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EFFECT OF WEATHER AND AGROTECHNICAL CONDITIONS ON THE CONTENT OF NUTRIENTS IN THE FRUITS OF MILK THISTLE (*Silybum marianum* L. Gaertn.)

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Abstract. Milk thistle (*Silybum marianum* L. Gaertn.) is recognized as a medicinal plant used for liver treatment. The aim of the present research was to determine the scope of variation in the content of nutrients in the fruits of milk thistle as a potential additive to animal feeds. The material was made up by whole achenes of thistle collected from the field experiment (2004–2006) carried out in Mochełek (53°13' N; 17°51' E). Two dates of sowing, three varied harvest methods and two sowing rates were applied. Weather conditions demonstrated a greater effect on the changes in the chemical composition than agrotechnical conditions. Changes in the content of total protein were least considerable, and those in the content of crude fibre and macroelements, especially calcium and magnesium – most considerable. The fruits contained, on average, 21.6% of fat in which linoleic acid accounted for 51.6% and total protein 16.1%, where glutamic acid was the dominant amino acid. The content of macroelements in $g \cdot kg^{-1}$ of d.m. was as follows: phosphorus – 6.1, potassium – 4.95, calcium – 7.6, magnesium – 2.6. A high content of iron was found – 82.3 $mg \cdot kg^{-1}$ of d.m. The fruits contained, on average ($g \cdot kg^{-1}$ of d.m.): 266.0 of crude fibre, 418.0 of NDF, 344.0 of ADF and 114.0 of ADL. Because of high content of cellulose-lignin fraction the whole fruits of milk thistle can be used only for ruminants.

Key words: cellulose-lignin fraction, linoleic acid, glutamic acid, macroelements, microelements, milk thistle achenes

INTRODUCTION

Due to the current EU ban on the use of antibiotics and stimulants in animal feeds, medicinal plants have been attracting interest of animal nutrition experts. Milk thistle

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(*Silybum marianum* L. Gaertn.) is such a plant [Cybulski and Radko 2006]. The pericarp of achenes accumulates silymarin, namely a complex of flavonolignans demonstrating liver-protective properties. At present animal feed production makes use of reserve material accumulated in cotyledons and the embryo of achenes in the plant. It is a by-product of silymarin production. The first stage of the production is just separating the pericarp from cotyledons and the embryo. Such material, according to Potkański et al. [1991], contains 21.5% of total protein, 15.25% of crude fat, 16.4% of crude fibre, 34.3% of nitrogen-free extracts and 6.0% of crude ash. That animal feed is considered to be a protein component for protein mixtures recommended for young cattle [Potkański et al. 1991]. According to other authors [Baranowska et al. 2003], the product contains 31–36% of protein, 30–35% of fat, 8–9% of derivatives of fat and flavonoids as well as about 5% of mineral salts.

Due to liver-protective properties of flavonolignans, there have been made continuous attempts at their use in animal nutrition, especially in high-performance animals whose liver, because of intensive feeding, is overburdened and threatened with damage. In the animal nutrition experiments there were applied mixtures of herbs with whole milk thistle fruits, silymarin concentrate as well as green matter in a form of silage [Piłat et al. 1999a, 1999b, Grabowicz et al. 2001, Urbańczyk et al. 2002, Wójcik et al. 2002, Korczak and Grabowicz 2003, Tedesco et al. 2004].

