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ECONOMIC AND QUALITATIVE VALUE OF THE RAW MATERIAL OF CHOSEN SPECIES OF MEDICINAL PLANTS FROM ORGANIC FARMING PART III. YIELD AND QUALITY OF HERB AND SEED YIELD OF SUMMER SAVORY (*Satureja hortensis* L.)*

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Abstract. In 2005-2007, in the field experiment, the yield and quality of summer savory herb of Polish cultivar Saturn in organic farming 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, weight of 1000 seeds, essential oil content, macro- and microelement content, nitrate content and microbiological purity. Only from Słońsk savory herb yield was higher compared with the yield from conventional cultivation though it contained high amount of stems. Organic savory herb was characterized by high content of essential oil and increased content of macro- and microelements. 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, microbiological purity, organic farming, *Satureja hortensis*, savory

INTRODUCTION

Summer savory *(Satureja hortensis* L.) is commonly cultivated in European countries. In Poland, this species is well acclimatized and can be grown in the area of all country. Air-dried herb *(Satureae herba)* is a raw material. The main active substances are: essential oil, tannins and minerals salts [Kholmüntzer 1985, Dachler and Pelzmann 1999]. Savory herb is widely used as a spice which stimulates digestion, neutralizes

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excessive fermentation and acts antibacterial. Savory is also recognized as a natural antioxidant [Balcerek and Modnicki 2007]. From 1994 savory cultivar Saturn has been cultivated in Poland [Czabajska et al. 1994].

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 savory 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 savory cultivar Saturn 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 'Saturn' was examined for its usefulness for organic cultivation. Seeds were sown directly into the soil at a rate of 10 g per plot [Dachler and Pelzmann 1999]. Raw material from the conventional cultivation from Plewiska was used as the control. At the beginning of savory flowering period, 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, the weight of 1000 seeds, essential oil content, macro- and microelement content, N-nitrate content and the microbiological purity.

The essential oil was hydrodistillated from the air-dried herb without stems, with Dering's apparatus following the methods recommended by Polish Pharmacopoeia VI [2002].

For evaluation of macro- and microelement content the plant material was subjected to "wet" mineralization:

- in a mixture of sulphosalicylic acid, sodium thiosulphate and selenium to determine total nitrogen,
- in concentrated sulphuric acid to determine P, K, Ca, Mg and Na,
- in mixture of HNO_3 and $HClO_4$ acids in 3:1 proportion to determine Fe, Mn, Cu and Zn.

After plant material mineralization the following elements were determined:

- N by the distillation method according to Kjeldahl on Parnas-Wagner apparatus,
- P by the colorimetric method with molybdate ammonium according to Schillak,
- K, Ca, Na by the photometric method,
- Mg, Fe, Zn, Cu, Mn by the atomic absorption spectrophotometric method (AAS- 3) [Nowosielski 1988, Kabata-Pendias and Pendias 1999].

N-nitrate content in the air-dried herb was determined by the Bremner distillation method in modification done by Starck after extraction in 2% acetic acid [Nowosielski 1988].

The evaluation of raw material microbiological purity was carried out in the Microbiology Laboratory following Polish Pharmacopoeia VI [2002] standards for raw materials treated with hot water (group III e). Numbers of aerobic bacteria, yeasts and moulds and *Escherichia coli* were estimated in the air-dried herb. Additionally, the number of intestinal bacteria from the family *Enterobacteriaceae* was evaluated. Investigations were made after 6 and 12 months of herb storage in darkness and at room temperature.

The obtained data were calculated by the method of analysis of variance using F-Fisher's test for two-way classification for years and localities without interaction between years and localities. The mean values were compared by the use of Students' t-test with a confidence level of 5%. Homogenous groups were constructed on the base of the LSD test.

RESULTS AND DISCUSSION

The average yield of fresh savory herb varied from 0.34 (Cedry) to 3.56 kg·m^{-2} (Słońsk) and the similar average yield of air-dried savory herb was from 51.0 (Cedry) to 302.5 g·m^{-2} (Słońsk); and both yields were significantly different (Table 1). The yield of fresh and dried herbs were also significantly different in all the tested years and most localities. Stem fraction in savory herbs was also significantly different and oscillated from 29.0 (Cedry) to 50.7% (Słońsk). The stem fraction in total air-dried herb has a strong effect on the commercial yield of herb, because herb for spice is produced without stems. Following the breeder's characteristic of savory cultivar 'Saturn', stem fraction should not be higher than 40% [Seidler-Łożykowska 2008]. The yield of savory organic herb from Plewiska was higher than that from conventional cultivation because the content of stems was smaller.

