Wheat and Flour Quality Relations in a Commercial Mill

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Abstract

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The bread-making quality of forty commercial winter wheat samples, grown in the western region of the Czech Republic, and their flours (white flours with ash content of about 0.5%) prepared in a commercial mill was studied. Standard analytical methods (ash and protein content, wet gluten), amylolytic activity measurement (falling number), rheological investigation (alveograph, gluten index), sedimentation test and laboratory baking test were used for characterization of wheats and flours. In addition NIR method was used to calculate ash, wet gluten, sedimentation value and protein content. Statistically significant correlations were found practically between all tested quality parameters of wheat and corresponding flour samples. However, the strongest correlation (r = 0.69–0.70) significant at 0.01 level exists between specific bread volume and protein and wet gluten content, determined both by standard or by NIR methods.

Keywords: wheat quality; flour quality; flour characteristic; specific bread volume; NIR

Baking quality of wheat flour described by means of analytical and rheological parameters is influenced mostly by wheat characteristics and milling process. Wheat quality depends on cultivar, climatic conditions, year and process of harvest and storage attendance (PŘÍHODA 1980; HUBÍK & NOVOTNÝ 1997). The mill industry requires uniform grain lots to predict milling and baking product quality and therefore the wheat parameter standardization before milling needs permanent examination.

Standard methods of wheat quality determination are mostly time-consuming and do not conform to a mill process. Screening methods are used to assess many quality parameters from a small amount of samples in a short time. NIR analysis of wheat and flour is aimed at the determination of moisture, ash, protein, wet gluten content and some quality characteristics (HRUŠKOVÁ 1995a). Most cereal laboratories are equipped with reflectance instruments using filter wheels or tilted filters. The disadvantage of filter instruments is their limited ability to use different spectral regions that correspond to the known absorption bands of common constituents of the material.

One of the aims of cereal research is to describe wheat technological quality by the number of parameters as small as possible to accelerate the process of wheat evaluation during mill supply (MANEV *et al*. 1994). Therefore, replacement ability of quality parameters and relations between wheat, flour and end-use product quality are essential for the cereal industry (TIPPLES *et al*. 1974; RUBENTHALER & POMERANZ 1984; BRANLARD *et al*. 1991; HUBÍK & NOVOTNÝ 1997). Prediction of baking product quality directly from wheat parameters helps to exclude unsuitable batches and to prepare an optimal storage and mixing system before the milling process.

Several reports were published concerning the relations between quality of wheat and corresponding flour but their generalization was limited by dependence on origin, growth year and cultivar. In addition, the results obtained in laboratory conditions or in a set of samples of wheat variety only were mostly different from the results of industry testing of commercial wheat.

BRANLARD *et al*. (1991) found a conclusive relation between sedimentation (SDS) value of wheat and baking volume of bread at 46 samples of French soft wheat. PERTEN *et al*. (1992) described a significant correlation between wheat protein content and flour wet gluten content. The dependence between wheat gluten quality and flour gluten quality determined by means of Glutomatic (expressed as Gluten Index – GI) was not proved (PERTEN 1990). MANEV *et al*. (1996) evidenced a negative relation between GI of Czech wheat and flour wet gluten content. These results agreed with the investigations of HOMMO *et al*. (1991), who found a negative correlation of wheat GI to baking bread volume in two sets of Finnish wheat samples. Wheat protein and wet gluten content significantly correlated with specific bread volume (TIPPLES *et al*. 1974; PŘÍHODA 1980; RUBENTHALER *et al*. 1987; OHM *et al*. 1998). The evidence of relations depends on the testing methods used, above all on baking test.

As for rheological tests, PŘÍHODA (1980) proved positive correlations of farinograph water absorption and extensigraph extensibility to specific bread baking volume in Czech flour samples from harvests 1978 and 1979. BRANLARD *et al*. (1991) reported an important positive correlation between bread volume and alveograph energy in French winter wheat. Relations between SDS value of wheat and Zeleny value of corresponding flour were also demonstrated (HRUŠKOVÁ *et al*. 1998).