The fruits of thistle grown in Poland, most frequently, contain from 2.2 to 3.0% of silymarin [Załęcki and Górna 1984, Andrzejewska and Skinder 2006, Andrzejewska and Sadowska 2007]. If thus thistle achenes are to be the source of silymarin for animals, then supplying an adequate dose of the active substance can require administering a relatively high amount of fruit. The pericarp of milk thistle achenes is woody and the content of crude fibre is about 25 g in 100 g of dry matter [Abu Jadayil et al. 1999]. The fruits contain fat rich in linoleic acid [Baranyk et al. 1975, Kaczmarek and Mrugasiewicz 1975, Szczucińska et al. 2003, Andrzejewska and Sadowska 2007] enriched with tocopherol [Hadolin et al. 2001]. Thistle protein contains some exogenous amino acids important in non-ruminant animal nutrition, e.g. arginine, histidine and tyrosine [Potkański et al. 1991, Andrzejewska and Sadowska 2007]. Thus feeding the animals with whole thistle fruits can have a considerable effect on the ration composition, and thus the functioning of the alimentary canal. With that in mind, it is justifiable to determine the range of variation in nutrients in whole milk thistle fruits. An earlier paper gives the range, however, the present research covered the achene reserve material [Andrzejewska and Sadowska 2007].

The aim of the present paper was to determine the range of changes in the content of nutrients in whole fruits of milk thistle as a potential animal feed additive, depending on the research years, the sowing date as well as the harvest date and method as well as on the sowing rate.

METHODS

The material for analyses was provided by the research performed over 2004–2006 at the Experiment Station of the Faculty of Agriculture at Mochełek (53°13'N;

17°51'E), the University of Technology and Life Sciences in Bydgoszcz. The experiment was set up on Luvisol, formed from heavy loamy sand, representing the agronomic category of light soil, mostly with the high or medium contents of macroelements (tab. 1). The milk thistle was grown after cereals in the third or fourth year after manure. The following fertiliser doses were applied pre-sowing: N – 50 $kg \cdot ha^{-1}$, P – 30.5 $kg \cdot ha^{-1}$ and K – 58 $kg \cdot ha^{-1}$. 'Silma', a Polish milk thistle cultivar, was sown.

Table 1. Forecrop, acidity and content of macroelements in the soil before milk thistle sowing
Tabela 1. Przedplon, odczyn i zawartość makroelementów w glebie przed siewem ostropestu

Year Rok	Forecrop Przedplon	pH [KCl]	Content of macroelements Zawartość makroelementów $mg \cdot 100 g^{-1}$ gleby		
			phosphorus fosfor	potassium potas	magnesium magnez
2004	maize kukurydza	5.6	8.0 h*	8.5 m	2.8 l
2005	barley jęczmień	6.5	10.3 vh	8.7 m	5.3 h
2006	maize kukurydza	6.3	8.1 h	8.9 m	6.9 h

vh – very high – bardzo wysoka, h – high – wysoka, m – medium – średnia, l – law – niska

Experimental factors:
1. Sowing date:
– possibly the earliest one (31.03. – 08.04.),
– about 14 days later (13.04. – 18.04.).
2. Harvest methods and dates:
– two-stage harvest; at the stage when 30% of the flower heads included pappus,
– single-stage harvest; at the stage when 30% of the flower heads included pappus,
– delayed single-stage harvest, at the stage when 50% of the flower heads included pappus, namely 4 days after the earlier single-stage harvest.
3. Sowing rate:
– 12 $kg \cdot ha^{-1}$,
– 24 $kg \cdot ha^{-1}$.

After harvest the achenes were finally cleaned and well-dried to the moisture of 8%. The results of all the chemical analyses concern whole fruits and they are given as converted into air dry matter.

The fat (oil) content was determined with the Soxhlet method, compliant with PN-ISO 6492:2005. The analysis of the composition of fatty acids was made with the gas chromatography method compliant with PN-EN ISO 5509:2001 and PN-EN ISO 5508:1996.

Total protein was defined with the Kjeldahl standard method, applying the nitrogen conversion rate: 6.25. The amino acid composition of protein was determined with the high-pressure chromatography method. Seven out of eight essential amino acids were determined (without tryptophan).

The contents of phosphorus and magnesium were determined with the colorimetric vanadium-molybdenum method, and potassium and calcium – with the flame photometry method. The contents of Mn, Cu, Zn, Fe were assayed applying the atomic absorption spectrometry method – PB 21, edition 3/10.11.2004; in the collective samples obtained from the entire experiment in 2004 and in 2005.

