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COMPOSITION OF ESSENTIAL OILS AND CONTENT OF MACRONUTRIENTS IN HERBAGE OF TARRAGON (*ARTEMISIA DRACUNCULUS* L.) GROWN IN SOUTH-EASTERN POLAND

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Abstract

Tarragon is a spice but also used for medicinal purposes. In Poland, tarragon plants are grown on plantations to produce herbage used as raw material. The aim of the study was to evaluate the yield of tarragon grown from seedlings in south-eastern Poland and to assess the content of minerals and essential oils in raw material. The experiment was established using seedlings produced in a greenhouse and planted at 30 x 40 cm spacing. The essential oil content in ground herbs was determined in a Deryng apparatus according to a method defined in Pharmacopoeia. Qualitative and quantitative composition of essential oils was characterized by means of gas chromatography coupled with the mass spectrometry (GC/MS) technique. Ground herb underwent determinations of total nitrogen, ammonia, nitrates, phosphorus, potassium, calcium, magnesium and sulfur. The level of atmospheric precipitation considerably affected the height of tarragon plants and fresh herb yields. Total nitrogen and potassium were dominant elements in tarragon herb (32.0 g kg^{-1} d.m. and 28.8 g kg^{-1} d.m., respectively). The content of essential oils in herb ranged from 0.75 to 0.95%. Presence of 35 compounds, including two unidentifiable ones, was detected in the essential oil. Most of the identified compounds were monoterpenes. The following substances dominated in the essential oil: elemicin (56.0%), sabinene (20.9%), methyleugenol (6.2%), and E-asarone (6.2%). These compounds belong to different chemical classes.

Key words: tarragon, yield, oil, elemicine, sabinene, macroelements.

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SKŁAD OLEJKU ETERYCZNEGO ORAZ ZAWARTOŚĆ MAKROSKŁADNIKÓW W ZIELU BYLICY ESTRAGON (*ARTEMISIA DRACUNCULUS* L.) UPRAWIANEJ W POŁUDNIOWO-WSCHODNIEJ POLSCE

Abstrakt

Bylica estragon jest rośliną przyprawową oraz wykorzystywaną w celach leczniczych. Surowcem jest ziele pozyskiwane w naszym kraju z upraw. Celem badań była ocena plonowania bylicy estragon uprawianej z rozsady w południowo-wschodniej Polsce oraz ocena zawartości składników mineralnych i zawartości olejku w surowcu. Doświadczenie założono z rozsady wyprodukowanej w szklarni, którą posadzono w rozstawie 30 x 40 cm. Zawartość olejku eterycznego w zielu otartym oznaczono w aparacie Derynga wg metody farmakopealnej. Skład jakościowy i ilościowy olejku eterycznego wyznaczono metodą chromatografii gazowej i spektrometrii masowej (GC/MS). W zielu otartym oznaczono zawartość azotu ogółem, azotu amonowego, azotanów, fosforu, potasu, wapnia, magnezu i siarki. Wielkość opadów atmosferycznych miała istotny wpływ na wysokość roślin bylicy estragon oraz plon świeżego ziela. W zielu estragonu stwierdzono największą zawartość azotu ogółem (3.20% d.m.) oraz potasu (2.88% d.m.). Zawartość olejku eterycznego w zielu wahała się od 0.75 do 0.95%. Stwierdzono obecność 35 związków w olejku eterycznym, z których dwa nie zostały zidentyfikowane. Większa liczba związków to monoterpeny. Głównymi związkami olejku estragonowego były: elemicin (56.0%), sabinen (20.9%), methyleugenol (6.2%) i E-asarone (6.2%). Związki te należą do różnych grup chemicznych.

Słowa kluczowe: bylica estragon, plon, olejek, elemicin, sabinen, makroelementy.

