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EFFECT OF PHYSICAL AND CHEMICAL PROPERTIES OF TRITICALE GRAIN ON ITS MILLING VALUE

ABSTRACT

Interrelationship between physical and chemical properties and milling value of spring and winter triticale grain was examined. Correlation coefficients were calculated on the basis of laboratory tests carried out on qualitatively differentiated material collected in 1995–1998. Physical and chemical properties of spring and winter triticale grain correlated first of all with the yield of middlings, as well as with the reduction and total flour yields in laboratory milling. Triticale grain of high 1000 grain weight, high vitreosity, high HL–weight and of over 2.8 mm thickness was characterized by good milling value. The content of total protein in winter triticale grain was correlated positively with reduction, flour yield but negatively with breaking flour yield. Worse results of milling, expressed by raised ash content of flour and lower milling effectiveness index, were obtained with the grain containing more protein and mineral components.

Key words: triticale, grain, milling value.

INTRODUCTION

High quality grain, conditioning products with desirable properties and nutritional value, determines the use of triticale for consumption. Therefore, more and more attention is paid in triticale breeding for its quality, to obtain highly yielding, but also technologically advantageous varieties. However, a breeder is not always in possession of an adequate quantity of grain to carry out a test laboratory milling or standard baking, which are the best way to determine its usable value. Therefore, we are in search of such elements which with high probability would allow an early anticipation of grain quality. These should be relatively simple to determine, require a small sample of grain for the analysis and can be assayed under conditions of an average breeding station. These requirements are complied with by rudimental determinations of chemical and physical characters which can be assayed in the same grain

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sample.Thus it seemed purposeful to search for the relations between physical and chemical characters of triticale grain and its milling value.

MATERIAL AND METHODS

Twenty seven samples of spring triticale and 36 of winter triticale, harvested in 1996–1999 were examined. Each year the same varieties were tested. Following physical characteristics experimental grains were tested for: 1000 grains weight, HL–weight, vitreosity and distribution of fractions of different thickness. Determinations were performed by the methods recommended by Jakubczyk and Haber (1983). Characteristics of chemical properties included determination of the contents of mineral components, starch (Ever's method) and total protein (Kjeldahl's method), using coefficient 6.25.

The milling value of grain was determined by milling in a Quadrumat Senior mill. The yields of middlings, breaking flour, reduction flour and total flour were determined. Besides, ash content in flour was determined and milling effectiveness coefficient expressed as the ratio of flour extract to its ash content.

In order to determine interrelation between grain quality and milling discriminants, coefficients of simple linear correlation were calculated, independently for spring and winter triticale.

RESULTS

Characteristics of the test material is presented in Table 1. The results point to a considerable differentiation among spring and winter triticale samples with respect of physical, chemical and milling properties of grain.

Basing on the calculated correlation coefficients the breaking flour yield was found to depend on grain quality only in the case of winter triticale. The quantity of this product was decreasing along with increasing vitreosity ($r=-0.73$) and total protein content in grain ($r=-0.62$) (Table 2).

In winter triticale the yield of reduction flour was first of all correlated with grain vitreosity and 1000 grains weight, and in spring triticale also with HL–weight (Tables 2,3). Grain vitreosity influenced the total flour yield only in spring triticale. The effect of HL–weight on the yield of particular grain milling products was higher in spring than in winter triticale. Coefficients of correlation between HL–weight and the yield of middlings, reduction and total flour yields varied in spring triticale from $r=0.62$ to $r=0.78$, and in winter variety from $r=0.35$ to $r=0.54$.

Higher the yield of reduction flour and total amount of this product was associated in milling triticale samples with prevalence of the grain of above 2.5 and 2.8 mm thickness. All indices for assessment of grain

milling value correlated negatively with the amount of grain fraction of 2.2–2.5 mm and 2.5–2.8 mm thickness.

