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ECONOMIC AND QUALITATIVE VALUE OF THE RAW MATERIAL OF CHOSEN SPECIES OF MEDICINAL PLANTS FROM ORGANIC FARMING PART IV. YIELD AND QUALITY OF HERB AND SEED YIELD OF SWEET MARJORAM (*Origanum majorana* L.)*

Katarzyna Seidler-Łożykowska[1], Romuald Mordalski[1], Wojciech Kucharski[1], Anna Golcz[2], Elżbieta Kozik[2], Joanna Wójcik[1]

[1] Institute of Natural Fibres and Medicinal Plants in Poznań
[2] Poznań University of Life Science

Abstract. In 2005-2007, in the field experiment, the yield and quality of sweet marjoram herb of Polish cultivar 'Miraż' in organic cultivation were tested. The experiment was established on six organic farms and one conventional farm in different localities in Poland. The following features were evaluated: fresh and dried herb yield, stem fraction in herb, seed yield, essential oil content, macro- and microelements content, nitrate content and microbiological purity. Organic marjoram herb yield only from one farm (Słońsk) was higher compared with the yield from conventional cultivation, though this herb contained high amount of stems. There were no seeds collected or the seed yield was very low in both organic and conventional farming. Both marjoram herbs, organic and conventional from Plewiska had similar quality (essential oil, macro- and microelements and nitrate content). Evaluation of microbiological purity showed that herb contamination from both types of cultivation did not exceed standard for raw materials treated with hot water.

Key words: essential oil, herb, marjoram, microbiological purity, organic farming, *Origanum majorana*

INTRODUCTION

Sweet marjoram (*Origanum majorana* L.) is commonly cultivated in European countries. In Poland, this species is well acclimatized and can be grown all over the country. The air-dried herb (*Majoranae herba*) is a raw material. The main active

Corresponding author – Adres do korespondencji: dr hab. Katarzyna Seidler-Łożykowska, Institute of Natural Fibres and Medicinal Plants in Poznań, Wojska Polskiego 71B, 60-630 Poznań, email: klozykowska@iripz.pl

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substances are: essential oil, tannins and flavonoids [Kholmüntzer 1985, Dachler and Pelzmann 1999]. Marjoram herb is widely used as a spice which stimulates digestion, but also is applied against bronchitis, especially for small children.

The introduction of medicinal plants into organic cultivation will help to obtain high quality raw material, as well as an increase in diversity of crop rotation which is very important on the organic farm [Seidler-Łożykowska et al. 2005]. Organic herb of marjoram can also be used as a supplement for animal forage which will protect them against some diseases and enhance their well-being. The main aims of the experiment were testing Polish marjoram cultivar 'Miraż' for organic cultivation, evaluation of its herb yield, quality and a possibility of obtaining organic seeds.

MATERIAL AND METHODS

The experiment was carried out on six certified organic farms located in: Cedry Wielkie (52°14' N; 18°50' E), Jary (51°17' N; 16°52' E), Wiry (50°50' N; 16°38' E), Bolewice (52°23' N; 16°07' E), Plewiska (52°21' N; 16°48' E), Słońsk (52°33' N; 14°48' E).

In 2005-2007 the experiments were established in the randomized complete block design in three replications. Each plot had 10 m^2. Polish cultivar 'Miraż' was examined for its usefulness for organic cultivation. Seeds were sown directly into the soil at a rate of 7 g per plot [Dachler and Pelzmann 1999]. Raw material from the conventional cultivation from Plewiska was used as the control. At full flowering of marjoram, raw material was collected by hand from an area of 1.0 m^2 of each plot. The herbs were dried in natural conditions, in a shaded and well ventilated place. The seed yield was also estimated from 1.0 m^2 of each plot and from the rest of each plot the seeds were collected to obtain organic seeds.

The following traits were estimated: the yield of fresh and air-dried herbs, the fraction of stems in herb, seed yield, essential oil content, macro- and microelements content, N-nitrate content and the microbiological purity.

Chemical, microbiological and statistical analyses were conducted according to the methods given in part III [Seidler-Łożykowska et al. 2009].

