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Chemical composition of essential oils of *Artemisia vulgaris* L. (mugwort) from North Lithuania

Asta Judžentienė[1] and

Justė Buzelytė[2]

[1] *Institute of Chemistry,*
A. Goštauto 9,
LT-01108 Vilnius, Lithuania
E-mail: judzent@ktl.mii.lt

[2] *Vilnius Gediminas Technical University,*
Faculty of Fundamental Science,
Saulėtekio 11, LT-10223,
Vilnius, Lithuania

The chemical composition of the essential oils of *Artemisia vulgaris* L. growing in Northern Lithuania has been studied. The wild growing plants were collected in seven localities at the early flowering stage in 2004 and 2005; oils were prepared by hydrodistillation of mugwort overground parts and analyzed by GC/MS. Germacrene D has been found as the first principal component in three oils (10.6–15.1%), in two oils as the second (12.1 and 13.4%) and in one oil as the third (10.3%). trans-Thujone was determined as the first major constituent in one oil (20.2%) and cis-thujone as the second dominant compound in one oil (12.9%). Chrysanthenyl acetate prevailed in one oil (23.6%). 1,8-Cineole was the predominant constituent in two oils (16.7 and 17.6%). Among the other major compounds were sabinene, β-pinene, artemisia ketone, caryophyllene. Eighty one identified components formed up 81.9–96.8% of the total oil content. Oxygenated monoterpenes made up 17.1–48.7%, while sesquiterpenes 17.1– 44.1% of the oils.

Key words: *Asteraceae*; *Artemisia vulgaris* L., essential oil composition, 1,8-cineole, cis-, trans-thujone, chrysanthenyl acetate, germacrene D, caryophyllene

INTRODUCTION

The genus *Artemisia* is one of the largest in the *Asteracea* family, consisting of more than 800 species which are widespread over the world. Many of *Artemisia* species grow in Eurasia, North and Central America and Northern Africa.

Several *Artemisia* species (*A. campestris*, *A. absinthium* and *A. vulgaris*) grow in Lithuania [1]. *Artemisia vulgaris* L., known as common mugwort, is a pesty weed frequent over the entire country. The plant is perennial, 50–150 cm in height, flowering by August and setting seeds by September. This species grows in open fields, roadsides and waste ground, often forming dense colonies. Several varieties of *A. vulgaris* are found in Lithuania [1].

A. vulgaris has been known not only as an edible plant (mostly as a spice) but also as a folk medicine resource. Mugwort essential oils are used for their insecticidal, antimicrobial and anti-parasitical properties [2–5]. In the paper [5] authors have reported that *A. vulgaris* essential oils have a significant fumigant and repellent effect on *Musca domestica*. The investigations of mugwort extracts indicated a hepatoprotective activity and validated the traditional use of this plant for various liver disorders [6]. In Oriental medicine, *A. vulgaris* has been used as an analgesic agent and in acupuncture therapy [7]. The emmenagogic properties of this plant are related to estrogenic flavonoids [8]. Mugwort leaves and stems contain traces of alkaloids.

Essential oils make a major contribution into the plant's biological activity as well. For that reason the chemical composition of mugwort oils has been investigated in several studies.

It has been determined that *A. vulgaris* growing in different European countries is dominated mostly by the monoterpene fraction. German mugwort oil is rich in sabinene (16%), myrcene (14%) and 1,8-cineole (10%) [9]. The oils from Italy contained camphor (47%) alone [10] or camphor (2–20%) together with myrcene (9–70%), 1,8–cineole (1–27%) or borneol (3–18%) as the major constituents [11]. The amounts of monoterpenes varied: camphor from 1 to 13%, 1,8-cineole 1–23% and terpinen-4-ol 1–19% in the leaf oils investigated in France [12].

α-Thujone or thujone isomer and camphor were determined as the main components in *A. vulgaris* from India [13]. The oils from Morocco were also rich in thujone / isothujone and camphor [14]. Oxygenated monoterpenes (1,8-cineole, camphor, α-terpineol) dominated in the essential oils of *A. vulgaris* of Vietnamese origin [15]. The plants cultivated under Indo-gangetic plain conditions produced leaf essential oil with 1,8-cineole (2.2–12.2%), α-thujone (0–11.4%), camphor (15.7–23.1%) and isoborneol (9.3–

20.9%) as predominant compounds, while flower oil was found to be rich in camphor (38.7%) [16].

