MILLING TEST RESULTS OF DIFFERENT WHEAT VARIETIES

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The grain and laboratory prepared flour from twenty samples of wheat varieties from twelve countries (harvest 2003 – international breeding test CIMMYT) was examined. The quality of the grain (bulk density, protein and wet gluten content, Falling Number, Zeleny test), the milling parameters (yield of semolina, yield of flours, extraction rate) and the quality of the flour (ash, protein and wet gluten content, Falling Number, Zeleny test) were determined. Modified wheat preparation operations and standard milling test with mill CD1 auto (Chopin) allowed to divide tested wheat into three groups according to their milling parameters and predicted their baking strength. The best milling parameters (extraction rate higher than 73%) were found for the varieties Ebi (GB), Bezostaja (RUS), MvEmese (HUN), Flamalb (ROM) and Intrada (US), kernel of which had bulk density higher than 85 $kg.hl^{-1}$, hardness higher than 52 units and ash content lower than 1.84%. Laboratory milled flour from these wheat provided bread with specific volume higher than 400 cm^3 per 100 g. Czech varieties belonged to the sets of wheat with worse milling quality (flour yield lower than 68%, bread volume lower than 350 cm^3 per 100 g). An important correlation (r = 0.59–0.79) significant at 0.01 level has been found between milling parameters and kernel hardness, flour protein content, farinograph water absorption and specific bread volume.

wheat varieties; mill CD1 auto; milling test; flour

INTRODUCTION

Experimental milling procedures are an integral part of wheat quality evaluation programs. However, these tests are barely designed to emulate exactly commercial milling processes. But, to be effective, an experimental milling must produce milled products in yield and end-use processing potential to those prepared by commercial mills. There are two requirements for production usable laboratory milled flour: careful wheat preparation before milling and similar flour composition (Dubois, Juhue, 2000).

The level of tempering required depends both on the initial moisture content of the grains and on their hardness. Generally, 16.5% moisture content is recommended for semi-hard wheat. Added water must be distributed as uniformly as possible over the surface of the grains. Homogeneity in tempering is important as well as the resting time (time between tempering and milling steps) which vary depending on the kernel structure. However, if tempering has been performed carefully, 15–24 hours rest period is appropriate (Pomeranz et al., 1985).

Three properties are affected by milling, including protein content, enzyme activity, and starch damage. As protein content increases from the centre to the periphery (the difference can vary from 50 to 60%), its quality, as expressed in baking strength, decreases significantly. Analyses of the flour stream on the milling diagram corroborates this observation. Most of the enzymes present in wheat grain are located in the aleurone layer, the peripheral part of the kernel, and in the germ. After reduction milling steps, enzymatic activity is higher than in flour from the break passage. The amount of starch damage has a large influence on the water absorption capacity of flour at various consistencies, resulting in different rheological parameters. In experimental mills, it is important to maintain the balance between flour produced by corrugated rolls and smooth rolls. According to these effects, the flour composition after milling test must contain proportions (central, middle and peripheral parts of kernel endosperm) equivalent to commercially milled flour (Jeffers et al., 1977).

Milling parameters evaluation of wheat varieties belongs to EU system of wheat grading to four quality classes (E – excellent, A – very good, B – good for breadmaking, and C – no for food processing use) according to the yield of flour with ash content to 0.55%. Czech system of wheat variety grading does not include yet this wheat characteristic, because of lack of standard milling test procedure and specification of laboratory mill equipment (Novotný, Jurečka, 1997).

The aim of the work was to compare the milling quality of twenty different wheat varieties by a standard milling test and their relations to kernel and flour parameters. Milling quality of Czech varieties was compared with foreign wheat samples.

MATERIAL AND METHODS

Twenty samples of winter wheat varieties coming from twelve countries (including four variety of Czech breeding) and the same planting production were obtained from an international compared plant experiment CIMMYT (harvest at 2003).

Wheat variety name and its origin are as follows:
Samanta, Vlasta, Šárka, SG-S1511-99 (Czech Republic),
Intrada, Jagger, TUBBS, OK 97908 (United States),
Prijma, MvEmese (Hungaria), Volnyskaja, Lutescens (Ukraina),
Flamalb (Romania), Maria (Bulgaria), Venera (Yugoslavia),
Bezostaja 1 (Russia), Ebi (Great Britain), WA 476/3 (Turkey),
Akinci 84 (Aserbaidchan), Oktjabrina 70 (Kazaschtan).