RESULTS AND DISCUSSION

The average yield of fresh marjoram herb varied from 0.31 (Cedry) to 1.21 $kg \cdot m^{-2}$ (Słońsk) and the similar average yield of air-dried marjoram herb was from 41.7 (Cedry) to 185.7 $g \cdot m^{-2}$ (Słońsk). Both yields were significantly different (Table 1). Stem fraction in marjoram herbs was also significantly different and oscillated from 22.1 (Plewiska) to 41.4% (Słońsk). The stem fraction in total air-dried herb has a strong effect on the commercial yield of herb because the herb for spice is produced without stems. Following the breeder's characteristic of marjoram cultivar 'Miraż', the stem fraction should not be higher than 30% [Seidler-Łożykowska 2008]. The yield of fresh marjoram organic herb from Plewiska was lower compare to control, while the yield of dried herb was higher, because organic herb contained less stems. The average seed yield was very low and varied from 0 (Cedry, Jary, Wiry) to 3.0 $g \cdot m^{-2}$ (Bolewice).

Essential oil content ranged from 1.6 (Cedry) to 2.4% (Wiry) and was significantly different in the most of localities (Table 1). There was no differences between essential oil content in organic herb from Plewiska and control. The essential oil content was high in all the years and these results exceeded that given by Dachler and Peltzman [1999], i.e. 1.3%, although in the breeding aims they claim that essential oil content should be higher than 2.0%. According to the breeder's characteristic of cultivar 'Miraż', the content of essential oil is 1.6% [Seidler-Łożykowska 2008].

Table 1. Marjoram herb yield, essential oil and stem fraction
Tabela 1. Plon ziela majeranku, zawartość olejku eterycznego i udział łodyg

Locality Miejscowość	Fresh herb yield Plon świeżego surowca $kg \cdot m^{-2}$	Dried herb yield Plon suchego surowca $g \cdot m^{-2}$	Stem fraction Udział łodyg %	Essential oil content Zawartość olejku eterycznego %
Bolewice	0.40 a	69.7 a	26.3 bc	2.2 bc
Cedry Wielkie	0.31 a	41.7 a	35.3 d	1.6 a
Jary	0.44 a	96.6 a	29.7 c	2.2 bc
Słońsk	1.21 b	185.7 b	41.4 e	2.1 b
Wiry	0.44 a	54.6 a	37.0 bc	2.4 c
Plewiska	0.39 a	82.5 a	22.1 a	2.0 b
Control – Kontrola	0.47 a	79.8 a	24.6 ab	2.0 b

a, b, c, d – values marked with the same letters do not differ significantly – wartości oznaczone tymi samymi literami nie różnią się istotnie

The content of N-nitrate in the air-dried marjoram was from 25.0 (Cedry) to 1137.5 $mg \cdot kg^{-1}$ (control) (Table 2). Leszczyńska [1994] obtained higher results while she analyzed nitrate content in medicinal plant raw materials of different origin. In her experiment, the range of nitrate content oscillated from 207.9 (St John's wort herb) to 16 921.0 (nettle herb) mg $KNO_3 \cdot kg^{-1}$ d.m. Both the present and the cited studies [Leszczyńska 1994, Nabrzyski and Gajewska 1996] showed that although spices are used in small amounts in daily diet, the nitrate content should be regarded while allowed daily intake (ADI) is calculated.

Table 2. Marjoram seed yield and nitrate content in herb
Tabela 2. Plon nasion majeranku i zawartość azotanów w zielu

Locality Miejscowość	Seed yield Plon nasion $g \cdot m^{-2}$	Nitrate content in herb Zawartość azotanów $mg \cdot kg^{-1}$
Bolewice	3.0	481.3
Cedry Wielkie	–	25.0
Jary	–	350.0
Słońsk	2.2	505.7
Wiry	–	87.5
Plewiska	2.5	1011.0
Control – Kontrola	0.3	1137.5

The positive correlation was found between fresh and air-dried herb yield, while the negative correlation between stem fraction and fresh and air-dried herb yield. Also, the positive correlation between air-dried herb yield and seed yield was found (Table 3).

