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THE EFFECT OF CULTIVATION INTENSITY ON MINERAL CONTENT IN GRAIN, FLAKES AND BRAN OF WINTER WHEAT (*Triticum aestivum* L.) PRELIMINARY STUDY

WPŁYW INTENSYWNOŚCI UPRAWY NA ZAWARTOŚĆ SKŁADNIKÓW MINERALNYCH W ZIARNIE, PŁATKACH I OTRĘBACH Z PSZENICY OZIMEJ (*Triticum aestivum* L.) – BADANIA WSTĘPNE

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Słowa kluczowe: *składniki mineralne, intensywność uprawy, ziarno pszenicy, produkty zbożowe*

STRESZCZENIE

Celem badań była ocena wpływu intensywności uprawy na zawartość Ca, Mg, Zn i Fe w ziarnie, płatkach i otrębach pozyskanych z dwóch nowych odmian pszenicy ozimej. Materiał badawczy stanowiło ziarno, płatki i otręby z pszenicy ozimej odmian Kobiera i Bogatka. Odmiany te pochodziły z upraw doświadczalnych z dwóch Stacji Oceny Odmian na terenie Dolnego Śląska w Zybiszowie i Tomaszowie Bolesławieckim w latach 2007-2008. Uprawa prowadzona była na dwóch poziomach intensywności: ekstensywnym i intensywnym. Zawartość składników mineralnych oznaczono metodą płomieniowej spektrometrii absorpcji atomowej (ASA). Na podstawie przeprowadzonych badań stwierdzono, że poziom uprawy nie wywierał istotnego wpływu na zawartość wszystkich analizowanych składników mineralnych zarówno w ziarnie jak i płatkach oraz otrębach. Jedynie zawartość Ca w badanych próbach była stabilna, niezależnie od odmiany, warunków pogodowych oraz intensywności i miejsca uprawy, natomiast ilość Fe istotnie zależała od warunków glebowych.

ABSTRACT

The aim of the study was to assess the effect of cultivation intensity on the Ca, Mg, Zn and Fe contents in winter wheat grain, flakes and bran. The initial material for the study comprised grain, flakes and bran of two winter wheat cultivars Kobiera and Bogatka. These cultivars were from two strain testing stations located in Lower Silesia, Zybiszów and Tomaszów Bolesławiecki in the years 2007-2008. The cultivation was conducted on two intensity levels: lower and higher. The mineral content was determined by the flame atomic absorption spectrometry (FAAS). The investigation showed that the level of cultivation had no significant effect on the content of all minerals analyzed in grain, flakes and bran. The Ca content in wheat grain, flakes and bran was stable, regardless of varieties, weather conditions, tillage intensity and cultivation place, furthermore soil conditions significantly affect Fe content in wheat grain, flakes and bran.

INTRODUCTION

During the last decade, whole grain cereal products have captured scientific and public attention as a human nutrition basis and possible means to maintain and improve health condition. Epidemiological evidence implicates a low dietary intake of plant fiber as an etiological factor in diseases such as colon cancer, appendicitis, diverticular disease and ischemic heart disease [2, 3, 13, 14]. In accordance with the principles of the food pyramid developed by the National Food and Nutrition Institute low-processed cereal products are classified almost in the base section of the food pyramid and should be consumed at least in five por-

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tions per day [4]. Cereal products constitute one of the most important source of minerals in human diet in Poland and state around 50% of daily requirement for this nutrient, especially K, P, Mg, Fe, Zn and Cu [5, 8]. The distribution of micronutrients within individual grains of cereal is uneven [10, 16]. Most micronutrients, especially minerals, are concentrated in the aleurone cells of grain, which is commonly removed as bran during milling. *Guttieri* [1] found that Fe and Ca concentrations in wheat flour were affected by genotype and also suggested that environmental conditions might affect mineral contents in field-grown wheat grains. No research, however, has been published on how cultivation intensity affects the concentration of minerals in the milling fractions of wheat grain.