Grain quality was evaluated by bulk density (Czech Standard 461011), wet gluten, ash and protein content, hardness (Inframatic 8620, Perten Instruments), Zeleny test (ISO 5529) and Falling Number (ISO 3093).

Wheat samples were manually cleaned and all impurities must be completely eliminated before tempering. Moisture content was determined according to the standard method (ČSN 461011-4) and water addition brings the moisture content to the required 16.5%. The following tempering process was provided with a rotary mixer BS-PO3 (CZ) at the glass container. Thirty minutes motion is necessary for the water to be uniformly distributed over the grain surface. Wheat sample in a container hermetically closed was left to rest in a cool, dry cabinet for 16 hr.

CD1 auto mill presents the automatic laboratory mill for production of flour and consists of one breaking side (made up of three fixed and fluted cylinders, assuring two milling passes and sifting by means of centrifugal helter with fixed sieve) and one reduction side (composed of two smooth rolls with adjustable pressure assuring one pass and sifting by means of centrifugal helter with fixed sieve). The pneumatic conveyor is used for lifting meal and middlings from the break to reduction mill side. With comparison of another laboratory mills, there are further advantages as automatic detection of end-grinding by means of infrared system, display of the milling flow, adjustable aspiration speed and meal feed screw, emptying system preventing pollution of the following test and arrangement of two working regime (Chopin protocol and individual protocol).

All wheat varieties were milled in a CD1 auto mill (Chopin, France) divided into four parts of each sample (single sample weight 530 g – Chopin protocol). Laboratory prepared flours were mixed for 15 min with a rotary mixer BS-P03 and then allowed to equilibrate for two days before quality testing.

The flours were examined for moisture content, wet gluten, ash, protein content (Inframatic 8620 Ash, Perten Instruments), Zeleny test (ISO 5529), Falling Number (ISO 3093). After ten days resting, farinograph test (ISO 55 30-1) and the laboratory breads were made (Czech baking test). Loaf volume was measured by rapeseeds displacement after two hours of cooling.

Milling wheat quality was usually described by six parameters (AACC, 2001). Milling yield of break flour, reduction flour, bran and shorts is simply defined as the proportion of these products by weight, derived by milling test, from a quantity of milled wheat usually computed at 14% of moisture. Extraction rate is defined as the amount of all obtained flour (break and reduction parts) from a quantity of milled wheat usually expressed at dry matter (Dubois, Juhue, 2000). Flour ash content and total yield of flour can be used to calculate a parameter "yield of Mohse", the number expressed ideal milling result with comparison of commercial measurement (Hampl, 1988).

The parameters of wheat kernel and flour quality, the results of milling test, farinograph absorption and baking test results are presented as average, range of min. and max. values and statistical description (standard deviation, c.v.). The relation between the milling parameters and the results of kernel and flour quality was evaluated using correlation analysis.

RESULT AND DISCUSSION

Kernel quality parameters determined by standard methods are given in Table 1 and for each of them important difference for single tested varieties were found. Mean values for all sets of samples corresponded to good quality class A (Novotný, Jurečka, 1997). Only for three wheat varieties lower bulk density than Czech standard required (78 kg.hl^{-1}) (Fig. 1) was measured. According to hardness value tested varieties can be divided into semi-hard (lower than 45 units) and soft. Hardness significantly correlated with all milling characteristics but no important relation to bulk density was

Table 1. Wheat quality parameters

Parameter		Mean value	Range of results	Standard deviation	c.v.
Bulk density	(kg.hl^{-1})	83	74–90	4.462	5.395
Hardness	(NIR unit)	50	41–56	4.948	9.857
Ash content	(% d.m.)	1.82	1.67–1.95	0.084	4.598
Protein	(% d.m.)	14.2	12.8–15.3	0.698	4.930
Wet gluten	(% d.m.)	28.9	24.9–32.1	2.071	7.177
Zeleny test	(ml)	58	42–69	8.621	14.788
Falling Number	(s)	341	195–419	65.254	19.136