The sesquiterpene fraction dominated in the mugwort oils from Cuba [17], where caryophyllene oxide (31%) was the predominant component, and from Vietnam [18] with β-caryophyllene (24%), β-cubebene (12%) and β-elemene (6%) as the major constituents.

The aim of the present study was to explore the chemical composition of *A. vulgaris* essential oils native to our country. At present, there are no data on the essential oil composition of Lithuanian mugwort.

MATERIALS AND METHODS

The aerial parts (up to ~50 cm) of mugwort plants (0.1–0.3 kg) grown wild were collected in July 2004 and 2005. The plants were gathered in 7 localities in Biržai , Mažeikiai, N. Akmenė, Šiauliai and Plungė districts.

All samples were collected at the early flowering stage. Voucher specimens were deposited in the Herbarium of the Institute of Botany (BILAS), Vilnius.

The plants were dried at room temperature (20–25 °C). The oils (0.2–0.4%) were prepared by hydrodistillation of 15–20 g of air-dried plants for 2.0 h, using hexane and diethyl ether mixture (1:1) as an organic collecting solvent.

Analyses by GC / MS were performed using a HP 5890 chromatograph interfaced to an HP 5971 mass spectrometer (ionization voltage 70 eV) and equipped with a CP-Sil 8 CB capillary column (50 m × 0.32 mm i. d., film thickness 0.25 μm). The oven temperature was held at 60 °C for 2 min, then programmed from 60 ° to 160 °C at a rate 5 °C/min, held for 1 min, then programmed at 160–250 °C at the rate 10 °C/min and finally isothermal at 250 °C for 5 min, using He as the carrier gas (1.0 ml/min). Injector and detector temperatures were 250 °C.

The percentage composition of the essential oils was computed from GC peak areas without correction factors. Qualitative analysis was based on a comparison of retention times, indexes and mass spectra with the corresponding data in the literature [19] and computer mass spectra libraries (Wiley and NBS 54K).

RESULTS AND DISCUSSION

A preliminary study on the chemical composition of essential oils of *Artemisia vulgaris* L. growing in North Lithuania was conducted. In the course of the study seven essential oils (content ranging within 0.2–0.4% (v/w)) of mugwort were analyzed by GC / MS (Table).

Germacrene D was determined as the first major constituent in three oils (10.6–15.1%), as the second in two samples (12.1 and 13.4%) and as the third in

Table. **Variation of essential oil composition of *Artemisia vulgaris* L. collected in North Lithuania**

Compound	**RI**	Interval
Santolina triene	909	0–0.6
Artemisia triene	927	0–0.2
α-Thujene	930	0–0.1
α-Pinene	939	0.3–2.9
Camphene	954	0–0.8
Sabinene	975	**0–8.4**
β-Pinene	979	**0.1–12.9**
Octen-3-ol	979	0–3.1
Myrcene	991	0.4–4.5
α-Terpinene	1017	0–0.4
Cymene	1025	0–1.1
1,8-Cineole	1031	**2.6–17.6**
Z-β-Ocymene	1037	0.5–2.7
γ-Terpinene	1060	t-2.0
Artemisia ketone	1062	**0–7.8**
Artemisia alcohol	1084	0–2.6
cis-Sabinene hydrate	1070	0–0.4
Terpinolene	1089	0–0.4
trans-Sabinene hydrate	1098	0–1.8
Linalool	1098	0–0.4
n-Nonanal	1101	0–1.3
cis-Thujone	1102	**0–12.9**
trans-Thujone	1114	**0–20.2**
iso-3-Thujanol	1138	0–1.4
Camphor	1146	0–7.4
trans-Sabinene hydrate	1146	0–4.3
Isoborneol	1162	t-0.7
Borneol	1169	0–2.2
Artemisyl acetate	1173	0–0.4
Terpinen-4-ol	1177	0.2–1.4
α-Terpineol	1189	0–1.6
γ-Terpineol	1196	0–0.3
Chrysanthenyl acetate	1265	**0–23.6**
iso-3-Thujyl acetate	1270	0–0.7
Isobornyl acetate	1286	0–0.4
n-Tridecane	1300	0–0.4
δ-Elemene	1338	0–1.5
(7-epi)-Silphiperfol-5-ene	1348	0–0.4
α-Terpinyl acetate	1349	0–0.6
Silphiperfol-4,7(14)diene	1361	0–0.2
α-Copaene	1377	0.3–1.0
β-Bourbonene	1388	0.3–1.4
β-Elemene	1391	1.1–2.3
β-Longipinene	1401	0–0.4
Caryophyllene	1414	**2.5–12.2**
β-Copaene	1432	0.4–1.5
Aromadendrene	1441	0–0.2
Z-β-Farnesene	1443	0–0.8
α-Humulene	1455	0.8–5.5
E-β-Farnesene	1457	0.1–0.9
β-Chamigrene	1478	0–1.0
γ-Muurolene	1480	0–0.3
Germacrene D	1485	**5.3–15.1**