INTRODUCTION

Over 800 plant species worldwide belong to *Artemisia* sp. genus (JUDŢENTIENË, BUZELYTË 2006). Tarragon (*Artemisia dracunculus* L.) can be found in natural habitats in central and northern Russia, in Siberia and North America (LAMER-ZARAWSKA et al. 2007, BALCEREK, MODNICKI 2008). Tarragon (*Dracunculi herba*) herbage is raw material. Owing to its aroma and taste, the herb is a popular spice (BALCEREK, MODNICKI 2008). JADCZAK and GRZESZCZUK (2008) recommend tarragon for direct consumption as an abundant source of minerals. Tarragon herbage can be also frozen (GRZESZCZUK, JADCZAK 2008). Medicinal properties of tarragon are well-recognized. Tarragon stimulates bile secretion, intensifies gastric acid production and stimulates digestion. Therefore, tarragon is recommended to patients, particularly children and elderly persons, who suffer from gastritis (LAMER-ZARAWSKA et al. 2007). Tarragon is grown on many continents, including Europe (LAMER-ZARAWSKA et al. 2007, BALCEREK, MODNICKI 2008).

Yields of herbal plants as well as the content of biologically active substances and minerals depend on many factors. The aim of the study was to assess the yielding of tarragon grown from seedlings in south-eastern Poland and to determine the content of minerals and essential oils in raw material. The qualitative and quantitative composition of essential oils from tarragon herbage was also determined.

MATERIALS AND METHODS

The experiments on tarragon were carried out in 2005-2006 at the Experimental Farm of the University of Life Sciences in Lublin (51°14'N 22°34'E). Seeds were purchased from the PNOS, Ożarów Mazowiecki. The seedlings were produced in a greenhouse. Seeds were sown in mid-March into boxes filled with peat substrate. After two weeks, seedlings were transferred into multi-cell pots. At the end of May, they were transplanted onto a field at 30 x 40 cm spacing. The plot area was 2.4 m^2. The experiment was set up in a randomized block design with replicates. During the vegetative season, the plantation was manually weeded twice and soil in the interspaces was loosened. The height of plants was determined before herbage harvest on 20 randomly selected plants. Herbage was cut at the beginning of flowering, i.e. at the end of August. Fresh herbage was weighed after the harvest, while the weight of air-dry and ground herbage was determined after drying under natural conditions. The content of essential oils was determined in dried material according to a method specified in the Pharmacopoeia (Polish Pharmacopoeia VI 2002).

The qualitative and quantitative composition of essential oils was characterized by means of gas chromatography coupled with the mass spectrometry (GC/MS) technique. Analyses were performed applying an ITS-40 device (GC/ITMS system by Finnigan MAT, USA) with a DB-5 column (J&W, USA) of 30 m length, 025 mm diameter, and 0.25 mm stationary phase film thickness. The injector temperature was 280°C, whereas the temperature gradient was 35°C for 2 minutes, afterwards raised by 4°C up to 280°C.

The qualitative analysis was made on the basis of MS spectra by comparing them with the NIST library (62 thousand spectra) and LIBR terpene library (TR) provided by Finnigan MAT. Identities of the recorded compounds were confirmed by retention indices from literature (ADAMS 2001).

Chemical analyses of ground tarragon herbage were performed in 2% acetic acid extracts by means of a versatile method according to NOWOSIELSKI (1988). Mineral nitrogen was determined by Bremner's method with Starck's modifications; total nitrogen was determined by Kjeldahl's method; phosphorus was assessed using ammonium metavanadate; sulfur was tested colorimetrically (Nicolet Evolution 300 spectrophotometer) using $BaCl_2$. Potassium, calcium and magnesium were determined by the AAS technique (Analyst 300 Perkin Elmer) after digesting the herbage at 550°C and dissolving the ash in diluted hydrochloric acid (1:2, v/v).

The results were statistically processed applying variance analysis for single classification at the significance level of α=0.05.

RESULTS AND DISCUSSION

The data presented in Table 1 indicate that thermal conditions in 2005--2006 favored the growth and development of tarragon plants. The mean air temperatures in May, June and August were similar to the average multi-annual ones. In July, the mean air temperature was slightly higher than the multi-year average.