The content of crude fibre and fractions NDF, ADF and AD was determined in 2005 and in 2006 in collective samples derived from the entire experiment. The analysis of the content of crude fibre was made with the Hannenberg-Stohmann method, compliant with PN-EN ISO 6865:2002. The analysis of the content of fractions NDF, ADF and AD were performed with ANKOM Technology Corp. (Fairport, NY) procedure.

The content of crude fat and total protein were defined in each year in the samples from each experimental replications. The contents of macroelements, microelements, crude fibre and fibre fraction were determined in the collective samples from the entire year. The analysis of the contents of fatty acids and amino acids was performed in collective samples representing those experimental factors which showed a significant effect on the content of fat (the sowing date) and protein (the sowing date).

The results of the determinations of the content of fat, protein and macroelements were verified with the analysis of variance. The evaluation of the significance of differences in treatment means involved the use of the Tukey test, at p = 0.05. ANWAR statistics software, developed by Rudnicki, the University of Technology and Life Sciences in Bydgoszcz, was also applied. For basic components, namely the contents of fat and protein, the coefficients of variation and for fatty acids – standard deviation are given.

Table 2. Mean daily air temperature (T) and total precipitation (P) over the milk thistle vegetation period at the Experimental Station at Mochełek against the long-term period
Tabela 2. Średnia dobowa temperatura powietrza (T) i suma opadów atmosferycznych (P) w okresie wegetacji ostropestu plamistego w Stacji Badawczej Mochełek na tle okresu wieloletniego

Month Miesiąc	2004		2005		2006		Long-term Okres wieloletni	
	T, ºC	P, mm	T, ºC	P, mm	T, ºC	P, mm	T, ºC	P, mm
April – Kwiecień	7.5	32.1	0.4	34.8	7.1	77.0	7.9	28.3
May – Maj	11.3	54.4	12.2	82.6	12.5	59.9	13.1	61.8
June – Czerwiec	14.7	39.6	14.9	30.5	16.8	21.8	15.9	46.1
July – Lipiec	16.4	53.5	19.4	33.6	22.4	24.2	17.9	85.8
Mean – Średnia, ºC Total – Suma, mm	12.5	179.6	13.5	181.5	14.7	182.9	13.7	222.0

Weather conditions. The weather pattern in 2004 and in 2005 was favourable to milk thistle growth and development. In 2006 first abundant precipitation at the beginning of April resulted in a delay in the sowing date and then high temperatures and rainfall deficit in June and July drastically shortened the plant vegetation period. The precipitation distribution across months varied across the research years, yet on average over the milk thistle vegetation period precipitation was about 40 mm lower, as compared with precipitation over the last 50 years (tab. 2). The number of days of milk thistle vegetation period was, in successive years, 2004 – 120 and 114, 2005 – 116 and 105, 2006 – 105 and 100 days, respectively for sowing made at the first and the second dates.

RESULTS

The content of fat in milk thistle fruits was more considerably determined by weather conditions in research years than by the experimental factors (tab. 1, 2, 3). The difference in the content of fat between extreme years was 45 $g \cdot kg^{-1}$. In the year 2006, which demonstrated the highest mean temperatures throughout the fruit ripening, achenes contained most fat. The fruits accumulated the lowest amount of fat in 2004; it was the coldest year, however the plant growing period was the longest. Of all the agrotechnical factors studied, the sowing rate was the only one which affected the change in the content of oil in achenes. On average for three-year research period it was demonstrated that increasing the sowing rate and thus increasing the density of plants resulted in a slight, although, significant decrease in the content of oil in milk thistle achenes. In 2006 the plants sown after mid April contained more oil in achenes than the plants sown earlier.