The objective of this study was to monitor relations between wheat and corresponding flour composition, rheological behaviour, and experimentally baked products in conditions of a Czech commercial mill.

MATERIALS AND METHODS

Forty samples of winter wheat from the harvest 1999 were taken from a commercial mill during five months. Wheat sampling was done every day at the same time before the first milling machine. White fine flour produced from this wheat was received by daily containers with time delay necessary for the milling technological process. The schedule of sampling made sure that samples of flours corresponded to samples of wheat with accuracy consistent with the technical and technological possibilities of the mill.

Wheat and flours were analysed on the same day as the sampling. Wheat and flour quality was determined according to Czech standard methods (wet gluten, its extensibility and elasticity – after hand washing and wet gluten including GI – according to ICC 155 at Glutomatic 2 2000 (Perten, Sweden), Falling Number according to ISO 3093 at FN (Perten, Sweden), SDS value – according to Czech standard 460102 at SEDI-tester and by means of NIR spectrophotometer Inframatic 8600, Perten (ash, wet gluten and protein content – according to Czech standard methods).

The rheological properties of flour were evaluated by means of alveograph MA 95 (Tripette, France) according to ISO 55 30.

The baking test was performed according to RMT methods with modifications (the used prescription was: flour 100%, dried yeast 0.8%, salt 2%, sugar 0.5%, vegetable oil 3% and water necessary for optimal consistency).

The dough from 2000 g of flour was prepared in mixer Diosna SP 24 (Dierks, Germany). Dough dividing into sixty pieces was made in Fortuna divider (Schoder, Germany). Czech machines were used for roll shaping and baking at 230°C for 12 min.

Bread volume was determined after two hours of cooling by means of rape seeds.

The prediction of specific bread volume from wheat and corresponding flour was made by NIR instrument too (Czech standard method).

At least two independent measurements per sample were made for each quality parameter tested, and the values were averaged for standard statistical analyses. The dependence between quality parameters of wheat and corresponding flour was evaluated using correlation coefficient *r* (critical value = 0.393 for forty samples). The mean standard of dependence was determined in the range r = 0.5–0.8.

RESULTS AND DISCUSSION

Wheat quality parameters determined by standard methods are reported in Table 1 and by NIR measurement in Table 2. Wheat quality was very similar in the test period

Table1. Average values of wheat quality parameters determined by standard methods

Parameter	Average	Minimum	Maximum	S.D.	Variation
OH (g/ml)	797	780	815	7.883	0.99
FN (s)	280	209	372	40.253	14.38
SDS (ml)	63	58	69	3.032	4.81
G_0 (%)	26.6	24.9	29.9	0.972	3.65
T_0 (mm)	115	85	145	15.325	13.33
P_0 (cm)	3	2	4	0.675	22.49
GG (%)	28.1	24.6	30.6	1.142	4.06
GI	67	52	83	8.085	12.07

OH – test weight
FN – falling number
SDS – sedimentation value
G_0 – wheat wet gluten content
T_0 – wheat gluten extensibility

Table 2. Average values of wheat parameters determined by NIR spectroscopy

Parameter	Average	Minimum	Maximum	S.D.	Variation
Pop (%)	1.45	1.28	1.83	0.113	7.81
SDS (ml)	60	54	66	2.378	3.99
G_0 (%)	24.9	23.8	26.0	0.627	2.52
N (%)	11.7	11.3	12.1	0.239	2.04

Pop – wheat ash content
G_0 – wheat wet gluten content
SDS – sedimentation value
N – protein content (N × 5.7)

and average values were typical of the Czech production environment (wheat test weight 780–815 g/l, protein 11.3–12.1%, wet gluten 24.9–29.9%). Wet gluten content assessed by Glutomatic was approximately about 5% higher than by hand washing. On the other hand, NIR values of wet gluten were found lower in all samples. These differences, as reported previously (PŘÍHODA *et al*. 1994), were due to a degree of washing and surface water removing by the reference method used for NIR gluten calibration. SDS value was measured with the accuracy which is suitable to predict from spectral analyses. PEKÁRKOVÁ & HRUŠKOVÁ (1999) determined three millilitre differences between the measured and computed data of wheat SDS value in NIR System 6500. According to GI (average 67 units) and SDS (average 63 ml) parameters the average wheat protein quality was evaluated as satisfactory for the environmental factors of 1999 harvest.