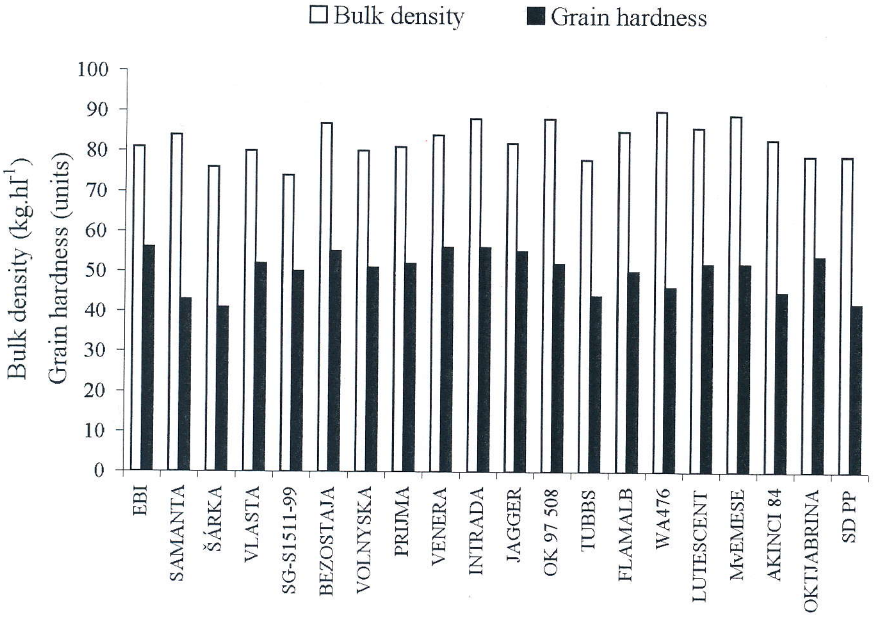

Fig. 1. Bulk density and grain hardness

found. Grain ash content varied with the wide range 1.67–1.95% and its significant negative correlation to bulk density was proved. Czech varieties can be described with the lower protein and wet gluten content. As Zeleny value shows, its quality is only average with comparison to foreign samples. Falling Number has the greatest variability from all kernel parameters (c.v. = 19.136%). For seventy per cent of samples value higher than 300 s were measured, which grain amylase activity is expressed as maximum for good milling flour parameters.

Milling condition for the Chopin CD 1 mill, above all the sample size for milling, was studied by Paszczynska et al. (1999) has a large effect on flour yield, ash and protein content of flours. Lowering the sample size from standard 530g resulted in decrease of milling yields.

Standard milling test at CD1 auto mill confirmed expressive different milling parameters of single varieties (Table 2) and all of them (yields of break and reduction flour, bran and midlings) varied in wide range (c.v. = 11.128–20.702%). Negative correlation between yields of break and reduction flour was calculated ($r = -0.974$). As it is obvious from Fig. 2, only for five samples yield of break flour was found higher than yield of reduction flour. The occurrence of this feature is connected with hardness of kernel endosperm, for these varieties hardness was measured lower than 45 units. The harder wheat is, the higher yield of reduction flour and the extraction rate are obtained. For example, variety Ebi with the highest extraction rate (75.4%) has hardness 56 units, low yield of break flour (25.5%) and high yield of reduction flour (48.5%). Significant correlation of all milling parameters with kernel hardness was proved (Table 5), negative for break flour ($r = -0.91$) and positive for reduction flour and extraction rate ($r = 0.905$ and 0.705). The yield flour of Mohse can be used for prediction of industrial wheat milling effect, which connects yield and ash content of flour. Probably for the half of tested varieties had calculated positive value of Mohse, so good results at commercial milling can be predicted.

