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STUDIES OF CHEMICAL COMPOSITION OF POLISH TRITICALE VARIETIES. II. CHEMICAL COMPOSITION OF FLOUR AND BRAN

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The chemical composition of flour and bran from grain of eight Polish Triticale varieties was investigated. The various samples were found to differ considerably as regards the content of most of the investigated components, especially the mineral ones. It may be assumed that the distribution of chemical components in the various Triticale varieties differs.

INTRODUCTION

As already mentioned in Part I of this work [2], Triticale is studies not only with the view of using it as fodder but also as food, especially in the baking industry. The relevant research focuses mainly on the technological properties of Triticale flour, as there are relatively few works dealing with the chemical composition and nutritive value of this flour and of other milled products. This state of affairs prompted the launching of our research.

The structure of Triticale kernel is very similar to that of parental species, but the existing differences in thickness of paricarp, dimensions of aleurone layer cells and in the degree of their filling with protein and other nutrients, as well as in structure of endosperm and size of starch granules [8, 16] have important technological consequences on the milling properties and chemical composition of the products of Triticale milling.

MATERIAL AND METHODS

Ten samples of flour and ten samples of bran produced by laboratory milling (in Quadrumat-Junior mill) of Triticale varieties and parental wheat and rye supplied by the plant breeding farm in Laski were investigated. The same samples of grain were used in our research presented in Part I of this research [2].

In addition to the analyses desribed in Part I of this work [2] the following determinations were performed:

— protein soluble in 5% NaCl (albumins and globulins) according to the method described by Kamiński [11] and modified ourselves,

— falling number, quantity and quality of gluten, and crude fiber according to routine method [10],

— phytin phosphorus by the method of Hang and Lantzsch [9].*

RESULTS AND DISCUSSION

MILLING PROPERTIES OF TRITICALE

The flour samples obtained from Triticale were of about 72% extraction (Table 1), higher than the extraction of rye flour by as much as ca 13% and not much lower than that of wheat flour (ca 76%). The investigated Triticale samples did not differ much as regards flour extraction rate which was in the range of ca 70-73%; a higher values (ca 75%) were obtained only for flour from the Presto variety.

Table 1. Flour extraction ash falling number

Sample	Flour extraction (%)	ash % dm		Falling number (s)
		flour	bran	
Triticale:				
Lasko	71.7	0.75	4.71	111
Grado	72.0	0.91	4.27	106
Dagro	73.4	0.97	4.77	113
Bolero	71.0	0.93	4.60	81
Salvo	70.3	0.77	4.39	166
Largo	71.5	1.16	4.36	169
Presto	74.9	0.99	4.83	88
LAD 285	70.0	0.91	4.56	157
x	71.8	0.93	4.56	124
wheat	76.3	0.76	5.52	287
rye	57.8	1.05	3.03	128

The milling properties of Triticale grain were the subject of relatively few works which as a rule reported a considerably lower flour extraction, often below 60% [1, 3, 5, 7, 8, 19, 20]. The values we obtained are thus high.

The ash content in Triticale flour samples was 0.93% d.m. on average, values intermediate between the respective for wheat (0.76%) and rye (1.05%). Noteworthy is the fact that the relatively wide range of ash content in the idividual samples (0.75–1.16%) as accompanied by small differences in flour

* The Lopez-Morcno method employed in part I of this work [2] in which the phytin compounds are determined precipitometrically, has turned out to be inadequate in the case of bran, given the intense colouring of acid extracts and difficulties in observing the end point of titration. Accordingly, in current research we referred to the method of Hang and Lantzsch [9] which consist in precipitating the ferric phytate and colorimetrically determining the excess Fe^{3+} irons.

extraction. This suggests that mineral components are distributed differently in various Triticale varieties.

The ash content in Triticale bran, about five times higher than in flour was also intermediate between the values for wheat and rye bran (4.56%. 5.52% and 3.03% d.m., respectively).