Table. continued

Compound	**RI**	Interval
(E)-β-Ionone	1489	0–0.4
β-Selinene	1490	0–0.7
Bicyclogermacrene	1500	0.9–2.2
n-Pentadecane	1500	0–0.3
β-Bisabolene	1506	0–0.6
δ-Amorphene	1512	0–0.2
γ-Cadinene	1514	t-0.4
δ-Cadinene	1523	0.3–2.4
α-Calacorene	1546	0–0.2
Silphiperfol-5-en-3-ol	1560	t-0.9
E-Nerolidol	1563	0–1.3
Davanone B	1565	0–0.2
Ledol	1569	0–0.1
Germacren-D-4-ol	1576	t-1.9
Spathulenol	1578	1.0–2.5
Caryophyllene oxide	1583	1.7–5.5
Davanone	1588	0–5.2
Salvial-4(14)-en-1-one	1595	0.2–0.9
cis-Artenuic alcohol	1597	0–2.0
Humulene epoxide II	1608	t-1.8
n-Hexadecane	1600	0–0.6
trans-Artenuic alcohol	1613	0–1.9
Caryophylla-4(14), 8(15)-dien-5-α.-ol	1641	t-0.9
epi-α-Muurolol	1642	0.4–1.4
Farnesyl acetate	1822	t-0.4
2-Lanceol acetate	1856	0–0.3
n-Nonadecane	1900	t-0.2
Phytol	1943	0.3–7.9
Total		81.9–96.8
Monoterpene hydrocarbons		6.9–26
Oxygenated monoterpenes		17.1–48.7
Sesquiterpene hydrocarbons		17.1–44.1
Oxygenated sesquiterpenes		8.6–15.6
Diterpenes		0.3–7.9

RI-Retention index on unpolar column CP-Sil 8CB

one oil (10.3%) (Table). trans-Thujone was determined as the first main component in one oil (20.2%) and cis-thujone as the second dominant compound in one oil (12.9%). Chrysanthenyl acetate prevailed in one oil (23.6%). 1,8-Cineole was a predominant constituent in two oils (16.7 and 17.6%). The other prevailing compounds were the following: sabinene, β-pinene, artemisia ketone and caryophyllene (Figure).

A sample from Biržai district contained trans-thujone (20.2%), sabinene (8.4%) and artemisia ketone (7.8%) as the main components. The oil was comprised mostly by compounds of thujane skeleton (33.3%), while compounds of menthane skeleton made 7% and of pinane 3.2%. Oxygenated monoterpenes (44.4%) together with monoterpene hydrocarbons (14.3%) comprised more than half of the oil. As the predominant constituents thujone and sabinene were determined in mugwort essential oils in other countries [4, 9, 13, 14, 16].

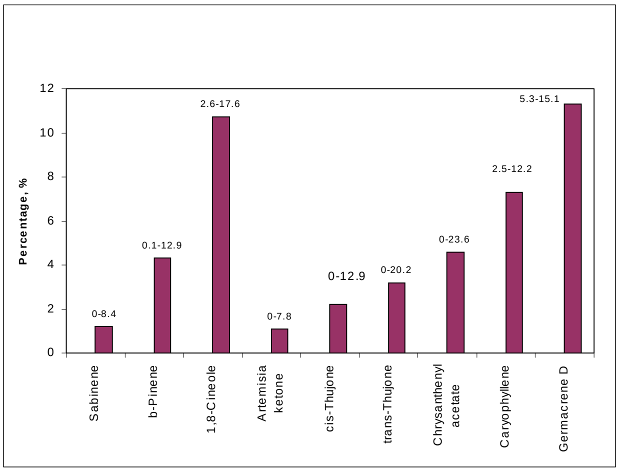

Figure. Variation of main constituents in essential oils of *Artemisia vulgaris* from North Lithuania

The oil of *A. vulgaris* collected in N.Akmenė district included 25.4% compounds of pinane skeleton and 14.6% of menthane. More than half of the oil content was formed by monoterpenoids. The main constituens were the following: chrysanthenyl acetate (23.6%), 1,8-cineole (13%) and germacrene D (10.3%). As the major constituent 1,8-cineole was determined in many countries, such as Italy, France, Germany, Vietnam and India [9, 11, 12, 15, 16], but there are no data on the dominant position of germacrene D and chrysanthenyl acetate in mugwort essential oils.