Table 1

Qualitative characteristics of spring and winter Triticale grain

Qualitative traits	Spring triticale		Winter triticale	
	Variability range	Variability coefficient [%]	Variability range	Variability coefficient [%]
1000–kernel weight [g]	25.1 – 54.2	23.0	2.61 – 57.5	21.1
HL–weight [kg/hl]	61.7 – 75.6	5.2	65.3 – 77.5	4.9
Vitreosity [%]	3 – 86	57.0	7 – 96	67
Share of grain of coarseness [in %]				
>2,8 mm	9.8 – 90.7	44.0	13.6 – 95.1	35.3
2,5 – 2,8 mm	8.1 – 45.4	40.6	4.1 – 44.2	41.5
2,2 – 2,5 mm	1.1 – 38.1	98.2	0.7 – 34.2	93.9
<2,5 mm	37 – 99	22.7	51 – 99	13.2
Protein content [%]	10.9 – 17.2	11.8	10.6 – 14.9	10.0
Starch content [%]	51.2 – 60.3	4.1	54.8 – 60.3	2.8
Ash content [%]	1.60 – 2.33	10.3	1.62 – 1.89	4.4
Total flour yield [%]	54.5 – 62.2	6.6	56.3 – 68.6	5.5
Breaking flour yield [%]	30.8 – 44.4	10.6	30.8 – 45.0	10.2
Reduction flour yield [%]	15.0 – 31.0	16.3	17.5 – 33.7	16.1
Ash content in flour [%]	0.50 – 0.66	8.7	0.49 – 0.68	8.5
Middlings yield [%]	17.2 – 33.0	14.8	20.3 – 36.2	14.7
Milling effectiveness coefficient	88.3 – 126.1	10.7	91.0 – 139.4	9.9

Table 2

Significant linear correlation coefficients between grain characters and milling properties of winter Triticale grain (P=0,95)

Qualitative traits	Flour yield			Middlings yield	Ash content in flour	Milling effectiveness coefficient
	Breaking	Reduction	Total			
1000–kernel weight		0.71	0.64	0.72		
HL–weight		0.38	0.54	0.35		
Vitreosity	–0.73	0.84		0.82	0.52	–0.38
Grain of coarseness 2,2 – 2,5 mm		–0.43	–0.56	–0.45		
Grain of coarseness 2,5 – 2,8 mm		–0.47	–0.45	–0.48		
Grain of coarseness >2,8 mm		0.50	0.54	0.51		
Grain of coarseness >2,5 mm		0.45	0.55	0.47		
Protein content in grain	–0.62	0.68		0.69	0.48	–0.37
Starch content in grain			0.52			0.38
Ash content in grain					0.43	–0.47

Table 3

Significant linear correlation coefficients between grain characters and milling properties of spring triticale grain (P=0,95)

Qualitative traits	Flour yield		Middlings yield	Ash content in flour	Milling effectiveness coefficient
	Reduction	Total			
1000–kernel weight	0.64	0.72	0.62		0.56
HL–weight	0.76	0.62	0.78		0.41
Vitreosity	0.72	0.48	0.71		
Grain of coarseness 2.2 – 2.5 mm	–0.43	–0.60	–0.42	0.47	–0.71
Grain of coarseness 2.5 – 2.8 mm	–0.61	–0.54	–0.57		
Grain of coarseness >2.8 mm	0.54	0.63	0.52	–0.38	0.66
Grain of coarseness >2.5 mm	0.41	0.57	0.40	–0.48	0.71
Protein content in grain				0.64	–0.71
Starch content in grain	–0.40			–0.49	0.50
Ash content in grain				0.70	–0.76

The yield of middlings and physical properties of triticale grain were interrelated similarly as with the yield of reduction flour, because of high correlation between the yield of middlings and the amount of flour from milling passage.

The yield of particular milling products depended on grain chemical properties only in the case of winter triticale. Grain with higher protein content yielded more middlings and reduction flour, and less breaking flour. Only total flour yield correlated with the content of starch (Table 2).

Spring triticale samples, containing a lot of small grains passing through 2.5 mm sieve, gave flour with high ash content (r=0.47) (Table 3). In winter triticale vitreosity was positively correlated with the content of mineral components in flour (r=0.52) (Table 2). In both forms ash content in flour depended on the contents of mineral components and protein in grain. The calculated correlation coefficients between those features were higher in spring than in winter triticale (Tables 2, 3). Grain of spring varieties with high starch content yielded flour with lower ash content (r=–0.49), the relation not observed with winter triticale.

In spring triticale the coefficient of milling effectiveness, reflecting the yield of flour and its ash content, was correlated with grain quality to a higher extent than in winter triticale. Correlation of milling effectiveness with 1000 grains weight, HL–weight, grain size fractions of >2.8 mm and starch content was positive, while that with grain fraction of 2.2–2.5 mm thickness as well as with protein and contents in grain was negative (Table 2). In winter varieties the coefficient of milling effectiveness correlated negatively with vitreosity and protein and ash contents, but positively with starch content. However, the values of calculated correlation coefficients were rather low (Table 3).