The flour quality parameters determined by standard methods (Table 3) and by NIR measurement (Table 4) appeared to be optimal for the manufacture of yeast leavened dough in an industrial bakery (ash 0.53–0.62%, wet gluten 30.3–35.6%, GI 68–97 units, FN 193–297 s). The flour rheological properties measured with an alveograph (Table 5) appeared to be well balanced as far as extensibility and elasticity are concerned. According to alveograph energy, the tested flour samples were suitable for bread baking (average 188). As a result, the nearly same specific bread volumes were obtained by a laboratory baking test (average 575 ml per 100 g of flour) and by NIR calculated from flour samples (average 576 ml per 100 g of flour) (Table 6). In the case of NIR prediction

Table 3. Average values of flour parameters determined by standard methods

Parameter	Average	Minimum	Maximum	S.D.	Variation
FN (s)	247	193	297	27.981	11.34
G_{30} (%)	32.8	30.3	35.6	1.286	3.92
T_{30} (mm)	134	100	170	16.757	12.51
P_{30} (cm)	2	1	4	0.819	40.97
GG (%)	29.9	26.4	34.7	1.590	5.32
GI	82	68	97	7.093	8.65

FN – falling number
T_{30} – flour gluten extensibility
GG – glutomatic wet gluten content
G_{30} – flour wet gluten content
P_{30} – flour gluten elasticity
GI – gluten index

Table 4. Average results of flour quality according to NIR spetroscopy

Parameter	Average	Minimum	Maximum	S.D.	Variation
Pop (%)	0.57	0.53	0.62	0.026	4.54
G_{30} (%)	31.3	29.4	33.2	0.926	2.96

Pop – flour ash content
G_{30} – flour wet gluten content

Table 5. Average results of alveograph parameters

Parameter	Average	Minimum	Maximum	S.D.	Variation
P (mm)	72.1	51.0	83.6	6.907	9.58
L (mm)	69	54	90	8.607	12.47
P/L	1.07	0.57	1.55	0.198	18.54
W	188	151	232	18.244	9.70

P – alveograph elasticity
L – alveograph extensibility
W – alveograph energie

Table 6. Average results of bread volume from baking test and NIR spetroscopy

Parameter	Average	Minimum	Maximum	S.D.	Variation
Mo_{pp}	575	420	672	55.007	9.57
Mo_{NIRm}	576	556	599	9.933	1.72
Mo_{NIRp}	656	631	678	10.805	1.65

Mo – specific bread volume (ml/100 g flour or groat)
Mo_{pp} – from standard baking test
Mo_{NIRm} – from flour according to NIR measurement
Mo_{NIRp} – from groat according to NIR measurement

from wheat groats, bread volume was higher approximately by 14% than the same characteristics obtained from corresponding flour. The difference can be explained by NIR instrument calibration, which depends on a special reference baking test for ground wheat. The bread volumes are important for wheat mixing before milling.

Wheat and corresponding flour quality parameters were assessed in order to find the ability to replace each other and a possibility to predict main flour characteristics from the wheat ones in conditions of a commercial mill. The substitute characteristics of wheat and flour can be determined from their statistical correlations. A statistically significant correlation was found between wheat and corresponding flour wet gluten content (r = 0.44, Fig. 1) as reported by PŘÍHODA (1980). Wet gluten quality described by GI value is a significant characteristic for wheat