Taking into account the current state of knowledge concerning the role of cereal products in prevention and dietary therapy of metabolic diseases and mineral supply, the authors decided to investigate whether cultivation intensity affects winter wheat grain (*Triticum aestivum* L.), flakes and bran mineral content.

MATERIAL AND METHODS

The initial material for study comprised grain of 2 new winter wheat cultivars Kobiera and Bogatka grown in 2 strain testing stations located in Lower Silesia – Zybiszów and Tomaszów Bolesławiecki in the years 2007-2008. Investigated cultivars grew at two levels of cultivation intensity – lower (A1) and higher (A2). The higher level differed from the lower firstly in higher nitrogen dose by 40 kg, secondly in application of fungicide, growth regulator and foliage dressing (tab. 1).

Obtaining of flakes

A two-stage hydrothermal processing was used to obtain wheat flakes. Samples of grain (300g) were treated with water vapor evaporation (121°C, 1 atm. in autoclave) and roasting (180°C, 20 min. in laboratory dryer) to obtain wheat flakes. Samples were cooled at room temperature for 24 h and minced using laboratory hammer shredder after hydrothermal processing.

Obtaining of bran

Samples of grain (1000g) were humidified to 16% of moisture and left for 18 h, then were milled on a Tripette & Renaud & Chopin CD1 laboratory mill. Flour extraction rates averaged 60% in this study. The term "bran" in this study refers to all kernel components (fine and coarse bran), except the white flour fraction.

Analytical methods

Samples of grain, flakes and bran were mineralized at 6 cm^3 70% HNO_3 (Nitric Acid, Baker Instra Analyzed for Trace Elements) in a microwave unit Milestone 1200 Mega. Grain, flakes and bran Ca, Mg, Zn and Fe concentrations in mineralized samples were analyzed by flame atomic absorption spectrometry (AAS Perkin--Elmer 3110). The certified reference material Rice NCS ZC73008(GSB-1) was also analyzed mineralized to ensure accuracy and reproducibility of the used method. The recovery of the certified Ca, Mg, Zn and Fe were: 92%, 104%, 100% and 95% respectively. All analyses were made in three replications.

Statistical analysis

All data are presented as means with their standard deviation (± SD). Statistical analyses were done using Statistica v 9.0 program. Data were compared using the *t-Student's* test.

Table 1. Soil conditions of the investigation
Warunki glebowe doświadczenia

Specification	Zybiszów		Tomaszów Bolesławiecki	
	2007	2008	2007	2008
Soil complex	2	2	3	3
Soil bonitation class	IIIa	IIIa	IVa	IVa
Soil fertility in P2O5	25,8	23,5	21,8	8,4
Soil fertility in K2O	40,3	43,3	23,8	19,9
Soil fertility in Mg	8,8	11,4	9,2	5,1
Reaction in 1 M KCl	6,2	6,1	6,0	5,2
Nitrogen rates–A1(kg.ha-1)	114	114	129	90
Nitrogen rates–A2(kg.ha-1)	154	154	169	130
Herbicide	Granstar, Starane	Starane	Cougar	Cougar
Fungicide A2	Juwell TT, Tango Star	Alert, Falcon	Juwell TT, Caramba	Talius, Alert, Charisma
Plant growth regulant –A2	Moddus	Moddus	Moddus	Moddus
Foliar fertilisation – A2	Basfoliar	Basfoliar	Basfoliar	Basfoliar

Table 2. The mean concentrations of minerals in winter wheat grain calculated for cultivar, level of tillage intensity, years and place of cultivation, in mg/100g ±SD
Średnie zawartości składników mineralnych w ziarnie pszenicy ozimej obliczone dla odmiany, intensywności, roku i miejsca uprawy, w mg/100g ±SD