Table 1

Mean air temperature and total precipitation in 2005 and 2006 against the background of multi-annual averages at the Felin Experimental Farm (Lublin)*

Specification	Month	2005				2006				1951-2005
		decade			mean	decade			mean	
		I	II	III		I	II	III		
Temperature (°C)	May	10.8	10.5	18.0	13.1	13.5	14.6	12.8	13.6	13.0
	June	13.4	17.2	17.4	16.0	11.6	17.9	21.1	16.9	16.5
	July	18.9	19.9	20.4	19.7	21.2	20.8	23.5	21.9	17.8
	Aug	16.5	16.4	17.8	16.9	18.4	18.3	15.6	17.3	17.1
Precipitation (mm)	month	decade			Σ	decade			Σ	1951-2005
		I	II	III		I	II	III		
	May	32.8	65.0	0.2	98.0	9.0	18.4	32.1	59.5	57.7
	June	47.1	7.4	1.4	55.9	28.4	0.0	9.5	37.9	65.7
	July	0.0	22.4	87.4	109.8	0.0	6.8	0.0	6.8	83.5
	Aug	103.9	3.2	1.6	108.7	73.0	79.7	45.6	198.3	68.6

*according to the Laboratory of Agro-meteorology at the University of Life Science in Lublin

In 2005, total precipitation from May until July was higher than in 2006 and considerably different from the multi-year average. Lack of rainfalls in mid-June and at the beginning and in mid-July 2006 could have affected the height of tarragon harvested at the end of August. The study revealed that the plants were significantly higher in 2005, when more intensive rainfalls were recorded (Table 2). The mean tarragon height reached 86.69 cm, which was similar to heights reported in literature (MARTYNIAK-PRZYBYSZEWSKA, WOJCIECHOWSKI 2004, MARTYNIAK-PRZYBYSZEWSKA 2005).

Substantially higher yield of raw tarragon herbage was recorded in 2005 (Table 2), owing to higher precipitation from May to July in 2005 than in 2006 (Table 1). The yield of air-dry herbage was also remarkably higher in 2005 (Table 2). However, no significant differences in ground tarragon herbage yield were found.

The share of ground tarragon herbage in air-dry herbage was 29.27%, i.e. stems that are discarded while grinding the material made up over 70% (Table 2). A lower share of ground in air-dry herbage was recorded in 2005 (26.20%) than in 2006 (32.34%).

Table 2

Height of plants, yield and essential oil content in the herbage of *Artemisia dracunculus* L.

Year	Height of plant (cm)	Yield of fresh herbage (kg m^{-2})	Yield of air dry herbage (kg m^{-2})	Yield of herbage without stems (kg m^{-2})	Share of herbage without stems in dry herb (%)	Essential oil (%)
2005	92.79	1.515	0.580	0.152	26.20	0.750
2006	80.60	1.260	0.470	0.152	32.34	0.950
Mean	86.69	1.387	0.525	0.152	29.27	0.850
$LSD_{0.05}$	0.050	0.025	0.029	n.s.	-	0.036

n.s. – non-significant differences

Significant differences in the content of essential oils in tarragon plants between the years were found (Table 2). More oils were determined in ground tarragon herb in 2006 than in 2005 (0.95% and 0.75%, respectively). LOPEZ-LUTZ et al. (2008) determined half of that amount of essential oils, i.e. 0.4%.

Thirty-five compounds, including two unidentifiable ones, were found in tarragon essential oils (Table 3). Substances from the phenylpropanoid class made up 62.2%. Studies by LOPEZ-LUTZ et al. (2008) revealed that the percentage of phenylpropanoid compounds was slightly lower, i.e. 52.2%. Terpenes dominated in oils of other species from *Artemisia* sp. (AKROUT et al. 2003, BARAZANDEH 2003, CHALCHAT et al. 2003, HAIDER et al. 2003, SHAFI et al. 2004, MORTEZA-SEMNANI, AKBARZADEH 2005, VILJOEN et al. 2005, JUDŢENTIENË, BUZELYTË 2006, KAZEMI, AKHAVANI 2009). The following substances prevailed in the tarragon essential oil: elemicine (56.0%), sabinene (20.9%), methyleugenol (6.2%) and E-asarone (6.2%). A similar content of elemicine (53.0%) was found by PINO et al. (1996). According to KOWALSKI et al. (2007), the elemicine concentration was lower (48.78%) and so was that of sabinene (18.88%). ARABHOSSEINI et al. (2006) reported sabinene, elemicine and methyleugonol to be the main components of tarragon essential oils. According to these authors, the sabinene and methyleugenol content was higher than in our experiment, i.e. 39.4% and 14.7%, respectively, although the level of elemicine was lower (16.0%). Methyleugenol also dominated in tarragon essential oils studied by LOPEZ-LUTZ et al. (2008), and its content was 35.8%.