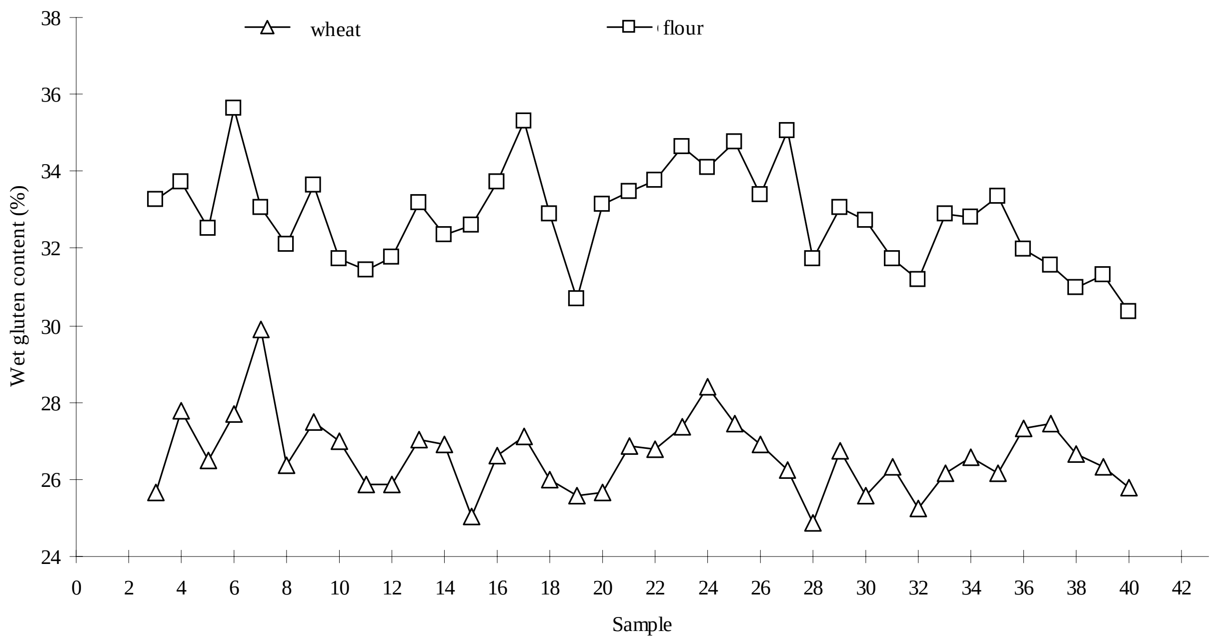

Fig. 1. Wheat and flour wet gluten content according to standatd method (hand washing) (r = 0.44)

