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CONTENT OF SOME NUTRIENTS IN NEW BLACK OAT STRAINS

Anna Ciołek[1], Bogusław Makarski[2], Ewa Makarska[1], Anna Zadura[2]

[1]Department of Chemistry
[2]Department of Biochemistry and Toxicology
Agricultural University in Lublin

Abstract

The nutritive benefits of oats for both human consumption and animal feeding stimulate scientifically based breeding efforts to obtain new varieties, including brown oat grain (black oat).It is a fodder the cereal is used chiefly for racehorses. The objective of the present research was to compare the contents of the selected nutrients, i.e. crude protein, crude fat, composition of fatty acids and minerals in grain of three black oat strains: CHD 28/75/01, CHD 28/ /33/02 and CHD 2909/01 with reference to two oat standard varieties (Bohun and Deresz), commonly grown in Poland. The three new black oat strains showed varied crude protein levels and a slightly lower crude fat content compared to the oat standard varieties Bohun and Deresz. The black oat strain CHD 28/75/01 exhibited the highest percentage of unsaturated fatty acids (UFA) and monounsaturated fatty acids (MUFA) versus the other strains and varieties. This oat strain grain is also characterized by a substantially higher content of magnesium, phosphorus, zinc, copper and iron than the other strains and varieties investigated.

Key words: oat, crude protein, crude fat, fatty acids, mineral elements.

dr Anna Ciołek, Katedra Chemii, Akademia Rolnicza w Lublinie, ul. Akademicka 15, 20-950 Lublin

ZAWARTOŚĆ WYBRANYCH SKŁADNIKÓW POKARMOWYCH W NOWYCH RODACH OWSA CZARNEGO.

Abstrakt

Zalety żywieniowe owsa, zarówno dla ludzi, jak i zwierząt, są bodźcem do prac hodowlanych nad nowymi odmianami, w tym owsa czarnego o brunatnej barwie ziarniaków. Jest to zboże paszowe, stosowane głównie do skarmiania koni wyścigowych. Celem pracy było porównanie zawartości wybranych składników pokarmowych, tj.**:** białka ogólnego, tłuszczu surowego, składu kwasów tłuszczowych oraz elementów mineralnych, w ziarnie trzech rodów owsa czarnego: CHD 28/75/01, CHD 28/33/02 i CHD 2909/01 w odniesieniu do dwu odmian wzorcowych owsa (Bohun i Deresz) powszechnie uprawianego w Polsce. U 3 nowych rodów owsa czarnego stwierdzono zróżnicowany poziom białka ogólnego oraz nieznacznie obniżony poziom tłuszczu surowego w stosunku do owsa odmian wzorcowych Bohun i Deresz. Nawiększy udział procentowy nienasyconych kwasów tłuszczowych (UFA) i jednonienasyconych kwasów tłuszczowych (MUFA), w porównaniu z pozostałymi rodami i odmianami, wykazano u rodu CHD 28/75/01. W ziarnie tego rodu stwierdzono również wyższą zawartość magnezu, fosforu, cynku, miedzi i żelaza w porównaniu z pozostałymi testowanymi rodami i odmianami.

Słowa kluczowe: owies, białko ogólne, tłuszcz surowy , kwasy tłuszczowe, składniki mineralne.

INTRODUCTION

Recently, there has been an increasing worldwide interest in oat, stimulated by the beneficial nutritive value of this cereal for humans and animals. The foods produced from oat grain show hypocholesterolemic activity due to the presence of water-soluble dietary fibre containing beta-glucan fraction. These polysaccharides are capable of binding cholesterol and bile acids in the digestive system (NEWMAN et al. 1992, WURSCH, PI-SUNYER 1997, GĄSIOROWSKI 2003). The chemical composition of oat grain is similar to that of other cereals, yet it is far richer in protein and fat. The content of exogenous amino acids is higher than in other cereals so the biological value of oat protein is also markedly higher. Beside proteins, fat substances constitute a major component of oat which shapes its physiological, nutritional and processing characteristics. Oat grain fat is rich in unsaturated fatty acids, which make up 80% of all the fatty acids (GĄSIOROWSKI, URBANOWICZ 1992, OZCAN et al. 2006, BANAŚ et al. 2007).

