
<td>9.0</td>
<td>10.8</td>
</tr>
<tr>
<td>Terpinen-4-ol</td>
<td>A</td>
<td>1179</td>
<td>6.2</td>
<td>0.7</td>
</tr>
<tr>
<td>Bornyl Acetate</td>
<td>A</td>
<td>1288</td>
<td>0.6</td>
<td>1.0</td>
</tr>
<tr>
<td>α-Copaene</td>
<td>A</td>
<td>1380</td>
<td>1.3</td>
<td>0.3</td>
</tr>
<tr>
<td>Caryophyllene</td>
<td>A</td>
<td>1425</td>
<td>5.3</td>
<td>19.6</td>
</tr>
<tr>
<td>α-Humulene</td>
<td>B</td>
<td>1459</td>
<td>1.6</td>
<td>5.0</td>
</tr>
<tr>
<td>Germacrene D</td>
<td>B</td>
<td>1474</td>
<td>3.2</td>
<td>23.3</td>
</tr>
<tr>
<td>ar-Curcumene</td>
<td>A</td>
<td>1479</td>
<td>0.5</td>
<td>6.0</td>
</tr>
<tr>
<td>β-Selinene</td>
<td>B</td>
<td>1492</td>
<td>2.1</td>
<td>1.2</td>
</tr>
<tr>
<td>α-Zingiberene</td>
<td>A</td>
<td>1498</td>
<td>1.0</td>
<td>14.9</td>
</tr>
<tr>
<td>δ-Cadinene</td>
<td>B</td>
<td>1505</td>
<td>0.8</td>
<td>3.9</td>
</tr>
<tr>
<td>Caryophyllene Oxide</td>
<td>A</td>
<td>1590</td>
<td>3.6</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Identification: A, mass spectrum (2008 NIST used for all MS comparisons) and retention index matched those of commercially available reference samples; B, mass spectrum and retention index matched literature values from Adams [35] and/or Blagojevic [4].°Retention Index on HP-5MS capillary column relative to a series of n-alkanes, nd=not detected, tr=less than 0.1%.

No additional detection of its presence was found in previously published data (see references in Table 2).

The compound trans-2-hexenal has been documented as being produced in plant wounding [20, 21]. It has been found in extracts from the leaves of Japanese Mugwort [22], but until now has not been detected in Artemisia vulgaris L. The presence of the oxidation product, 2-hexenoic acid, has been reported in the oil from a German sample of Artemisia vulgaris L. [23].

Artemisia vulgaris L., most commonly known as Mugwort, has been studied for its insecticidal [1, 2] and antimicrobial properties [3-5]. In addition, estrogenic flavonoids from this plant have been investigated [6]. The chemical composition of the oil obtained by hydrodistillation of the aerial parts of Artemisia vulgaris L. has been reported from various world regions such as Egypt [7], Cuba [8], Vietnam [9], France [10], Italy [11] and The Republic of Bashkortostan [12]. To our knowledge there are no studies on the composition of the oils obtained by hydrodistillation of the aerial parts of Artemisia vulgaris L. originating from the USA.

Table 1 lists the chemical composition obtained by gas chromatography-mass spectroscopy (GC-MS) analysis of the oils from buds (AVBO) and fresh leaves (AVLO), of Artemisia vulgaris L. growing wild in Erie, PA. during 2010. Quantitative data were obtained from total ion current (TIC) area percentages without the use of internal standards. This method has been used previously to quantify the compositions of essential oils [13, 14] and accounted for over 92% of the volatiles from both the AVBO and the AVLO.

While Vulgarole has been suggested as a marker for A. vulgaris L. [15], it was not detected in the aerial parts of Artemisia vulgaris L. from Erie, PA., although it was found in samples from Italy [16] and Germany [17]. The presence of a single enantiomer was elucidated in 1991 [15]. Vulgarole has however, been reported in a sample of Capsicul using GC-MS [18] and in a sample of Artemisia moorcroftiana Wall from the Kashmir region of India [19].