Table 3. Correlation coefficient between the traits of marjoram
Tabela 3. Współczynnik korelacji pomiędzy cechami majeranku

Specification Wyszczególnienie	Fresh herb yield Plon świeżego surowca	Air-dried herb yield Plon suchego surowca	Stem fraction Udział łodyg	Essential oil content Zawartość olejku eterycznego	Seed yield Plon nasion
Dried herb yield Suchy surowiec	0.94*	–	–	–	–
Stem fraction Udział łodyg	-0.75*	-0.62*	–	–	–
Essential oil content Zawartość olejku eterycznego	0.12	0.10	-0.07	–	–
Seed yield Plon nasion	0.86	0.88*	-0.73	0.52	–
Weight of 1000 seed Masa 1000 nasion	0.34	0.18	-0.20	-0.31	-0.06

* significant correlation – korelacja istotna

The average content of phosphorus, magnesium and copper in organic herb from Plewiska was on the similar level compared to control, while conventional herb (control) contained more nitrogen, potassium, calcium and iron but less manganese and zinc compare with organic herb from Plewiska (Table 4). Macroelement content, except magnesium, in the marjoram herb of both organic and conventional cultivation was lower compared with that cited by Marsh et al. [1976]. Compared with the results obtained by Marsh et al. [1976], the content of iron was lower in marjoram herb except that originated from Plewiska, both organic and control. Also the content of copper was lower in all the localities, while the contents of zinc and manganese were higher compared with those cited by Marsh et al. [1976]. According to Kabata-Pendias and Pendias [1999], in Polish climatic conditions copper content ranged from 5-20 $mg \cdot kg^{-1}$ [Kabata-Pendias and Pendias 1999]. The levels of copper content in marjoram herbs obtained from both types of cultivation could be placed within the ranges set also by other authors [Marsh et al. 1976, Suchorska et al. 2006].

Table 4. Content of macro- [%] and microelements [$mg \cdot kg^{-1}$] in dried marjoram herb
Tabela 4. Zawartość makro- [%] i mikroelementów [$mg \cdot kg^{-1}$] w suchym zielu majeranku

Locality Miejscowość	N	P	K	Ca	Mg	Na	Fe	Mn	Cu	Zn
Jary	2.87	0.34	2.47	1.58	0.53	0.007	535	134	11.5	111.6
Słońsk	2.48	0.28	1.77	2.32	0.44	0.020	704	56	13.3	56.5
Wiry	2.52	0.24	2.35	2.20	0.29	0.007	495	17	11.3	340.6
Plewiska	2.43	0.25	1.95	2.12	0.38	0.011	818	248	15.4	55.3
Control – Kontrola	2.57	0.26	2.08	2.41	0.37	0.011	891	120	15.2	36.5

The analysis of the microbiological purity of the raw material after 6 and 12 months of storage showed a great diversification of microbiological contamination of marjoram, depending on herb origin (Table 5). The most contaminated herb was from Bolewice and Jary while the least one from Wiry. Although marjoram herb from Słońsk contained also a high amount of aerobic bacteria, all of the investigated herbs were below the level of standard contamination for raw material treated with hot water [Polish Pharmacopoeia 2002]. Soil and organic fertilization are the main sources of microbiological contamination of raw material [Kędzia 1999]. After 12 months of storage the microbiological contamination of storage herb was diminished at different rates. According to Kędzia [1999], there are two main reasons for this process: 1) bacteria have different susceptibility for dryness and 2) plant active substances (esp. essential oil, anthocyanins and tannins) have a strong effect on raw material microbes [Kędzia 1999]. Contamination of raw material produced organically should be controlled, especially for *Escherichia coli* content, following the fact that organic manure is a basic type of fertilization.

Gross value of the obtained marjoram yield per 1 hectare depended on yield obtained in the analyzed localities (Table 6). Purchasing-price per 1 kg of conventional dried marjoram herb was used. The highest value of marjoram herb was obtained in Słońsk and the lowest in Cedry. The highest value was correlated with the high yield of herb.