All laboratory prepared flours met the Czech requirements for smooth bright flour (Table 3). Ash content and protein content varied in wide range (0.50–0.60%, 10.5–14.2%). Ash content correlated negatively with bulk density of grain ($r = -0.555$). The highest protein content was measured for the variety OK 97 (13.8%) and Lutescens (14.2%). Significant correlations were found between flour protein content, grain hardness and all milling parameters (Table 5). Zeleny test and Falling Number value of flours corresponded with these measured for kernels. The water absorption (measured on the farinograph) varied in range 48.2–66.4%, which shows on the presence of weak and strong flours. The highest value was obtained for the variety Prijma (66.4%), the

Table 2. Milling quality parameters

Parameter		Mean value	Range of results	Standard deviation	c.v.
Yield of break flour	(14% m.m.)	30.1	23.8–43.6	6.074	20.182
Yield of reduction flour	(14% m.m.)	40.3	17.4–48.5	8.352	20.702
Yield of bran	(14% m.m.)	16.5	14.1–21.1	1.834	11.128
Yield of shorts	(14% m.m.)	10.2	7.3–12.9	1.780	17.522
Yield of Mohse		1.3	–9.1–8.9	4.187	312.79
Extraction rate	(% d.m.)	71.8	61.8–75.4	2.979	4.148

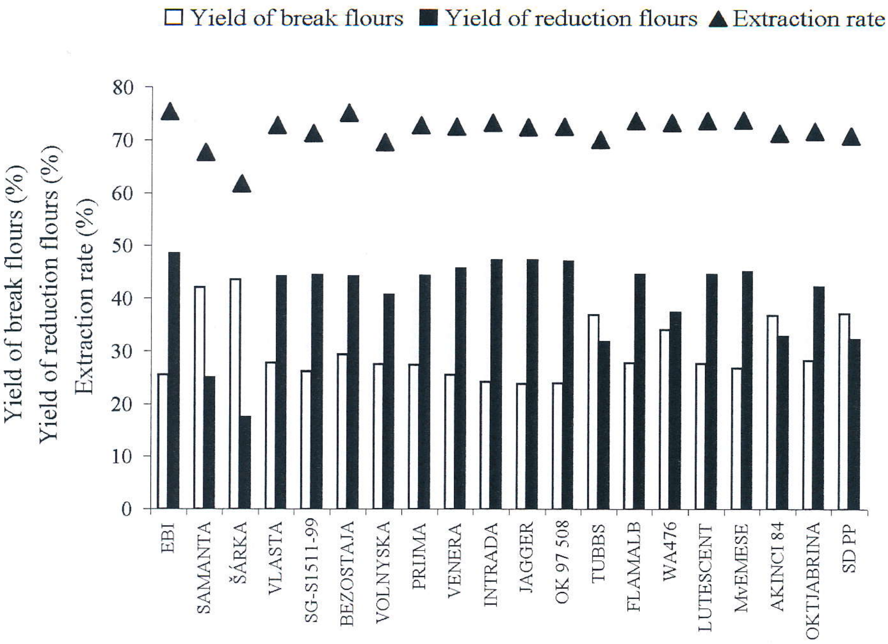

Fig. 2. Milling parameters of wheat parameters

lowest one for the variety Vlasta (48.3%). Statistically important relations of water absorption to grain hardness, milling parameters (negative correlation to yield of break flour) and flour protein content were proved. B o n a et al. (2001) proposed important correlation (r = 0.46) between water absorption and yield of flour from eighty Hungarian wheat varieties from 2000 year's harvest.

Loaf volume as important direct parameter of wheat baking quality was ascertained at range 311–438 cm^3 per 100 g and its average value of tested set corresponded to wheat class A. The highest specific bread volume provided flour with the Czech variety CS S1511-99. Significant correlation of bread volume to flour protein content (r = 0.572), yield of break flour (r = –0.604) and reduction flour (r = 0.559) were found. No correlation between bread volume and water absorption was found as declared K o n o p k a et al. (2004) for Polish wheat of A and B classes. The relation of extraction rate and specific bread volume is obvious from Fig. 3, which illustrated that varieties with extraction rate higher than 73% provided mostly breads with volume higher than 400 cm^3 per 100 g.

After the extraction rate, the set of wheat was divided into three groups (Table 4). The group with extraction higher than 73% contains seven sample, middle set (70–73%) ten samples and group with the worst extraction rate (lower than 70%) only three samples. To these milling characteristics of wheat can be added other grain and flour feature, as bulk and loaf volume (for the first set higher than 400 cm^2 per 100 g). However, in the second group some varieties were classified with worse milling parameters, but their baking quality was very good (for example SG S1511-99 and OK 97). As wheat breeders confirm, technological quality of wheat consists of many milling and baking characteristics, some of them can sometimes work against each others, so wheat quality class form their compromise.