Characteristics		Ca	Mg	Zn	Fe
Cultivar	Bogatka	30,64 ± 5,47	122,24 ± 12,13	2,20 ± 0,29	2,78 ± 0,36
	Kobiera	33,48 ± 4,46	127,74 ± 17,24	2,33 ± 0,31	2,87 ± 0,38
p		n.s	n.s	n.s	n.s
Level of tillage intensity	A1	31,70 ± 5,13	124,81 ± 14,71	2,25 ± 0,33	2,84 ± 0,45
	A2	33,02 ± 5,10	125,16 ± 15,66	2,28 ± 0,29	2,82 ± 0,44
p		n.s	n.s	n.s	n.s
Years	2007	33,09 ± 5,27	113,24 ± 6,14	2,15 ± 0,15	2,74 ± 0,45
	2008	31,03 ± 4,92	136,73 ± 10,43	2,38 ± 0,13	2,92 ± 0,63
p		n.s	0,0002	n.s	n.s
Strain Testing Station	Zybiszów	32,86 ± 5,40	120,12 ± 10,96	2,36 ± 0,33	3,11 ± 0,13
	Tomaszów Bolesławiecki	31,27 ± 4,88	129,85 ± 16,96	2,17 ± 0,25	2,54 ± 0,29
p		n.s	n.s	n.s	0,001
Range		25,21 – 38,97	102,96 – 153,49	1,73 – 2,92	2,19 – 3,32

$p < 0,05$
n.s – not statistically significant difference

RESULTS AND DISCUSSION

Mineral content of wheat grain

Ca, Mg, Zn and Fe contents in wheat grain from two varieties are summarized in table 2. The Ca, Mg, Zn and Fe contents in wheat grain ranged from 25.21 to 38.97, from 102.96 to 153.49, from 1.73 to 2.92, from 2.19 to 3.32 mg/100g, respectively. Mineral contents of grain obtained in the current study were comparable with those obtained by other authors [9, 12, 17]. The mean Fe concentrations of grain obtained in Zybiszów were significantly higher than those obtained in Tomaszów Bolesławiecki. That could be related to soil conditions - better soil bonitation class (good wheat complex) in Zybiszów than in Tomaszów Bolesławski (defective wheat complex). Comparison of values for the variables in two successive years showed, that Mg concentrations were significantly lower in 2007 than those obtained in 2008. Soil Mg content is strongly connected with rainfall during vegetation period the higher rainfall, the stronger Mg migration into soil and worse Mg assimilation by wheat [7, 15]. In 2007 rainfalls were considerably higher than in 2008 in investigated region. Furthermore, soil's pH was lower in 2008, and it fostered Mg assimilation. The differences between mean values of Zn and Fe concentration in wheat grain calculated for individual varieties, year of cultivation, tillage intensity and cultivation place were not significant.

Table 3. The mean concentrations of minerals in wheat flakes calculated for cultivar, level of tillage intensity, years and place of cultivation, in mg/100g ± SD
Średnie zawartości składników mineralnych w płatkach pszennych obliczone dla odmiany, intensywności, roku i miejsca uprawy, w mg/100g ± SD

Characteristics		Ca	Mg	Zn	Fe
Cultivar	Bogatka	28,25 ± 4,51	125,38 ± 11,19	2,14 ± 0,21	3,94 ± 0,69
	Kobiera	30,82 ± 5,04	125,87 ± 18,06	2,38 ± 0,25	4,00 ± 0,58
p		n.s	n.s	n.s	n.s
Level of tillage intensity	A1	26,15 ± 5,14	126,95 ± 14,39	2,27 ± 0,16	3,92 ± 0,48
	A2	29,76 ± 4,79	124,29 ± 15,52	2,32 ± 0,30	4,02 ± 0,76
p		n.s	n.s	n.s	n.s
Years	2007	28,56 ± 4,90	114,34 ± 5,04	2,17 ± 0,13	4,31 ± 0,63
	2008	30,50 ± 4,83	136,90 ± 11,63	2,43 ± 0,25	3,63 ± 0,40
p		n.s	0,001	0,02	0,02
Strain Testing Station	Zybiszów	29,84 ± 3,91	120,06 ± 8,03	2,31 ± 0,30	4,29 ± 0,71
	Tomaszów Bolesławiecki	29,23 ± 5,83	131,18 ± 17,78	2,28 ± 0,17	3,65 ± 0,26
p		n.s	n.s	n.s	0,03
Range		23,66 -38,46	105,22 -154,29	2,01 – 2,88	3,10 -5,18