Compared to other cereals, oat grain is low in saccharides, like starch (average 53%) and cellulose, but it is abundant in soluble fibre fractions, which prove vital in maintaining the beneficial microflora of the intestines, stimulating generation of probiotic bacteria of milk fermentation and inhibiting development of pathogens (KOLANOWSKI 1998, GAJEWSKA et al. 2002).

Comparison of the content of minerals in oat grain and other cereals indicates that oat is far more abundant in Ca, Fe, Zn and Mn. Consequently, oat grain is recognized as an excellent source of dietary minerals for

humans and animals. The content of minerals in hulled oat grain is considerably higher than in dehulled grain. However, although the qualities of oat prove to be beneficial, the cultivation area of this cereal systematically decreases all over the world. Currently, oat grain is mainly used as fodder for animals and only as little as 5% of the total crop yield is utilized by the food industry. The breeders make efforts to market new varieties of black oat. Black oat is very popular, especially as a staple constituent of a diet for racehorses. Moreover, it is a major nutritional supplement of grain feed given to animals taking part in races, as it enhances their performance as a short- and medium-term energy supplement, essential during competitions.

The present research compared the content of basic nutrients in three black oat strains and two standard varieties commonly grown in Poland. The qualitative evaluation included crude protein, crude fat, fatty acid composition and mineral content.

MATERIAL AND METHODS

The experimental material embraced two yellow-grain oats varieties, Deresz and Bohun, of average hull content. These two varieties served as reference for three black oat strains: CHD 28/75/01, CHD 28/33/02 and CHD 2909/01, which were obtained from the Breeding Station DANKO in Choryń. Black oat is a fodder cereal, used chiefly as a component of the equine diet.

For analytical examinations, we used oatmeal produced by thorough grinding in a laboratory mill. In the test material, crude protein in grain samples was determined according to Kjeldahl method using a Kiel-Foss apparatus whereas crude fat content was assessed according to the Soxhlet method, on Soxtec MT-6 apparatus. The minerals were analyzed using AAS method on a UNICAM 939 apparatus, after wet mineralization of oatmeal in a mixture of $HCIO_4$ and HNO_3 (5:1 ratio). Percentage of fatty acids in oat grain triglycerides was determined by the gas chromatography method, after their esterification process (methyl ester form).The results were analyzed statistically using Statistica program version 5 and a single factor analysis of variance ANOVA test at significance levels of 0.01 and 0.05.

RESULTS AND DISCUSSION

Figure 1 presents the crude protein content in the strains and varieties of oat. In oat grain, the protein content usually ranges from 11 up to 15% (Bartnikowska et al. 2000). Owing to an elevated lysine content, the

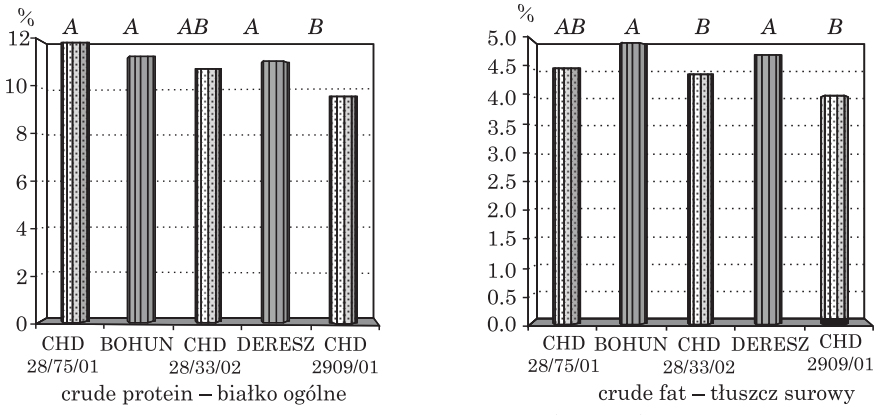

Fig. 1. Content of crude protein (%) and crude fat (%) in ground grain of oat strains and cultivars