Czech wheat samples can be described by lower bulk density and hardness, which corresponded to worse milling parameters (specially Samanta and Šárka belonged to the third group). For these varieties, the highest yield of break flour was obtained (42.1% and 43.6%). Their baking quality was characterised lower protein content, low water absorption and at bread test small bread volume was obtained. Varieties Vlasta and SG S1511-99, classified to the second group, had harder endosperm structure, what is connected with higher yield of reduction flour (44%), average water absorption (60%) and according to bread volume they belong to wheat varieties of middle baking quality.

Table 3. Flour quality parameters

Parameter		Mean value	Range of results	Standard deviation	c.v.
Moisture	(%)	14.9	14.2–15.7	0.411	2.759
Ash content	(% d.m.)	0.50	0.50–0.60	0.027	4.914
Protein	(% d.m.)	12.4	10.8–14.2	0.778	6.283
Wet gluten	(% d.m.)	36.1	31.8–41.5	2.263	6.270
Falling Number	(s)	370	234–450	55.959	15.130
Water absorption	(%)	58.1	48.2–66.4	4.749	8.170
Bread volume	(cm^3/100 g)	381	311–438	33.134	8.703

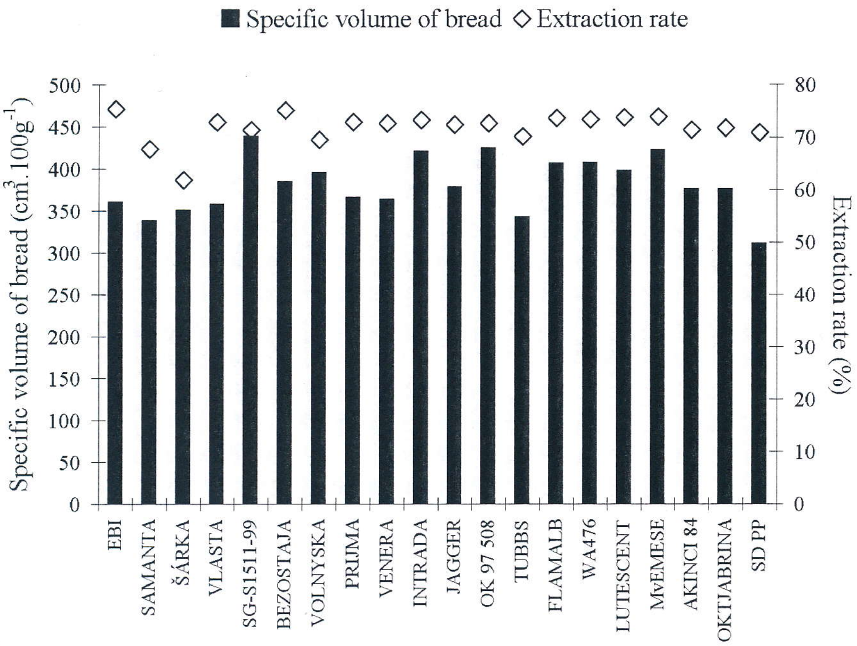

Fig. 3. Extraction rate and specific volume of bread

Table 4. Variety sets according to extraction rate value

Set/extraction rate	Variety name
1 Higher than 73%	Ebi, Bezostaja, Intrada, WA 476, MvEmese, Lutescsent, Flamalb
2 Range 70–73%	Vlasta, SG S1511-99, Prijma, Venera, Jagger, OK 97, TUBBS, Akinci 84, Oktjabrina, SD PP
3 Lower than 70%	Samanta, Šárka, Volnyska