The ash content in Triticale flour and bran confined to the range staked out by the respective content in wheat and flour has already been pointed out in previous works [1, 3, 8, 14, 17].

The values of falling number in Triticale flour, lower than these wheat (Table 1) are surprising since many authors found earlier that Triticale is characterized by low values of this index. It is yet to be clarified whether these low falling numbers are due to a high activity of amylolytic enzymes in Triticale, or to a grater susceptibility of Triticale starch to amylases [3, 5, 12].

PROTEIN COMPOUNDS

The total protein content in Tritical flour varied from 10.7% to 13.0% d.m. (Table 2) and was usually between the values for wheat (12.1%) and rye (8.5%). As in the case of grain (Part I of this work [2]) none of the Triticale flour samples was exceptional as regards protein content. Ahmed and McDonald [1] report their own studies and quote the finding of several other authors, and their values of protein are higher: 11.4-15.9%.

Table 2. Total protein, protein soluble in 5% NaCl, gluten, starch, and reducing sugars in flour

Sample	Total protein*	Protein soluble in 5% NaCl	Wet gluten (%)	Starch	Reducing sugars
	(% dry matter)			(% dry matter)	
Triticale:					
Lasko	11.3	3.2	**	75.8	2.8
Grado	10.7	2.7	13.8	75.5	2.9
Dagro	11.1	2.8	19.4	77.3	2.2
Bolero	11.0	3.3	13.2	76.5	1.6
Salvo	12.3	3.1	24.6	79.8	3.1
Largo	13.0	3.2	-[2]	74.7	5.3
Presto	11.0	3.1	12.2	77.4	3.6
LAD 285	12.2	3.2	15.6	74.2	2.0
$\bar{x}$	11.6	3.1	16.5	76.4	2.9
wheat	12.1	2.3	38.2	71.7	0.2
rye	8.5	3.4	-[2]	78.6	3.2

*) The nitrogen-to-protein conversion coefficient was 5.70 for Triticale and wheat flour, and 5.83 for rye flour [18]
**) Gluten could not be washed out

The Triticale flour samples we studied contained about 2.7–3.3% of protein soluble in a 5% NaCl solution (albumins and globulins which amounted to 25-30% of all the protein; this value is lower by 5-7% from that given by Ahmed

and McDonald [1] and Chen and Bushuk [6]. The content of gluten proteins and of the so called residue protein, calculated as a difference, was thus 70–75% of total protein, value higher than in rye flor (60%) and lower than in wheat flour (81%).

There were considerable differences in wet gluten content (12–25%), and it was impossible to wash out gluten from two flour samples (from Lasko and Largo varieties). The quality of the gluten obtained from these samples was very poor. Worth stressing is that it was possible to wesh out gluten from most of the investigated flour samples, unlike in some earlier studies in which there were many problems with this process, sometimes preventing it altogether [3, 5, 8, 19]. Analysing the reasons for the small quantities of gluten and for its poor quality, Chen and Bushuk [6] point out the Triticale flour contains more proteins soluble in water and salt solutions (albumins and globulins) and less, of residue protein as compared with wheat protein.

Triticale bran contained more protein than flour (Table 3) — about 15% on average — but the differences we found were not as great as those reported in previous works, sometimes amounting to as much as 7% protein in dry matter [1, 4, 5, 8].

Table 3. Total protein, protein soluble in 5% NaCl, sugars and crude fiber in bran (in % dry matter)

Sample	Total protein[1]	Protein soluble in 5% NaCl	Reducing sugars	Crude fiber
Triticale:				
Lasko	15.8	5.9	2.8	10.1
Grado	13.7	5.0	3.2	11.0
Dagro	14.2	4.6	4.5	10.7
Bolero	14.7	4.9	1.4	9.7
Salvo	14.6	5.0	0.5	8.9
Largo	15.2	5.7	2.9	7.5
Presto	15.9	5.4	2.5	5.1
LAD 285	16.5	5.2	5.1	4.3
$\bar{x}$	15.1	5.2	2.9	8.4
wheat	16.0	4.5	2.7	7.2
rye	14.1	4.3	2.7	7.0

[1] The nitrogen-to-protein conversion coefficient for bran was 5.26 [18]

Protein soluble in 5% NaCl constituted about 31.5-37% of total protein in bran. The available literature brings no data about the fractonation of proteins from Triticale bran. The fact that bran contains more albumins and globulins than flour is quite obvious since in Triticale grain — as in the grain of other cereals — there are more of these proteins in the outer parts of the grain, especially in the aleurone layer.