Our analysis of the chemical composition revealed that the mean content of total nitrogen in tarragon herbage was 32.0 g kg^{-1} d.m. (Table 4). The average level of ammonia nitrogen in the same material was 1.41 g kg^{-1} d.m. The tarragon herbage harvested in 2006 contained more total nitrogen but less ammonia. Nitrates were absent in tarragon herbs.

Table 3

Chemical composition, retention indices and percentage composition of the *Artemisia dracunculus* L. essential oil (2005-2006)

Compounds	Retention indice (RI)	(%)
1	2	3
α-Thujene	929	0.3
α-Pinene	936	0.2
Sabinene	975	20.9
β-Pinene	979	0.4
β-Myrcene	991	0.8
α-Terpinene	1017	0.4
p-Cymene	1025	0.2
Limonene	1029	0.2
(Z)-β-Ocimene	1037	0.8
(E)-β-Ocimene	1051	0.5
γ-Terpinene	1062	0.6
cis-Sabinene hydrate	1070	0.3
Terpinolene	1089	0.2
trans-Sabinene hydrate	1098	0.3
allo-Ocimene	1132	0.1
Terpinen-4-ol	1177	1.1
α-Terpineol	1189	0.1
Thymol	1290	0.5
Carvacrol	1299	0.3
Elemene	1338	0.1
Citronellylacetate	1353	0.8
Geranyl acetate	1381	0.4
Methyl eugenol	1404	6.2
β-Caryophyllene	1418	0.2
Germacrene D	1485	0.2
β-Ionone	1489	0.1
Bicyclogermacrene	1500	0.1
δ-Cadinene	1523	0.1
Elemicin	1557	56.0
n.i.	1574	0.1

cont. Table 3

1	2	3
Spathulenol	1578	0.7
Caryophyllene oxide	1583	0.1
n.i.	1617	0.1
T-Muurolol	1651	0.1
E-Asarone	1676	6.2
Total		99.7
Groupe components:		
Monoterpene		35.7
Sesquiterpene		1.6
Phenylopropanoid		62.2
Other		0.2

n.i. – not identified

Table 4

The content of macroelements in the herbage of *Artemisia dracunculus* L. (g kg^{-1} d.m.)

Year	N-total	N-NH_4	N-NO_3	P	K	Ca	Mg	S
2005 2006	28.25 35.80	1.53 1.30	- -	2.65 4.30	29.60 28.05	11.75 11.20	1.30 0.90	2.35 2.00
Mean	32.02	1.41	-	3.47	28.82	11.47	1.10	2.17
$LSD_{0.05}$	0.319	0.013	-	0.077	0.064	n.s.	n.s.	n.s.

n.s. – non-significant differences

The mean concentration of phosphorus in tarragon herbage was 3.47 g kg^{-1} d.m. Significantly more phosphorus was determined in 2006 (4.3 g kg^{-1} d.m.), a year characterized by less precipitation than 2005 (2.65 g kg^{-1} d.m.).

Tarragon herbage accumulated large amounts of potassium. The level of this element was considerably different in particular years of the experiment. More potassium was recorded in 2005 (29.6 g kg^{-1} d.m.) than in 2006 (28.1 g kg^{-1} d.m.).

No substantial differences in calcium, magnesium and sulfur concentrations in tarragon herbage between the particular years were reported. The mean content of calcium was 11.47 g kg^{-1} d.m., while that of magnesium was 1.1 g kg^{-1} d.m. The sulfur concentration in tarragon herbage reached 0.21% d.m. Jadczak and Grzeszczuk (2008) reported high contents of minerals in tarragon grown for direct consumption.

Other authors (Özcan 2004, Özcan, Akbulut 2007) report that concentrations of potassium and calcium in herbal plant species were on similar levels as in the present experiment. The levels of magnesium and phosphorus found in our experiment were lower than those recorded by the above authors.

CONCLUSIONS

1. Atmospheric precipitation had a significant influence on the height of tarragon plants. In 2005, tarragon plants were higher. Also, fresh herbage and air-dry yields were superior owing to more rainfall.

2. Significantly more essential oils, total nitrogen and phosphorus were determined in tarragon herbage in 2006.

3. The phenylpropanoid substances prevailed in the essential oil. Elemicin, sabinene, methyleugenol and E-asarone dominated in tarragon essential oil.

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