Rys. 1. Zawartość białka ogólnego (%) i tłuszczu surowego (%) w śrucie owsianej badanych rodów i odmian

proteins in oat have the highest biological value among the cereals (SÄRKIJÄRVI, SAASTAMOINEN 2006). Another advantage of oat proteins is their good digestibility (PEDO et al. 1999, FRĄTCZAK et al. 2003). Compared to some other cereal species, negative correlation between grain yield and protein content proved weak (BARTNIKOWSKA et al. 2000). Oat grain of CDH 28/75/01 strain was characterized by a higher crude protein (11.91%±0.85) level than Deresz and Bohun varieties. The protein concentration in this strain was similar to that reported by PISULEWSKA et al. (1997) for naked oat grown on light soil. The lowest crude protein content was determined in oat grain from CDH 2909/01 strain (9.580% ± 0.080). There was no statistically significant difference in the protein level between the standard varieties Bohun and Deresz. In agricultural practice, this parameter can be strongly modified through different levels of nitrogen fertilization, while the technological treatment of oat grain dehulling increases protein content.

The present research revealed that the highest crude fat content was in oat grain of Bohun and Deresz varieties (Fig. 1). Bohun variety, according to the BS DANKO, proves to be high in fat, with an average 5.7% fat content. The analysis performed on this variety showed that its fat content, 4.94%±0.05, was the highest among all the oat samples. The lowest crude fat content was detected in oat grain of CHD 2909/01 strain (4.00%±0.07). All the new black oat strains contained less crude fat than Bohun and Deresz varieties.

Table 1 presents fatty acid percentage in triglycerides of the oat strains and varieties studied. Among the cereals, oat appears to be the

most valuable cereal product due to the elevated content of unsaturated fatty acids (UFA) compared to saturated fatty acids (SFA). Our study showed that the highest unsaturated fatty acid level (83.17%) was in CHD 28/75/01oat strain. The other oat samples, except Bohun (80.33%), had similar UFA proportion (over 81%). In a human organism, the fatty acid desaturation can proceed exclusively between the C9 and C10 carbon atom, therefore the polyunsaturated fatty acids (PUFA), i.e. linoleic and linolenic acid, must be consumed from the dietary sources. In this aspect, the most beneficial was grain of CDH 2909/01 strain, which contained 43.80% of PUFA, while the lowest PUFA proportion was observed in the black oat strain CDH 28/75/01 (39.88%). These results were similar to those reported by KAMIŃSKA (2003). Currently, a growing physiological role is attributed to the monounsaturated fatty acids (MUFA), which are known to promote atherosclerosis prevention. The highest percentage of MUFA (43.29%) was established in CDH 28/75/81 black oat strain, whereas the lowest one – in CDH 2909/01 (37.60%). Among the fatty acids composing the dietary fat, the most frequent appears to be double bond cis configuration, although in some foods fatty acids may occur in a trans isomer form. The loose their biological value and become an energy source only. In all the oat varieties investigated, the presence of trans isomer was confirmed referring to C18:1. However, in each case similar quantities trans isomer fatty acids were obtained (approximately 1% of all the fatty acids).