Table 3. Content of crude fat in the dry matter of milk thistle fruits
Tabela 3. Zawartość tłuszczu surowego w owocach ostropestu plamistego

Factor Czynnik	Factor level Poziom czynnika	2004		2005		2006		Mean – Średnia 2004–2006	
		$g \cdot kg^{-1}$	$LSD_{0.05}$ $NIR_{0.05}$	$g \cdot kg^{-1}$	$LSD_{0.05}$ $NIR_{0.05}$	$g \cdot kg^{-1}$	$LSD_{0.05}$ $NIR_{0.05}$	$g \cdot kg^{-1}$	$LSD_{0.05}$ $NIR_{0.05}$
Sowing date Termin siewu	31.03 – 08.04	196	n.s.	214	n.s.	228	1.10	213	n.s.
	13.04 – 18.04	189		227		246		219	
Harvest date and method Termin i sposób zbioru	H1*	186	n.s.	207	n.s.	233	n.s.	209	n.s.
	H2*	199		223		235		219	
	H3*	192		232		243		220	
Sowing rate Ilość wysiewu	12 $kg \cdot ha^{-1}$	196	n.s.	222	n.s.	235	n.s.	218	25
	24 $kg \cdot ha^{-1}$	189		219		239		214	
Means for years Średnie dla lat		192		221		237		216	
Coefficient of variation, % Współczynnik zmienności								11	

n.s. – non-significant difference, różnica nieistotna
* H1 – two-stage harvest, H2 – single-stage harvest, H3 – delayed single-stage harvest
H1 – zbiór dwuetapowy, H2 – zbiór jednoetapowy, H3 – zbiór jednoetapowy opóźniony

The composition of fatty acids of oil obtained from milk thistle was dominated by unsaturated acids and their average content was 79.0% (tab. 3). The highest share of oil was accounted for by polyunsaturated acids (52.1%), dominated by linoleic acid. The average content of monounsaturated acids was 26.9%, dominated by oleic acid. Over 2004 and 2005 linoleic acid accounted for over 50.0% of the fatty acids composition. In 2006 the share of linoleic acid decreased to 45.4%, accompanied by an increase in the share of oleic acid. Saturated acids accounted for an average of 21.0% of the fatty acids composition, dominated by palmitic acid.

The synthesis of fat and its composition were affected by the weather pattern at the final period of plant vegetation (tab. 2, 3, 4). The higher the air temperatures in the years researched, the higher the content of fat in achenes and the lower the content of linoleic acid accompanied by an increase in oleic acid. High air temperatures over milk thistle ripening resulted in a decrease in the amount of linoleic acid, accompanied by an increase in oleic acid.

Table 4. Composition of fatty acids of milk thistle oil depending on the research years, %
Tabela 4. Skład kwasów tłuszczowych oleju z ostropestu plamistego w zależności od lat badań, %

Fatty acid – Kwas tłuszczowy		2004	2005	2006	2004–2006 (±SD)
Saturated fatty acids (SFA) Nasycone kwasy tłuszczowe	myristic (C 14:0) mirystynowy	0.1	0.1	0.1	0.1±0.01
	palmitic (C 16:0) palmitynowy	8.5	8.7	9.3	8.83±0.39
	margaric (C 17:0) margarynowy	0.1	0.1	0.1	0.09±0.01
	stearic (C 18:0) stearynowy	5.2	5.4	5.8	5.45±0.51
	arachidic (C 20:0) arachidowy	3.5	3.6	3.8	3.67±0.32
	behenic (C 22:0) behenowy	2.8	3.0	2.8	2.86±0.19
	∑ SFA	20.2	20.9	22.0	21.0±1.12
	∑ SFA/∑ PUFA	0.4	0.4	0.5	0.4
Monounsaturated fatty acids (MUFA) Jednonienasycone kwasy tłuszczowe	palmitoleic (C 16:1) palmitoleinowy	0.1	0	0.1	0.1±0.03
	oleic(C 18:1) oleinowy	23.1	22.6	31.6	25.7±4.78
	gadoleic (C 20:1) gadoleinowy	1.0	1.0	1.0	1.0±0.04
	∑ MUFA	24.2	23.6	32.8	26.9±4.82
Polyunsaturated fatty acids (PUFA) Wielonienasycone kwasy tłuszczowe	linoleic (C 18:2) linolowy	55.0	54.5	45.2	51.6±5.39
	linolenic (C 18:3) linolenowy	0.3	0.3	0.2	0.27±0.04
	∑ PUFA	55.3	54.7	45.4	52.1±5.61