DISCUSSION

Tests of triticale previously used proved that its milling value could not be inferred to easily determinable quality of grain. This results, among others, from the occurrence of occasional and often not significant correlations between most of physical or chemical properties of grain and the milling parameters determined. In Seibel's opinion (Seibel 1974), characters determining its shapeliness, i.e. 1000 grains and HL–weight, practically are not sufficient for judging about grain milling properties. Out of physical grain properties he distinguishes leveling of thickness as a factor deciding on technological process optimal for flour yield. This opinion was corroborated by other authors (Ajzikowicz 1975, Watson *et al.* 1977, Bogdanowicz 1982a, 1982b, Biskupski *et al.* 1992, Sitkowski 1994). The results presented allow us to state that milling value of triticale grain can be sufficiently estimated baring on physical and chemical properties proposed for determination.

As for correlations, a particular attention should be paid to the interrelations between the amount of middlings, milling and total flour yields and the weight of 1000 grains, grain thickness and HL–weight. The last–mentioned character influenced the yield of particular milling fractions particularly in the case of spring triticale.

The influence of 1000 grains weight on total yield of rye flour was reported by many authors. For instance, Biskupski (1964) reported a significant though low coefficient between those parameters, while Karolini-Skaradzińska (1980) found that interrelationship in rye was determined by origin of the material. Ohm *et al.* (1988) reported that the yield wheat flour was significantly correlated with grain weight. On the other hand, Gaines *et al.* (1997) reviewed the reports proving that milling properties of wheat grain were independent of kernel size. Our presented results point to a positive correlation between 1000 grains weight and the yield of middlings as well as reduction and total yield of triticale flour. Grain thickness, which according to Seibel (1974) is the most reliable prognostic milling value of wheat, holds also for triticale varieties.

Also vitreosity appeared to be a good index for assessment of the milling value of grain. Vitreous triticale grain yielded more flour, and consequently the yield of middlings–and thus of flour from a milling passage was higher. Similar relation was found by earlier researchers (Biskupski *et al.* 1984, 1992, Gil 1996, 1997). In winter triticale vitreosity influenced positively proportions of flour obtained from subsequent passages. Biskupski *et al.* (1992) pointed to the possibility of anticipating the breaking flour yield basing on winter triticale grain vitreosity.

The results of Bogdanowicz (1982) evidenced a negative relation between the total protein content in rye grain and the breaking and total flour yields. According to this author total flour yield of either spring or winter triticale variety was not related to grain protein content. However, in winter triticale changes in protein content of grain led to changes in proportions of passage fractions in total flour; the content of protein being

positively correlated with reduction, and negatively with breaking flour yields.

Several significant correlations were found between flour ash content, the milling effectiveness index and physical and chemical characters of grain. These correlations were particularly evident in spring triticale. In that case the most informative were the contents of ash and protein and grain thickness.

Detailed studies on the nutritional composition, milling and baking quality of triticale have been conducted in past years (Cacak–Pietrzak *et al.* 1995, Haber, Lewczuk 1988, Haber *et al.* 1976, Marci *et al.* 1986, Nagi *et al.* 1984). The data obtained indicate that although nutritional quality of triticale is considered to superior that of wheat, a higher ash content, lower milling yields of flour, and inferior loaf volume and texture discourage from commercial baking use of triticale.

In spite of worse milling properties, triticale grain with high protein and ash content should be used in preparing products with better nutritional value. Studies by Pena and Amaya (1992) indicate that triticale flour blends of with wheat flour up to 50% produce bread with a quality similar to wheat bread.

CONCLUSIONS

1. Determination of physical properties of spring and winter triticale grain allow us to infer with sufficient certainty the milling value of triticale varieties. The correlations involve the amount of middlings, and the yields of reduction and total flour.
2. triticale grain of high 1000 grain weight, high HL–weight and high number of grain of over 2.8 mm thickness was characterized by good milling value. Correlation coefficients of HL–weight with the yield of particular milling fractions were higher in winter than in spring triticale.
3. Vitreosity of triticale grain of either spring or winter varieties provided information about high middlings and reduction flour yields, and in winter triticale also about low breaking flour yield.
4. Out of chemical grain components determined the content of total protein provides the best information on winter triticale grain milling properties. High content of protein contributed to a final product with advantageous proportion of breaking to reducing flour yield. Spring or winter triticale grain containing high content of protein and mineral components, gave flour with high ash content and low milling effectiveness.

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