Table 5. Microbiological purity of marjoram herb after 6 and 12 months of storage
Tabela 5. Czystość mikrobiologiczna ziela majeranku po 6 i 12 miesiącach przechowywania

Locality Miejscowość	Aerobic bacteria Bakterie tlenowe in – w 1 g		Yeasts and moulds Drożdże i pleśnie in – w 1 g		Enterobacteriaceae Enterobakterie in – w 1 g		*Escherichia coli* in – w 1 g	
	6 m.	12 m.	6 m.	12 m.	6 m.	12 m.	6 m.	12 m.
Plewiska	97 600	30 250	53	10	65 500	5 150	<10	<10
Bolewice	355 000	150 000	1 500	280	196 000	25 000	80	<10
Słońsk	292 700	46 000	373	30	57 000	18 750	<10	<10
Wiry	15 650	1 100	52	10	1 100	130	<10	<10
Jary	331 500	107 000	35	30	22 400	10 000	<10	<10
Control – Kontrola	139 600	8 250	47	15	10 900	285	<10	<10
Standard	10.000.000		100.000		–		100	

Table 6. Gross values of marjoram herb yield per 1 ha
Tabela 6. Wartości brutto plonu ziela majeranku z 1 hektara

Locality – Miejscowość	Minimum	Maximum – Maksimum
Bolewice	3 485.17	4 879.23
Słońsk	9 287.44	13 002.42
Jary	6 491.50	9 088.10
Wiry	2 729.00	3 820.60
Cedry	2 087.00	2 921.80
Plewiska	5 175.75	7 246.05
Control – Kontrola	3 962.00	5 546.80
Price per 1 kg of herb Cena 1 kg ziela	5.00	7.00

CONCLUSIONS

1. Marjoram herb yield from one location (Słońsk) was the highest compared with the yield from other organic and conventional cultivation, but contained the highest amount of stems.
2. The quality of marjoram herb from organic farming (essential oil content, the content of some macro- and microelements, microbiological purity) was similar to that from conventional cultivation.
3. Marjoram cultivar 'Miraż' is suitable for both organic and conventional cultivation, but its seed production should be improved.

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GOSPODARCZA I JAKOŚCIOWA WARTOŚĆ SUROWCA WYBRANYCH GATUNKÓW ROŚLIN LECZNICZYCH Z UPRAW EKOLOGICZNYCH CZ. IV. PLON, JAKOŚĆ ZIELA ORAZ PLONY NASION MAJERANKU (*Origanum majorana* L.)

Streszczenie. W latach 2005-2007 w doświadczeniu polowym zlokalizowanym w sześciu miejscowościach badano plonowanie, jakość surowca majeranku ogrodowego oraz

przydatność polskiej odmiany ‘Miraż’ do upraw ekologicznych. Oceniano następujące cechy surowca: plon świeżego i powietrznie suchego surowca, udział łodyg w surowcu, plon nasion, zawartość olejku eterycznego, makro- i mikroskładników oraz azotanów, a także czystość mikrobiologiczną. Plon surowca majeranku pochodzącego z uprawy ekologicznej ze Słońska był większy niż z uprawy konwencjonalnej. Surowiec ten charakteryzował jednak się dużym udziałem łodyg. Uzyskano mały plon nasion majeranku zarówno w uprawie ekologicznej, jak i kontroli. Surowce majeranku pochodzącego z uprawy ekologicznej w Plewiskach oraz kontroli charakteryzowały się podobnymi parametrami jakościowymi (zawartością olejku, makro- i mikroelemantów, azotanów). Ocena czystości mikrobiologicznej wykazała, że stopień zanieczyszczenia surowca majeranku zarówno z uprawy ekologicznej, jak i konwencjonalnej nie przekraczał dopuszczalnych norm dla surowców poddawanych działaniu gorącej wody.

Słowa kluczowe: czystość mikrobiologiczna, majeranek, olejek eteryczny, *Origanum majorana*, uprawa ekologiczna, ziele

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