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

Locality Miejscowość	Fresh herb yield Plon świeżego surowca kg·m^{-2}	Dried herb yield Plon suchego surowca g·m^{-2}	Stem fraction Udział łodyg %	Essential oil content Zawartość olejku eterycznego %
Bolewice	1.35 b	96.7 ab	32.3 bc	5.2 ab
Cedry Wielkie	0.34 a	51.0 a	29.0 a	5.9 b
Jary	1.51 b	147.6 bc	34.4 c	5.0 ab
Słońsk	3.56 c	302.5 d	50.7 d	4.7 ab
Wiry	0.48 a	117.9 b	31.9 bc	5.5 b
Plewiska	1.14 b	175.8 c	29.6 a	5.0 ab
Control – Kontrola	1.57 b	173.7 c	30.9 b	4.3 a

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

The average seed yield was from 0 (Bolewice) to 48.1 g·m^{-2} (Wiry) and the biggest weight of 1000 seeds were obtained in Jary (0.52 g), while the smallest one in Słońsk

(0.39 g) (Table 2). Both traits were significantly different in three years of experiment, while the weight of 1000 seeds was also different in all localities. The seed yield from organic cultivation in Plewiska was lower in comparison to control, while weight of 1000 seeds was higher.

Table 2. Savory seed yield, weight of 1000 seeds, nitrate content in herb
Tabela 2. Plon nasion cząbru, masa 1000 nasion, zawartość azotanów w zielu

Locality Miejscowość	Seed yield Plon nasion $g \cdot m^{-2}$	Weight of 1000 seeds Masa 1000 nasion g	Nitrate content in herb Zawartość azotanów $mg \cdot kg^{-1}$
Bolewice	–	–	2537.5
Cedry Wielkie	26.5 a	0.46 b	1225.0
Jary	28.9 a	0.52 d	1225.0
Słońsk	39.0 ab	0.39 a	1618.8
Wiry	48.1 b	0.46 b	92.2
Plewiska	32.1 ab	0.50 cd	291.8
Control – Kontrola	47.7 ab	0.45 b	729.5

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

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

Table 3. Correlation coefficient between the traits of savory
Tabela 3. Współczynnik korelacji pomiędzy cechami cząbru

Specification Wyszczególnienie	Fresh herb yield Plon świeżego surowca	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	0.93*	–	–	–	–
Stem fraction Udział łodyg	-0.90*	-0.75*	–	–	–
Essential oil content Zawartość olejku eterycznego	0.36	-0.49*	0.13	–	–
Seed yield Plon nasion	0.13	0.10	-0.23	0.30	–
Weight of 1000 seed Masa 1000 nasion	-0.33	-0.40	0.39	0.48	-0.28

* significant correlation – korelacja istotna

Essential oil content ranged from 4.3 (control) to 5.9% (Cedry) (Table 1). The essential oil in herb from organic cultivation in Plewiska was higher than in control. The essential oil content was high in all the years and these results exceeded that given by Dachler and Peltzman [1999]: 1.0-1.5%. According to the breeder's characteristic of cultivar 'Saturn', the content of essential oil is 4.0%.

The content of N-nitrate in the air-dried savory was from 92.2 (Wiry) to 2537.5 mg·kg^{-1} (Bolewice) and varied according to its origin (Table 2). Similar results were obtained by Leszczyńska [1994], who 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·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 the daily diet, the nitrate content should be regarded while allowed daily intake (ADI) is calculated.

In organic herb from Plewiska the average content of nitrogen, phosphorus, potassium was similar to conventional one, while the content of magnesium, manganese, copper and zinc was higher (Table 4). The content of calcium and iron was higher in savory herb originated from conventional cultivation in Plewiska. Macroelement content in savory herb from both organic and conventional cultivation was higher, except calcium content, compared with that cited by Marsh et al. [1976]. Compared with the results obtained by Marsh et al. [1976], in organic herb the content of iron was higher, except the herb grown in Jary, and the content of zinc was also higher, except the herb originated from the control and Wiry. According to Kabata-Pendias and Pendias [1999], in Polish climatic conditions copper content ranged from 5-20 mg·kg^{-1} [Kabata-Pendias and Pendias 1999]. The levels of copper content in savory 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·kg^{-1}] in dried savory herb
Tabela 4. Zawartość makro- [%] i mikroelementów [mg·kg^{-1}] w suchym zielu cząbru