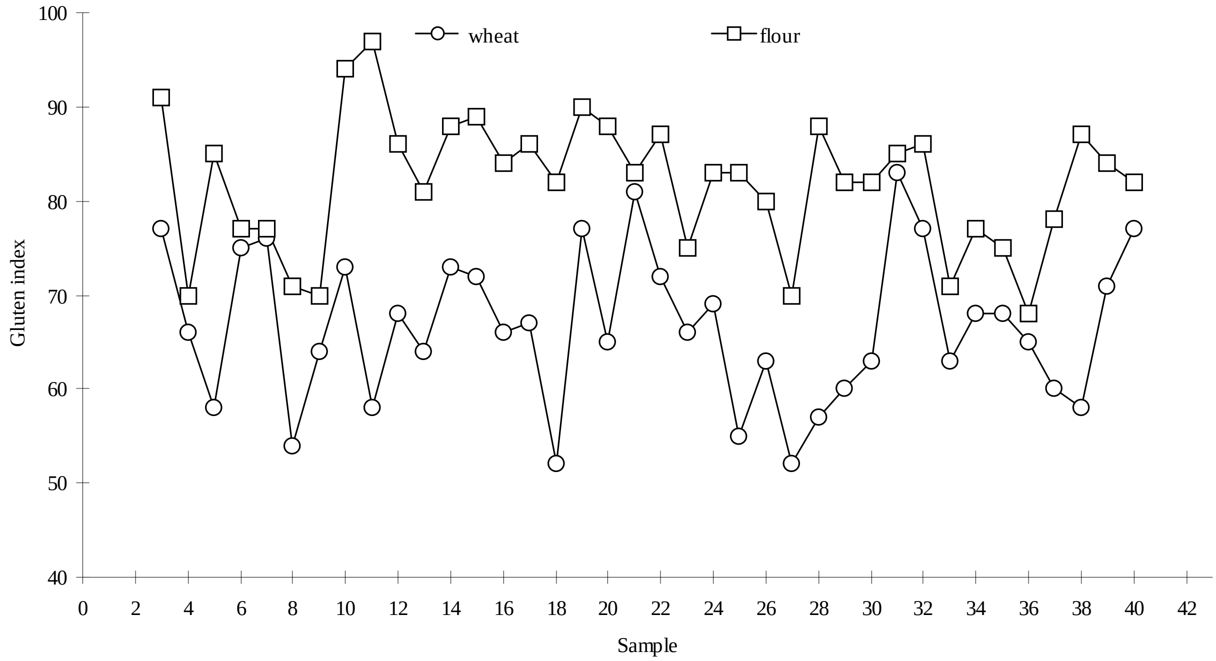

Fig. 2. Wheat and flour Gluten Index on Glutomatic 2 2000 (r = 0.44)

and flour, but their values differed approximately by 15 % (Fig. 2).

Significant correlations were found practically between all tested quality parameters of wheat and corresponding flour samples at 0.01 level:

1. negative correlation between elasticity of wheat wet gluten and extensibility of flour wet gluten (r = –0.53)
2. positive correlation between wheat GI and alveograph ratio (r = 0.52)
3. positive correlation between wheat wet gluten according to Glutomatic measurement and bread volume according to NIR measurement (r = 0.54)
4. wheat ash content and bread volume from wheat groats according to NIR measurement (r = 0.59)