±SD – standard deviation, odchylenie standardowe

The average content of total protein in the three-year period was 161 g in 100 g of d.m. of fruits (tab. 5). The content of protein was an extremely stable feature (coefficient of variation 1%), however, despite that, it was demonstrated that the delay in the sowing date was connected with a greater accumulation of that nutrient in achenes. The amino acid composition of milk thistle protein was dominated by glutamic acid and then aspartic acid and arginine (tab. 6). Of all the amino acids determined, methionine was found at the smallest amount.

Table 5. Content of total protein in the dry matter of milk thistle fruits
Tabela 5. Zawartość białka ogółem w owocach ostropestu plamistego

Factor Czynnik	Factor level Poziom czynnika	2004		2005		2006		Mean 2004–2006	
		$g \cdot kg^{-1}$	LSD	$g \cdot kg^{-1}$	LSD	$g \cdot kg^{-1}$	LSD	$g \cdot kg^{-1}$	LSD
Sowing date Termin siewu	31.03 – 08.04 13.04 – 18.04	159 159	n.s.	157 164	22	163 164	n.s.	15.9 16.2	25
Harvest date and method Termin i sposób zbioru	H1* H2* H3*	158 159 159	n.s.	161 160 160	n.s.	162 164 164	n.s.	16.0 16.1 16.1	n.s.
Sowing rate Ilość wysiewu	$12\ kg \cdot ha^{-1}$ $24\ kg \cdot ha^{-1}$	159 159	n.s.	161 161	n.s.	165 162	n.s.	16.1 16.0	n.s.
Means for years Średnie dla lat		159		161		163		161	
Coefficient of variation, % Współczynnik zmienności								1	

n.s. – non-significant difference
* H1 – two-stage harvest, H2 – single-stage harvest, H3 – delayed single-stage harvest
H1 – zbiór dwuetapowy, H2 – zbiór jednoetapowy, H3 – zbiór jednoetapowy opóźniony

Table 6. Milk thistle protein amino acid composition depending on the sowing date
Tabela 6. Skład aminokwasowy białka ostropestu plamistego w zależności od terminu siewu

Amino acid – Aminokwas	31.03. – 08.04.	13.04. – 18.04.	Mean Średnia
Glutamic acid – Kwas glutaminowy	18.80	18.54	18.67 ± 1.02
Aspartic acid – Kwas asparaginowy	8.54	8.36	8.45 ± 0.7□
Glycine – Glicyna	4.90	5.13	5.02 ± 0.23
Alanine – Alanina	2.90	2.85	2.87 ± 0.25
Tyrosine – Tyrozyna	3.44	3.41	3.42 ± 1.12
Serine – Seryna	4.14	3.95	4.05 ± 0.35
Histidine – Histydyna	3.37	3.52	3.45 ± 0.67
Arginine – Arginina	7.01	7.12	7.06 ± 0.69
Threonine – Treonina	3.26	3.35	3.31 ± 0.45
Methionine – Metionina	0.86	0.85	0.85 ± 0.42
Valine – Walina	3.74	3.84	3.79 ± 0.49
Phenylalanine – Fenyloalanina	0,59	0,61	0,60 ± 0.03
Isoleucine – Izoleucyna	2.95	2.98	2.97 ± 0.50
Leucine – Leucyna	5.57	5.67	5.62 ± 0.60
Lysine – Lizyna	4.41	4.57	4.49 ± 0.44
Total – Suma	74.48	74.75	74.62
Exogenous amino acids in total Suma aminokwasów egzogennych	21.38	21.87	21.63