$p < 0,05$
n.s – not statistically significant difference

Table 4. The mean concentrations of minerals in wheat bran calculated for cultivar, level of tillage intensity, years and place of cultivation, in mg/100g ± SD
Średnie zawartości składników mineralnych w otrębach pszennych obliczone dla odmiany, intensywności, roku i miejsca uprawy, w mg/100g ± SD

Characteristics		Ca	Mg	Zn	Fe
Cultivar	Bogatka	48,40 ± 12,62	255,79 ± 35,19	4,47 ± 0,58	5,70 ± 1,06
	Kobiera	56,82 ± 12,76	279,29 ± 68,72	4,64 ± 0,76	5,52 ± 0,88
p		n.s	n.s	n.s	n.s
Level of tillage intensity	A1	52,06 ± 13,82	253,28 ± 39,11	4,57 ± 0,63	5,74 ± 0,96
	A2	52,16 ± 13,07	281,80 ± 65,44	4,55 ± 0,74	5,49 ± 0,98
p		n.s	n.s	n.s	n.s
Years	2007	53,85 ± 14,10	262,23 ± 70,66	4,29 ± 0,77	5,86 ± 1,28
	2008	51,37 ± 12,65	272,85 ± 34,91	4,82 ± 0,43	5,37 ± 0,38
p		n.s	n.s	n.s	n.s
Strain Testing Station	Zybiszów	54,86 ± 13,44	253,11 ± 28,07	4,77 ± 0,80	6,27 ± 0,89
	Tomaszów Bolesławiecki	50,36 ± 13,05	281,93 ± 70,20	4,35 ± 0,45	4,95 ± 0,36
p		n.s	n.s	n.s	0,006
Range		35,89 – 76,60	187,48 – 415,58	3,20 – 5,41	4,18 – 7,55

$p < 0,05$
n.s – not statistically significant difference

Mineral content of wheat flakes

Mineral contents in flakes are shown in table 3. The Ca, Mg, Zn and Fe contents in wheat flakes ranged from 23.66 to 38.46, from 105.22 to 154.29, from 2.01 to 2.88, from 3.10 to 5.18 mg/100g, respectively. The content of the following four minerals was similar to those presented in Tables of food content and nutritive value [6]. Likewise in the raw material – grain, the Fe content in flakes was significantly higher in Zybiszów as compared to Tomaszów Bolesławiecki, and also Mg content was significantly lower in 2007 than 2008. Furthermore significantly higher Zn and lower Fe concentrations in 2008 in comparison to 2007 were observed. The effect of varieties, climatic conditions in a given year, tillage intensity and cultivation place were not significant for the concentrations of Ca in wheat flakes.

Mineral content of wheat bran

Contents of analyzed minerals in wheat bran are presented in table 4. The Ca, Mg, Zn and Fe contents of bran ranged from 35.89 to 76.60, from 187.48 to 415.58, from 3.20 to 5.41, from 4.18 to 7.55 mg/100g, respectively. The Ca, Fe and Mg contents of bran obtained in the current study were comparable with those obtained by other authors [11, 12]. However, Zn content of wheat bran was insensibly lower than those obtained by *Peterson* [11] and *Ruibal-Mendieta* [12]. Likewise in grain and flakes, the Fe bran content was significantly higher in Zybiszów in comparison to Tomaszów Bolesławiecki. The effect of varieties, year, tillage intensity and cultivation place were not significant for the concentrations of Ca, Mg and Zn in wheat bran.

CONCLUSIONS

1. Tillage intensity has no significant influence on mineral concentration of wheat grain, flakes and bran.
2. The Ca content of wheat grain, flakes and bran is stable, regardless of varieties, weather conditions, tillage intensity and cultivation place.
3. The soil conditions significantly affect Fe content of wheat grain, flakes and bran.

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