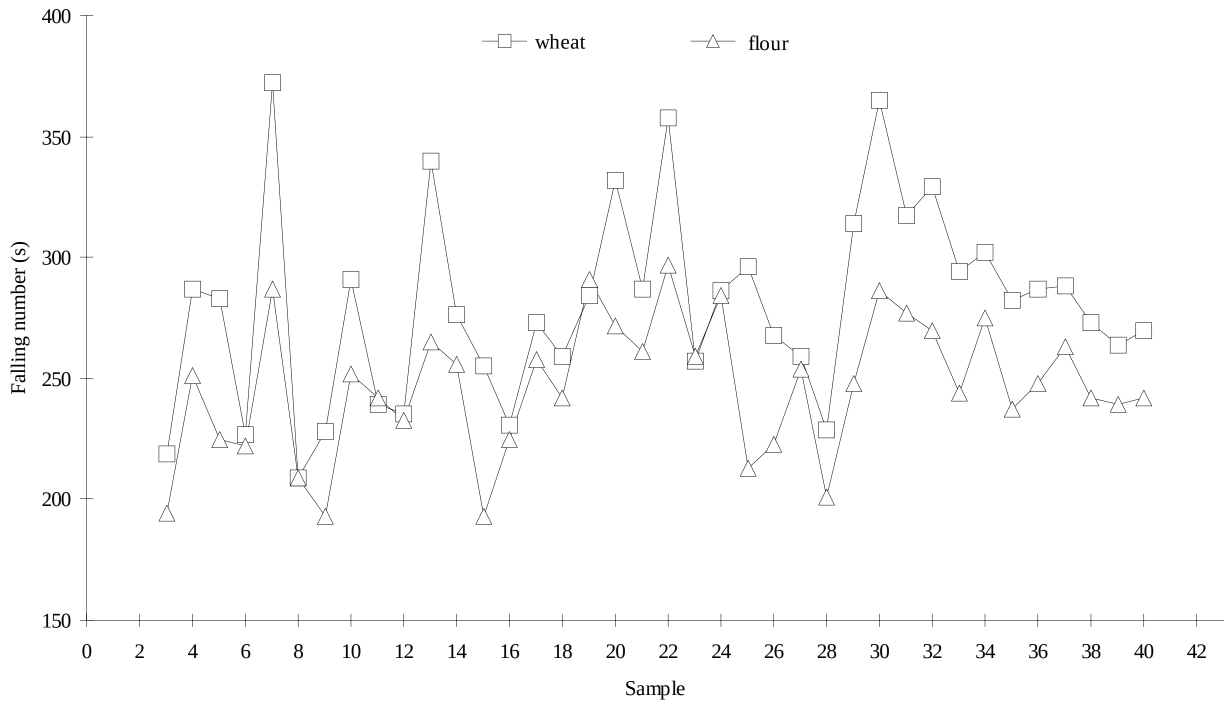

Fig. 3. Wheat and flour falling number (r = 0.76)

5. wheat wet gluten content and flour wet gluten content according to NIR measurement (r = 0.68)
6. wheat wet gluten content and bread volume according to NIR measurement (r = 0.69)
7. flour protein and wet gluten content according to NIR measurement (r = 0.69)
8. wheat wet gluten content and bread volume from groats according to NIR measurement (r = 0.70)
9. wheat protein content and bread volume from groats according to NIR measurement (r = 0.71)
10. wheat wet gluten and bread volume from flour according to NIR measurement (r = 0.71)
11. falling number of wheat and flour (r = 0.76).

Bread volume from groats and flour were highly influenced by both protein quantity and protein quality, as reported previously. The correlation coefficient depends on the set of samples and methods of analysis (comparison of the determination of wet gluten and protein content by reference and NIR tests). The negative relation between wheat wet gluten elasticity and flour wet gluten extensibility was reported by MANEV *et al*. (1994) in wheat variety samples.

The correlation of wheat GI characteristics with alveograph ratio describing the flour viscoelastic behaviour was mentioned by BRANLARD *et al*. (1991).

The relationship between wheat ash content and bread volume from groats according to NIR measurement appears to be important for wheat breeding where ash is an indicator of the proportion of bran in grain.

The relation between wheat falling number and flour falling number was evident, but the differences between them depend on the grinding process (HRUŠKOVÁ 1995b) (Fig. 3).

Significant correlations between wheat and flour quality parameters were used for their replacement and to simplify the quality control system in an industrial mill.

Conclusions

Wheat technological quality and parameters of corresponding white flour obtained in a commercial Czech mill were described by means of usual analytical and rheological methods including a laboratory baking test. The relationships between the results of measurements were analysed with an objective to quickly predict bread volume from commercially prepared flour. The correlation coefficients were calculated between wheat and corresponding flour analytical and rheological characteristics and volume of experimentally baked product. A significant, positive correlation was determined between protein content and specific bread volume regardless of their measurement. Similar results were obtained for wet gluten content although the correlations were slightly lower in magnitude. Based on wheat composition and wheat gluten quality, corresponding flour and end-use product quality can be estimated.

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Souhrn

HRUŠKOVÁ M., HANZLÍKOVÁ K., VARÁČEK P. (2000): **Vztahy jakosti potravinářské pšenice a pšeničné mouky zjištěné v podmínkách průmyslového mlýna**. Czech J. Food Sci., **19**: 189–195.

Soubor 40 vzorků potravinářské pšenice a z ní vyrobené pekařské mouky speciál hladké v podmínkách průmyslového mlýna je charakterizován analytickými a reologickými ukazateli, které byly zjištěny referenčními metodami a pomocí NIR spektrofotometru Inframatic 8600. Jakost mouky je také hodnocena měrným objemem pečiva stanoveným modifikovanou RMT metodou. Mezi jakostními znaky pšenice a mouky bylo zjištěno 11 statisticky průkazných korelací lineárního charakteru. Obsah bílkovin a mokrého lepku pšenice nejvíce ovlivňují objem pečiva.

Klíčová slova: potravinářská pšenice; jakostní znaky; pšeničná mouka; měrný objem pečiva; korelace

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