Table 7. Content of macroelements in milk thistle fruits depending on the research year, $g \cdot kg^{-1}$ d.m.
Tabela 7. Zawartość makroelementów w owocach ostropestu plamistego w zależności od roku badań

Year Rok	Phosphorus Fosfor	Potassium Potas	Magnesium Magnez	Calcium Wapń
2004	5.27	4.54	3.56	8.41
2005	6.03	4.72	1.53	6.68
2006	6.98	5.59	2.75	6.45
Mean – Średnia	6.09	4.95	2.61	7.18
Coefficient of variation, % Współczynnik zmienności	10.6	10.3	31.0	15.9

Table 8. Content of microelements in milk thistle fruits depending on the research year, $mg \cdot kg^{-1}$ d.m.
Tabela 8. Zawartość mikroelementów w owocach ostropestu plamistego w zależności od roku badań

Year Rok	Iron Żelazo	Copper Miedź	Zinc Cynk	Manganese Mangan
2005	89.0	8.2	49.6	43.7
2006	75.5	8.7	61.1	57.6
Mean – Średnia	82.3	8.5	55.4	50.7

Table 9. Content of crude fibre and the fractions of fibre of milk thistle fruit depending on the research year, $g \cdot kg^{-1}$ d.m.
Tabela 9. Zawartość włókna surowego i frakcji włókna w owocach ostropestu plamistego w zależności od roku badań

Year Lata	Crude fibre Włókno surowe	NDF	ADF	ADL
2004	299.0	446.0	374.0	127.0
2005	233.0	391.0	315.0	102.0
Mean – Średnia	266.0	418.0	344.0	114.0

NDF – neutral detergent fiber (hemicellulose, cellulose, lignin) – neutralne włókno detergentowe (hemiceluloza, celuloza, lignina)
ADF – acid detergent fiber (cellulose, lignin) – kwaśne włókno detergentowe (celuloza, lignina)
ADL – acid detergent lignin (lignin) – kwaśne ligniny detergentowe (lignin)

The experiment factors did not differentiate the content of macroelements in thistle fruits significantly and so Table 7 gives the results representing mean for research years only. Milk thistle achenes contained most calcium and then phosphorus, respectively. Most phosphorus and potassium were accumulated by plants in 2006 and magnesium and calcium – in 2004.

The content of iron, zinc and manganese varied across the research years, while the content of copper remained similar (tab. 8).

Milk thistle achenes demonstrated a high level of crude fibre and the difference across years was as much as 66 $g \cdot kg^{-1}$d.m. The detergent analysis of fibre fractions showed a dominant share of the-most-difficult-to-digest cellulose-lignin fractions (tab. 9).

DISCUSSION

The whole milk thistle fruits, as compared with the reserve material, were obtained from the fruits without dry pericarp containing in 1 kg of dry matter about 100 g fat less, 80 g of total protein as well as 4 g of phosphorus less. The content of potassium, calcium and magnesium was, however, similar in both of the substances [Andrzejewska and Sadowska 2007].

The weather conditions, which varied across the years, had a much greater effect on the level of concentration of all milk thistle fruit components evaluated than the agrotechnical conditions. Of all the milk thistle fruit nutrients analysed, the content of protein was the most stable feature, whereas the content of magnesium and calcium changed most considerably. Taking up nutrients by plants depends first of all on the level of their content in soil and the soil acidity. The lowest content of phosphorus in thistle fruits observed in 2005 could result from the fact that soil pH was the lowest at that time. However, in spite of a relatively low pH the content of magnesium and calcium in fruits was the highest then.

The fatty acids composition of milk thistle oil, with linoleic acid prevailing, is similar to the soybean oil, commonly applied in nutrition, and sunflower oil. The application of whole achenes of milk thistle of high content of vitamin E [Hadolin et al. 2001] and flavonolignans can thus offer an antioxidant effect on monounsaturated fatty acids which prevail in milk thistle oil.