CARBOHYDRATES

The content of starch in Triticale flour (74–80% d.m.) was as a rule in between the respective content in wheat and rye flours (Table 2). Our values are basically in agreement with those reported by other authors [8, 12, 13].

The content of reducing sugars varied widely from 1.6 to 5.3% d.m. (ca 2.9% d.m. on average) and was as a rule similar to the content in rye flour. In wheat flour the content of reducing sugars was only 0.2% d.m.

The high content of reducing sugars may be a feature peculiar to Triticale, or may be the result of increased activity of amylolytic enzymes.

It is interesting to note that in Triticale bran the differences in reducing sugars content were even ten-fold, the values ranging from about 0.5% to about 5.1% d.m. (Table 3). The available literature lacks data which may be used for comparison.

The more than two-fold differences in crude fiber content in Triticale bran (4.3–11% d.m.) are probably the result of different thicknesses of the pericarp layer in the investigated Triticale varieties. The fact that Triticale bran is as rich a source of fiber as wheat bran may be of importance from nutrition point of view.

MINERAL COMPONENTS

Apart from the basic components, we also determined the content of some of the mineral components affecting the nutritive value of Triticale flour and bran (Tables 4-7).

Phosphorus content in Triticale flour (Table 4) ranged from 182 to 301 mg/100 d dry matter, and was as a rule higher than in wheat and rye flour. Phytin phosphorus accounded for an average of 42% of total phosphorus in Triticale

Tabele 4. Total and phytin phosphorus in flour and bran (in mg/100 g dry matter)

Sample	Flour		Bran	
	P_{total}	P_{phyt}	P_{total}	P_{phyt}
Triticale:				
Lasco	262	127	1177	887
Grado	248	110	994	813
Dagro	239	105	1109	915
Bolero	253	107	982	918
Slavo	228	67	1031	968
Largo	301	126	1093	1028
Presto	182	77	1350	1195
LAD 235	282	119	1204	1123
$\bar{x}$	251	105	1118	981
what	221	63	1447	1399
rye	161	82	709	653

flour, the exception being Salvo flour where this value was much lower — about 29%. Total and phytin phoshorus content are similar to those reported by Lorenz et al. [14] and Singh and Reddy [17] who, like the authors of this paper, also noted the large difference in phytin content displayed by the various flour samples, and the fact that Triticale flour usually contains more phytin compounds that wheat of rye flour. This fact may have important nutritional consequences in Triticale flour is to be used in the food industry.

Potassium content (Table 5) ranged from 239 to 337 mg/100 g d.m. and was higher than in wheat and rye flour values by an average of ca 66 mg and 39 mg, respectively. These values are similar to those obtained by Singh and Reddy [17] and higher by about 100 mg/100 g than those given by Lorenz et al. [14].

Table 5. Content of potassium, calcium, sodium and manganese in flour (in mg/100 g dry matter)

Sample	K	Ca	Na	Mg
Triticale:				
Lasko	251.4	19.9	3.5	65.7
Grado	273.7	18.1	3.3	64.3
Dagro	265.4	19.3	3.6	79.4
Bolero	238.9	20.6	3.1	64.9
Salvo	336.6	18.6	4.3	74.3
Largo	271.6	18.1	4.7	138.3
Presto	282.3	20.2	5.1	45.0
LAD 285	267.5	23.7	3.0	65.6
$\bar{x}$	273.4	19.8	3.8	74.9
wheat	207.2	21.4	4.8	46.5
rye	234.3	16.8	3.2	50.0

Worth noting are the results of magnesium content in Triticale flour which are about twice higher than those obtained by the authors just mentioned. Flour from grain of Largo variety had an exceptionally high magnesium content: 138 mg/100 g d.m. On average, Triticale flour contained more of this component than the flour from rye and wheat, ca 25 mg and 29 mg/100 g respectively. This is an important fact given the role of this element in human physiology.