Table 1
Tabela 1

Fatty acids content (%) in grain of different oat cultivar and strains
Udział kwasów tłuszczowych (%) w ziarnie różnych odmian i rodów owsa

Fatty acids Kwasy tłuszczowe (%)	Oat cultivar and strains – Odmiany i rody owsa				
	CHD 28/75/01	Bohun	CHD 28/33/02	Deresz	CHD 2909/01
14:0	0.17	0.22	0.25	0.27	0.26
16:0	14.50	17.04	16.93	16.74	16.70
16:1	0.23	0.21	0.19	0.24	0.22
18:0	1.05	1.53	0.92	1.13	1.06
18:1c	40.56	37.37	38.87	39.17	35.44
18:1t	1.28	1.00	1.03	0.97	1.01
18:2c	38.06	38.78	38.44	38.82	42.12
18:3c	1.82	1.56	1.47	1.66	1.68
20:0	0.17	-	0.14	0.13	0.14
20:1	1.22	0.78	1.26	0.80	0.93
22:2	0.00	0.63	0.29	0.00	0.00
Other – Inne	0.94	0.88	0.21	0.07	0.44
SFA	15.89	18.79	18.24	18.27	18.16
UFA	83.17	80.33	81.55	81.66	81.4
MUFA	43.29	39.36	41.35	41.18	37.60
PUFA	39.88	40.97	40.20	40.48	43.80

Black oat grain differed from the standard varieties by a higher ash content (Tab. 2). A similar relationship was found by GAMBUŚ et al. (2006) who recorded a 3.35% ash content in yellow hull oat, and 3.66% in black hull oat. The highest percentages of available ash in oat strains were found in CHD 28/75/01 (2.528%±0.019) and CHD 2909/01 (2.502%±0.016), while cv. Bohun variety was the poorest in ash (2.159% ± 0.034). These results are slightly higher than those concerning ash content in oat grain established by SKIBNIEWSKA et al. (2002) – 2.05%.

The highest potassium level was in black oat strains CDH 2909/01 (0.423% ± 0.016) and CDH 28/33/02 (0.378% ± 0.081). CDH 28/75/01 strain contained less potassium (0.331% ± 0.032) compared to the standard varieties, although the difference between CHD 28/75/01 and CHD 28/33/02 versus the standard varieties was not statistically significant. GAMBUŚ et al. (2006) found that the potassium level in flour produced from black hull oat reached 0.292%, while in flour of yellow hull oat it was 0.324%. SOUCI et al. (2000) reported a higher range of this element content in oat grain, i.e. 0.338 – – 0.387%, but it was still under the level reported for black oat strain CHD 2909/01.

A significantly higher phosphorus level, compared to the other samples, was determined for CHD 28/75/01 strain (0.388% ± 0.004) and Bohun variety (0.362% ± 0.009); this was even higher than quoted by Souci et al. (2000), where it varied from 0.332 up to 0.352%. In the study by GAMBUŚ et al., (2006), the phosphorus content was 0.411% in black oat grain and 0.361% in yellow grain oat. The difference in phosphorus between the standard varieties and CHD 28/33/02 and CHD 2909/01 strains was not statistically significant at p?0.05.

Magnesium in the oat strains differed from that in the standard varieties. Grain of CHD 28/75/01 and CHD 2909/01 strains proved richer in this element than the standard varieties. The highest magnesium level was determined in the strains CHD 28/75/01 (0.117% ± 0.014) and CHD 29090/01 (0.114% ± 0.019). These values were close to those reported by SKIBNIEWSKA et al. (2002), GAMBUŚ et al. (2006) and SOUCI et al. (2000).

The content of calcium in the oat samples ranged from 0.001 up to 0.015% and its highest contents was determined in CHD 28/33/02 and CHD 2909/01 strains as well as Deresz variety, whereas CHD 28/75/01 strain and Bohun variety contained significantly less Ca. However, the range of the calcium values for the strains and varieties studied was markedly lower compared to the results given by SOUCI et al. (2000) and SKIBNIEWSKA et al. (2002).

As for manganese, two statistically homogeneous groups at $p \leq 0.01$ were determined: strains CHD 28/75/01 and CHD 2909/01 with a higher manganese content and the remianing samples with a lower manganese level. Likewise, the study by GAMBUŚ et al. (2006) showed higher manganese content in black oat.