Locality Miejscowość	N	P	K	Ca	Mg	Na	Fe	Mn	Cu	Zn
Jary	2.70	0.45	3.28	1.26	0.65	0.008	330	131	14.0	130.1
Słońsk	3.02	0.39	2.38	2.35	0.56	0.012	634	45	12.4	51.7
Wiry	2.52	0.40	2.20	1.92	0.47	0.008	619	28	13.4	40.6
Plewiska	2.74	0.33	2.43	2.29	0.55	0.009	564	164	12.7	59.8
Control – Kontrola	2.81	0.34	2.41	2.72	0.46	0.011	583	75	12.2	35.7

The analysis of microbiological purity of the raw material after 6 and 12 months of storage showed a great diversification of microbiological contamination of savory, depending on herb origin (Table 5). The most contaminated organic herb was from Bolewice and the least from Plewiska. Organic herb from Plewiska was less contaminated compare to control. Although savory from Słońsk and Cedry contained high amount of aerobic bacteria, all of the investigated herbs were below the level of standard contamination [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 of 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 savory yield per 1 hectare depended on yield obtained in analyzed localities (Table 6). Purchasing-price per 1 kg of conventional dried savory herb was used. The highest value of savory herb was obtained in Słońsk and the lowest in Cedry.

Table 5. Microbiological purity of savory herb after 6 and 12 months of storage
Tabela 5. Czystość mikrobiologiczna ziela cząbru po 6 i 12 miesiącach składowania

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	14 400	3 300	13	15	4 150	260	<10	<10
Bolewice	287 500	140 000	360	13	160 000	11 000	<10	<10
Słońsk	284 500	115 250	68	10	119 100	6 450	<10	<10
Cedry	283 000	32 500	70	10	59 000	16 500	<10	<10
Wiry	160 500	9 500	30	20	24 800	1 650		
Jary	221 700	10 150	50	20	27 050	4 950	<10	<10
Control – Kontrola	66 150	37 250	17	10	30 550	16 050	<10	<10
Standard	10.000.000		100.000		–		100	

Table 6. Gross values of savory herb yield per 1 ha, PLN
Tabela 6. Wartości brutto plonu ziela cząbru z 1 ha, zł

Locality – Miejscowość	Minimum	Maximum – Maksimum
Bolewice	3 383.33	4 833.33
Słońsk	10 588.74	15 126.76
Jary	5 164.72	7 378.17
Wiry	4 124.98	5 892.83
Cedry	1 786.17	2 551.67
Plewiska	6 151.76	8 788.22
Control – Kontrola	6 829.32	9 756.17
Price per 1 kg of herb – Cena 1 kg ziela	3.50	5.00

CONCLUSIONS

1. Savory 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 content of essential oil and some macro- and microelements (Mg, Mn, Cu, Zn) in savory herb from organic farming was higher than that from conventional cultivation.
3. The satisfying yield of good quality of savory seeds was obtained in the conditions of organic farming.
4. Savory cultivar Saturn is suitable for both organic and conventional cultivation.

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GOSPODARCZA I JAKOŚCIOWA WARTOŚĆ SUROWCA WYBRANYCH GATUNKÓW ROŚLIN LECZNICZYCH Z UPRAW EKOLOGICZNYCH CZ. III. PLON, JAKOŚĆ ZIELA ORAZ PLONY NASION CZĄBRU (*Satureja hortensis* L.)

Streszczenie. W latach 2005-2007 w doświadczeniu polowym zlokalizowanym w sześciu miejscowościach badano plonowanie, jakość surowca cząbru ogrodowego oraz przydatność polskiej odmiany do upraw ekologicznych. Oceniano następujące cechy surowca: plon świeżego i powietrznie suchego surowca, udział łodyg w surowcu, plon nasion, masę 1000 nasion, zawartość olejku eterycznego, makro- i mikroskładników oraz azotanów, a także czystość mikrobiologiczną. Plon surowca cząbru pochodzącego z uprawy ekologicznej tylko z jednej lokalizacji (Słońsk) był większy niż z uprawy konwencjonalnej. Surowiec ten jednak charakteryzował się dużym udziałem łodyg. Surowiec cząbru pochodzącego z upraw ekologicznych charakteryzował się wysoką zawartością olejku eterycznego oraz zwiększoną zawartością makro- i mikroskładników. Ocena czystości mikrobiologicznej wykazała, że stopień zanieczyszczenia surowca

cząbru zarówno z uprawy ekologicznej, jak i konwencjonalnej nie przekraczał dopuszczalnych norm dla surowców poddawanych działaniu gorącej wody.

Słowa kluczowe: cząber, czystość mikrobiologiczna, olejek eteryczny, *Satureja hortensis*, uprawa ekologiczna, ziele

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