Milk thistle fruits show a high content of iron, which is comparable with the content of that element in dry soybean seeds [Kunachowicz et al. 2000]. Abu Jadayil et al. [1999] claim that a relatively high concentration of iron in achenes is characteristic for that species and, besides, it occurs in a form easily-available to animals.

The milk thistle protein amino acids are dominated by glutamic acid and, although the analytical method adopted did not consider all the amino acids, however, based on them and drawing on the results reported by Potkański et. al [1991], one can find that it is protein poor in sulphur amino acids and it is the methionine which is the limiting amino acid.

Milk thistle fruits include a combination of precious nutrients. The greatest energy and health-enhancing significance is reported for oil with the advantage of unsaturated fatty acids, however, also the protein content and a very high content of mineral substance and, mostly, the presence of flavonolignans showing antioxidant and liver-protecting properties. While planning nutrition which would involve whole milk thistle achenes, however, one shall consider a high fibre content. Potkański et al. [1991] report on the reserve material of milk thistle fruits, being appropriate only for ruminants, which makes it possible for the whole fruits, which would be the source of silymarin for animals, to be used only for ruminants. They could be used as an additive to silage made from other plants like grasses or maize.

CONCLUSIONS

1. Variable weather and agrotechnical conditions resulted in a change in the total protein content least considerably, while the content of crude fibre and macroelements, especially calcium and magnesium – most considerably.
2. Oil is the most precious milk thistle fruit nutrient; it contains over 50% of polyunsaturated fatty acids.
3. Milk thistle fruits demonstrate a high iron content.
4. The nutrient limiting the use of milk thistle achenes in non-ruminant nutrition is a high content of crude fibre and cellulose-lignin fractions.

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WPŁYW WARUNKÓW POGODOWYCH I AGROTECHNICZNYCH NA ZAWARTOŚĆ SKŁADNIKÓW POKARMOWYCH W OWOCACH OSTROPESTU PLAMISTEGO (*Silybum marianum* L. Gaertn.)

Streszczenie. Ostropest plamisty (*Silybum marianum* L. Gaertn.) jest rośliną leczniczą mającą zastosowanie w leczeniu wątroby. Celem badań było określenie zakresu zmienności zawartości składników pokarmowych w owocach ostropestu plamistego jako potencjalnego dodatku do pasz dla zwierząt. Materiał stanowiły całe niełupki ostropestu zebranego z doświadczenia polowego prowadzonego w latach 2004–2006 w Mochełku (53°13'N; 17°51'E). Stosowano dwa terminy siewu, trzy metody zbioru oraz dwie normy wysiewu. Warunki pogodowe w latach miały większy wpływ na zmiany składu chemicznego niż warunki agrotechniczne. W najmniejszym stopniu zmieniała się zawartość białka ogólnego, a w największym zawartość włókna surowego i makroelementów, w tym zwłaszcza wapnia i magnezu. Owoce zawierały średnio 21.6% tłuszczu, w którym 51.6% stanowił kwas linolowy, 16.1% białka ogólnego, gdzie dominującym aminokwasem był kwas glutaminowy. Zawartość makroelementów wynosiła: fosforu – 6.1, potasu – 4.9, wapnia – 7.6, magnezu – 2.6 $g \cdot kg^{-1}$ s.m. Stwierdzono wysoką zawartość żelaza – 82.3 $mg \cdot kg^{-1}$ s.m. Owoce zawierały średnio ($g \cdot kg^{-1}$ s.m.): włókna surowego – 266.0, NDF – 418.0, ADF – 344.0 i ADL – 114.0. Ze względu na wysoką zawartość frakcji celulozowo-ligninowych, całe owoce ostropestu mogą być stosowane tylko dla przeżuwaczy.

Słowa kluczowe: frakcja celulozowo-ligninowa, kwas linolowy, kwas glutaminowy, makroelementy, mikroelementy, niełupki ostropestu

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