The content of calcium (18–24 mg/100 g d.m.) and sodium (ca 4 mg/100 g d.m.) in Triticale flour samples were similar to those in wheat and rye flour, and not different from those reported by other authors [14, 17].

Mineral elements were also determined in bran (Tables 6 and 7) which is known to be an exceptionally rich source of mineral elements several times as rich as flour.

Phosphorus content in Triticale bran ranged from 982 to 1350 mg/100 g d.m. (Table 4), in between the values for wheat and rye bran. These amounts were about five times higher than in flour, and about two and a half times higher than in grain (Part I [2]).

Tabele 6. Content of potassium, calcium, sodium and magnesium in bran (in mg/100 g dry mattter).

Sample	K	Ca	Na	Mg
Triticale:				
Lasco	1412	99	15	336
Grado	1712	115	13	379
Dagro	1611	147	17	352
Bolero	1785	127	21	392
Slavo	1683	144	23	332
Largo	1540	119	14	337
Presto	1817	97	14	391
LAD 235	1502	86	11	351
$\bar{x}$	1633	100	16	359
what	1009	116	20	429
rye	1251	84	15	232

Table 7. Contcnt of manganese, zinc, iron and copper in bran (ppm in dry matter)

Sample	Mn	Zn	Fe	Cu
Triticale:				
Lasko	113	146	171	15
Grado	191	157	142	16
Dagro	120	169	180	19
Bolcro	105	166	172	27
Salvo	124	152	194	23
Largo	190	171	192	25
Presto	114	185	184	29
LAD 285	116	164	169	26
$\bar{x}$	134	164	176	22
wheat	84	129	259	27
rye	76	96	177	16

As in the case of total phosphorus, the content of phytin compounds in Triticale bran (981 mg P_{phyt}/100 g d.m.) ranged between the analogous content in wheat (1399 mg P_{phyt}/100 g d.m.) and rye (653 mg P_{phyt}/100 g d.m.) bran; this amounted to about 90% of total phosphorus. There was only one work in the available literature [17] with data on phytin compounds in Triticale bran, and this gives values about five times lower than those found in this work. The fact that Triticale bran contains less of these compounds than wheat bran has a clear significance in animal feeding, and may also be of importance in human nutrition.

As can be seen in Table 6, Triticale bran contained much more potassium than wheat or rye bran, namely 1.6% dry matter which is about six times more

than in flour. The values for the various samples differed by as much as ca 400 mg/100 g.

The values for calcium, sodium and magnesium content in Triticale bran were between the corresponding values for wheat and rye bran. The amounts of calcium and magnesium were, respectively, four and three times higher than in grain (cf. [2]) and five and six times higher than in flour.

Triticale bran is characterized by a high content of trace elements (Table 7), on average three or four times higher than in the previously studied grain (cf. [2]).

The average manganese content 134 ppm. which is twice the content in rye bran. There were considerable differences among the various Triticale bran samples, of up to 87 ppm, the values of manganese content ranging from 105 to 191 ppm.

Zinc content was also higher in Triticale bran (164 ppm) than in wheat and rye bran (129 and 96 ppm, respectively).

Iron content (ca 176 ppm on average) was much lower than in wheat bran (ca 259 ppm) and the same as in rye bran (177 ppm). The differences between the various Triticale samples did not exceed 50 ppm.

Cooper content in the investigated Triticale bran samples ranged fairly widely from 15 to 29 ppm.