We investigated two mugwort oils obtained from plants collected in Mažeikiai district. In one oil, 1,8-cineole (16.7%) and germacrene D (13.4%) and β-pinene (12.9%) were the major compounds, while in the other one germacrene D (15.1%), cis-thujone (12.9%) and caryophyllene (11.2%) prevailed. Thujone dominated in mugwort oils from unspecified location, India and Morocco [4, 13, 14, 16], while caryophyllene or its oxide dominated in oils from Vietnam and Cuba [16–18].

Another two essential oils were obtained from *A. vulgaris* collected in the northwestern part of the country (Plungė district.). Germacrene D dominated in both oils (10.6 and 12.5%); the second main constituents were caryophyllene (12.2%) and β-pinene (8.4%) and the third component was 1,8-cineole (8.1 and 11.8%) in both oils. Sesquiterpenoids were the dominant fraction in boths oils.

The oil of mugworts from Šiauliai district contained appreciable amounts of 1,8-cineole (17.6%), germacrene D (12.1%) and caryophyllene (7.1%). Chrysanthenyl acetate was the fourth main component (6.9%), which dominated in plants collected in Biržai district. The content of monoterpenoids (41.5%) and sesquiterpenoids (40.85) was similar in this oil.

Eighty one identified constituents in all seven oils made up 81.9–96.8% of the total content. Oxygenated monoterpenes made up 17.2–48.7%, while sesquiterpenes 17.1–44.1% of the oils. The data showed that the amounts of compounds with different carbon skeletons and the content of major constituents varried significantly.

CONCLUSIONS

The chemical composition of the essential oil of *Artemisia vulgaris* L. growing in North Lithuania was investigated. The data obtained in this study showed a remarkable quantitative variation of constituents in the oils. To the major constituents belonged sabinene, β-pinene, 1,8-cineole, artemisia ketone, cis and trans-thujone, chrysanthenyl acetate, germacrene D and caryophyllene. Most of these constituents dominated in mugwort oils in other countries, however, there are no data in the literature on the prevalence of germacrene D and chrysanthenyl acetate in *A. vulgaris* essential oils.

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Asta Judžentienė, Justė Buzelytė

ŠIAURĖS LIETUVOJE AUGANČIO PAPRASTOJO KIEČIO (*Artemisia vulgaris* L.) ETERINIŲ ALIEJŲ CHEMINĖ SUDĖTIS

Santrauka

Paprastojo kiečio antžeminė dalis surinkta septyniose augavietėse, penkiuose Šiaurės Lietuvos rajonuose (2004–2005 m.). Hidrodistiliacijos būdu gauti eteriniai aliejai buvo analizuojami dujų chromatografijos/masių spektrometrijos metodu. Germakrenas D nustatytas kaip pirmasis vyraujantis junginys trijuose aliejuose (10,6–15,1%), dviejuose - kaip antrasis (12,1 ir 13,4%) ir viename mėginyje - kaip trečiasis komponentas (10,3%). trans-Tujonas buvo pirmasis pagrindinis junginys viename eteriniame aliejuje (20,2%), o cis-tujonas kaip antrasis komponentas kitame mėginyje (12,9%). Chrizantenilo acetatas vyravo taip pat viename aliejuje (23,6%). Didžiausias kiekis 1,8-cineolio nustatytas dviejuose mėginiuose (16,7 ir 17,6%). Kiti pagrindiniai trys komponentai buvo šie: sabinenas, b-pinenas, artemizija ketonas, kariofilenas. Aštuoniasdešimt vienas identifikuotas junginys sudarė 81,9–96,8% aliejaus, kur oksiduotų monoterpenų dalis -17,1–48,7%, o seskviterpenų – 17,1–44,1%. Daugelis pagrindinių komponentų, nustatytų šiame darbe, taip pat yra vyraujantys kitose šalyse tirtuose paprastojo kiečio eteriniuose aliejuose, tačiau literatūroje nerasta duomenų apie chrizantenilo acetato ir germakreno D chemotipo aliejus.