Table 5. Correlation of milling characteristics, kernel and flour parameters

		1	2	3	4	5	6	7	8	8	10	11
Bulk density	1	1										
Hardness	2	0.3080	1									
Protein of grain	3	0.2549	0.4042	1								
Ash of grain	4	–0.5558	–0.3852	–0.4439	1							
Yield of break flour	5	–0.2665	**–0.9141**	**–0.4845**	0.4536	1						
Yield of reduction flour	6	0.3536	**0.9050**	***0.4750***	–0.5041	**–0.9742**	1					
Extraction rate	7	***0.5316***	**0.7054**	0.3964	–0.5687	**–0.7294**	**0.8631**	1				
Ash of flour	8	***–0.5546***	–0.4461	–0.0565	**0.5950**	0.3702	–0.3785	–0.3432	1			
Protein of flour	9	0.2563	**0.6022**	**0.6566**	–0.3549	**–0.7308**	**0.7243**	**0.5841**	–0.0675	1		
Water absorption	10	0.0303	**0.7630**	0.3312	–0.0460	**–0.7968**	**0.7638**	***0.5139***	–0.0500	***0.5504***	1	
Specific bread volume	11	0.4208	0.4522	0.2571	–0.3901	**–0.6044**	***0.5597***	0.3845	–0.3595	***0.5723***	0.4342	1

$r_{krit\ 0.05}$ = ***0.4555***, $r_{krit\ 0.01}$ = **0.5751**

The known inter-relationships between some physical properties and the technological quality of wheat grain are used in practice for the prediction of its commercial suitability. Comparison of the data obtained for Czech and foreign wheat varieties showed only approximate results (valid exactly for 2003 harvest) because of different climatic conditions of the year growing, which strongly influenced the grain properties (Sadowska et al., 2003).

CONCLUSION

Evaluation of grain quality, milling parameters and quality of flour obtained in the milling test for a set of twenty different varieties coming from twelve countries with different breeding and the same planting conditions made possible to compare technological quality of four Czech wheat. According to milling characteristics (extraction rate higher than 73%, 70–73% and lower than

70%), three groups of wheat were classified. To these wheat sets belong different baking parameters of flour, especially protein content, farinograph absorption and bread volume. However, in the widest second the set variety with worse milling and good baking parameters can be found and vice versa. Significant correlations were obtained between the milling parameters, grain hardness, flour water absorption and specific bread volume.

All Czech varieties represented the species of weak wheat and Samanta and Šárka milling parameters were evaluated as worse in the tested set. Vlasta and SG S1511-99 belong to wheat of middle milling and baking strength. According to the Czech grading system these wheat varieties were classified as classes A and B.

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Received for publication on May 30, 2004
Accepted for publication on August 2, 2004

HRUŠKOVÁ, M. – ŠVEC, I. – JIRSA, O. (Vysoká škola chemicko-technologická, Ústav chemie a technologie sacharidů, Praha, Česká republika):

Výsledky mlýnského pokusu s různými odrůdami pšenice.

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Předmětem sledování byly vlastnosti zrna a laboratorně připravené mouky z 20 vzorků odrůd pšenice (sklizeň 2003 – mezinárodní šlechtitelský pokus CIMMYT). Kvalita zrna (objemová hmotnost, obsah bílkovin a mokrého lepku, číslo poklesu a Zelenyho test) a mlynářské znaky (výtěžnost krupic a mouk) a kvalita mouky (obsah popela, bílkovin a mokrého lepku, číslo poklesu a Zelenyho test) byly zjištěny standardními metodami. Příprava zrna před mletím a standardní mlecí pokus na laboratorním mlýně CD1 auto (Chopin) umožňují rozdělit soubor odrůd do tří skupin podle jejich mlynářských znaků a následně podle pekařské síly. Nejlepší výsledky (výtěžnost mouk vyšší než 73 %) vykazovaly odrůdy Ebi (Velká Británie), Bezostaja (Rusko), MvEmese (Maďarsko), Flamalb (Rumunsko) a Intrada (USA). Také jejich další jakostní znaky byly nadprůměrné (objemová hmotnost vyšší než 85 $kg.hl^{-1}$, tvrdost vyšší než 52 jednotek, obsah popela v zrnu nižší než 1,84 %). Z mouky těchto pšenic bylo vyrobeno pečivo s měrným objemem nad 400 cm^3 na 100 g. České odrůdy byly zařazeny do skupiny s průměrnými a horšími mlýnskými znaky. Statisticky průkazné korelace (r = 0,59–0,79) na hladině významnosti 99 % byly nalezeny pro vztah mlýnských parametrů, tvrdosti zrna, obsah popela v mouce, farinografickou vaznost a měrný objem pečiva.

odrůdy pšenice; mlýnský pokus; laboratorní mlýn CD1 auto; pšeničná mouka

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