Table 2
Tabela 2

Content of mineral nutrient components in grain of oat strains and cultivars
Zawartość składników mineralnych w ziarnie rodów i odmian owsa

Oat Owies	K	P	Mg	Ca	Mn	Fe	Zn	Cu	Ash % d.w. Popiół % s.m.
	% d.w. – % s.m.				mg•kg^{-1}d.w. – mg•kg^{-1}s.m.				
CHD 28/75/01	0.331^{b}±0.032	0.388^{a}±0.004	0.117^{a}±0.015	0.001^{B}±0.000	49.1^{A}±5.0	48.9^{A}±6.8	41.7^{A}±6.0	5.5^{A}±0.2	$2{,}528^{A}$±0.019
Bohun	0.326^{b}±0.028	0.362^{ab}±0.009	0.104^{ab}±0.001	0.009^{B}±0.001	36.3^{B}±1.1	43.0^{A}±6.0	38.0^{A}±0.4	5.2^{A}±0.6	2.159^{B}±0.034
CHD 28/33/02	0.378^{ab}±0.081	0.3402^{b}±0.005	0.083^{b}±0.012	0.015^{A}±0.003	34.1^{B}±3.0	31.5^{B}±0.5	24.6^{B}±2.3	2.8^{B}±0.1	2.437^{A}±0.022
Deresz	0.355^{ab}±0.015	0.345^{b}±0.005	0.089^{b}±0.014	0.013^{AB}±0.001	32.0^{B}±2.6	44.9^{A}±2.8	23.6^{B}±7.1	3.4^{B}±0.3	2.274^{B}±0.000
CHD 2909/01	0.423^{a}±0.016	0.320^{b}±0.002	0,114a±0.016	0.014^{AB}±0.002	58.2^{A}±8.6	29.7B±1.5	24.6^{B}±3.6	3.3^{B}±0.6	2.502^{A}±0.016

A, B – statistically significant differences at $p \leq 0.01$ – różnice istotne statystycznie gdy $p \leq 0{,}01$
a, b – statistically significant differences at $p \leq 0.05$ – różnice istotne statystycznie gdy $p \leq 0{,}05$

The iron content in grain oat appeared to be the highest in CHD 28/75/ /01 strain and the standard varieties. The strains CHD 28/33/02 and CHD 2909/01 contained significantly less Fe. This is in contrast to GAMBUŚ et al. (2006), who found more iron in black oat compared to yellow hull oat.

Among the oat samples under investigation, CHD 28/75/01 strain and Bohun variety proved to be most abundant in zinc and copper. The other samples were shown to contain zinc below the values presented by SOUCI et al. (2000) and SKIBNIEWSKA et al. (2002). However, the oat grain copper content in all the samples investigated was within the limits reported by SOUCI et al.(2000), i.e. 23 – 0.7 mg·100 g^{-1}.

The present research revealed that CHD 28/75/01 strain had the highest level of phosphorus, magnesium, iron, zinc and copper in oat grain but its potassium content was the lowest. Among the strains and varieties examined, oat grain of CHD 28/33/02 strain showed the highest calcium level, although it was the poorest in magnesium, manganese, zinc and copper. The strain CHD 2909/01 was shown to contain more potassium and manganese but less phosphorus and iron than the other strains.

CONCLUSIONS

1. The new black oat strains showed differentiated levels of crude protein and a slightly lower crude fat content compared to the oat standard varieties: Bohun and Deresz.

2. The black oat strain CHD 28/75/01 had the highest content of unsaturated fatty acids (UFA) and monounsaturated fatty acids (MUFA) compared to the other strains and varieties.

3. Black oat grain of CHD 28/75/01 strain had a substantially higher content of magnesium, phosphorus, zinc, copper, manganese and iron than the other strains and varieties investigated.

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