α-Zingiberene has also not been previously reported for Artemisia vulgaris L.. This compound occurs at relatively high concentrations in Ginger [24], which was used to provide additional conformation of its presence (see experimental).

Table 2 lists the four major components of A. vulgaris L. from Erie Pennsylvania, in addition to published data from other countries. Major analyte composition varies geographically in most, but not all, cases. The major analytes, for example, found in the leaves and buds of the plant from geographically different areas in (Minaga area) and outside (Akatochi and Uokiri areas) of Hiroshima City,
Japan remained essentially the same, although their percentages fluctuated [25]. In addition it has been reported that “A. vulgaris L. from four different British sources gave oils of essentially identical compositions” [26].

It appears that seasonal studies produce similar results. The major analytes in plants from Japan [25], Vietnam [27] and India [28] remain essentially the same, independent of the time of harvest, accompanied by fluctuations in their individual percentages.

The contrast between volatile oil content from the leaves and buds in samples from Erie, Pennsylvania can also be seen in Table 2. AVLO contains less monoterpene and more sesquiterpene than AVBO. This difference can also be noted for A. vulgaris originating from other countries. With this observation it is tempting to speculate on the “leaf/bud” composition for which only aerial parts of the plant were used for analysis.

In some cases the published data reports total analyte composition of less than 75% or greater than 100%. This data should be interpreted with caution. Wherever possible the data in Table 2 are reported for maximum volatile composition.

Experimental

**Plant material:** Fresh *Artemisia vulgaris* L. plants were collected during July 2010 through August of 2010 from Erie, Pennsylvania. The plant identity was confirmed by Dr. Marlene Cross, Department of Biology, Mercyhurst University. A voucher specimen is deposited in the Herbarium of the Tom Ridge Center, Erie Pennsylvania. The leaves and buds (before flowering) were washed, separated and dried before analysis.

**Isolation of Essential Oils:** Approximately 334 grams of buds were introduced into a two liter round bottom flask after grinding using a Green Machine (MJ575, Miracle Exclusives, Danbury, CT). Distilled water in the amount of 1.68 L was added and the entire mixture subjected to hydrodistillation using a Clever-disher-type apparatus. Approximately 966 mg of essential oil (AVBO) was collected after four hours. A similar procedure was followed using mature fresh leaves of the plant; 600 grams of which yielded 560 mg of light yellow oil (AVLO). All samples were stored at -4°C but allowed to warm to room temperature (23°C) before analysis.

**Gas Chromatography-Mass Spectroscopy Analysis:** GG-MS analysis of the oils was performed using an Agilent 7890A gas chromatograph and a 5975C mass selective detector from the same company. Volatile analyte separation was achieved using three different fused silica capillary columns from Agilent Technologies. HP5-MS (30 m x 0.25 mm i.d., film thickness 0.25 µm); DB624 (30 m x 0.25 mm i.d., film thickness 0.32 µm) and CyclodexB (30 m x 0.25 mm i.d., film thickness 0.25 µm).

Carrier Gas: Helium; Constant Flow: 1 mL/min; Injector temperature 250°C; Temperature program for the first two columns:
50°C for 3 min. 5°C/min. to 250°C; 15 min. hold at 250°C. The Cyclosil B column was held isothermally at 140°C and used only to provide additional α-Zingiberene/ar-Curcumene confirmation. The volume injected was 0.1 µL (0.1% solution in methanol), with a split ratio of 1/20. Mass spectra were obtained by electron ionization at 70 eV (ion source 150°C; quad. 230°C; transfer line 250°C).

**Identification of Essential Oil Compounds**: Wherever possible, mass spectral data and calculated retention indexes for authentic compounds were used for comparison (National Institute of Standards and Technology Library, Scientific Instrument Services, Ringoes, NJ, 2008). Ginger oil (Sigma-Aldrich) was used as a reference sample for α-Zingiberene and ar-Curcumene. Kovats retention indices were calculated relative to C<sub>n</sub>-C<sub>n+2</sub> n-alkanes.

**References**


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