Our values concerning the content of iron and manganese in Triticale bran are in general similar to those obtained by Lorenz et al. [14] and Singh and Reddy [17]. These authors, however, found twice higher manganese content and twice lower content of calcium, zinc and copper than we did in this research.

One must keep in mind that bran is not a standard product and that its yield obtained during milling of grain vary, this having obvious influence on its chemical composition. Given the fact that mineral components concentrate mainly in the outer parts of the kernel, even small differences in the extraction of flour and bran may lead substantial differences in the mineral composition of these products of milling.

CONCLUSIONS

1. Triticale grain exhibited good milling qualities, this being evidenced by the relatively high flour extraction of ca 72%, which was about 13% higher than in case of rye and about 6% lower than in case of wheat.

2. Investigated flour and bran samples were found to differ considerably as regards the content of most of the analyzed components. It may be expected that chemical components in the kernels of different Triticale varieties are distributed differently.

3. The content of basic components in Triticale flour and bran was usually between the corresponding values for wheat and rye, and was as follows (average values expressed in % dry matter):

— in flour: ash — 0.93, protein — 11.6, starch — 76, sugars — 2.9;

— in bran: ash — 4.56, protein — 15.1, crude fiber — 8.4, sugars — 2.9.

4. Protein soluble in 5% NaCl (albumins and globulins) in Triticale flour and bran constituted 25–30% and 31.5-37% of total protein, respectively, the values being in between those for wheat and rye flour.

5. The content of phosphorus, potassium and manganese in Triticale flour (251, 273 and 75 mg/100 g dry matter, respectively) were higher, and the content of calcium and sodium (20 and 4 mg/100 g, respectively) similar to those in wheat and rye flours.

6. Triticale bran contained the following amounts of mineral components in dry matter (mean values): P — 1120 mg, K — 1633 mg, Mg — 359 mg, Na — 16 mg, Fe — 176 ppm, Mn — 134 ppm, Zn — 164 ppm, Cu — 22 ppm. The content of phosphorus, magnesium, calcium, sodium and copper were in between the values for wheat and rye bran, the content of potassium,manganese and zinc were higher, and the content of iron — lower than in wheat or rye.

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BADANIA NAD SKŁADEM CHEMICZNYM POLSKICH ODMIAN PSZENŻYTA. II. SKŁAD CHEMICZNY MĄKI I OTRĄB Z PSZENŻYTA

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Streszczenie

Przeprowadzono badania nad składem chemicznym mąki i otrąb uzyskanych z przemiału ziarna ośmiu krajowych odmian pszenżyta. Ziarno pszenżyta charakteryzowało się dobrymi właściwościami przemiałowymi: wyciąg mąki był tylko o ok. 6% niższy od wyciągu mąki pszennej. Stwierdzono znaczne zróżnicowanie pomiędzy badanymi próbkami mąki i otrąb z pszenżyta w zawartości większości oznaczanych składników. Zawartość podstawowych składników chemicznych w mące pszenżytniej była następująca (wartości średnie w % sm/: popiół — 0,93%, białko — 11,6%, skrobia — 76%, cukry — 2,9%; a w otrębach: popiół — 4,56%, białko — 15,1%, błonnik — 8,4%, cukry — 2,9%.

Białka rozpuszczalne w 5% NaCl (albuminowe i globulinowe) w mące i otrębach z pszenżyta stanowiły odpowiednio: 25-30% i 31,5-37% białka ogółem. Mąka z pszenżyta zawierała następujące ilości składników mineralnych (wartości średnie): P — 251 mg, K — 273 mg, Mg — 75 mg, Ca — 20 mg, Na — 4 mg/100 g s.m., natomiast otręby zawierały: P — 1120 mg, K — 1633 mg, Mg — 359 mg, Ca — 100 mg, Na — 16 mg, Fe — 176 ppm, Mn — 134 ppm, Zn — 164 ppm i Cu — 22 ppm.