Wheat Sedimentation Values and Falling Number

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Abstract

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Technological quality of wheat from 2001 and 2002 harvests and its changes in the course of one-year storage were evaluated using protein content, SDS and Zeleny tests and falling number. Average values from the analyses of ten partial samples that were taken from five Central Bohemian producers (beet-producing region) during the period of eleven months (from October to August) characterise wheat standard quality for the mill processing and it is possible to explain their variations by the effect of the harvest year in the comparable wheat variety composition. With regard to similar climatic conditions of the years 2001 and 2002, there were not found any marked differences in protein content (2001 – average 12.4%, 2002 – average 12.8%) and Zeleny test (2001 – average 52 ml, 2002 – average 55 ml) but the falling number was significantly different (2001 – average 321 s, 2002 – average 287 s). During the storage time in agricultural operations no conclusive changes in protein content were found though protein quality slightly decreased according to the SDS and Zeleny test values. Falling number values of wheat from 2001 harvest slightly increased, which was not evidential for the set of samples from 2002. Statistically significant correlations were calculated between the falling number value of wheat and its laboratory-manufactured flour in both harvest years (r = 0.556 in 2001, r = 0.825 in 2002). The value of Zeleny test significantly correlates with SDS test (r = 0.531 in 2001, r = 0.787 in 2002) as well as with protein content.

Keywords: wheat; SDS test; Zeleny test; falling number; storage

The quality of food wheat is affected by many factors, particularly variety, locality and growing conditions (weather, agricultural engineering, fertilisation) and furthermore by harvesting method, postharvest treatment and storage. Thereby it is possible to explain the differences in the technological quality of wheat industrially manufactured in various regions, various years and also during storage in agricultural operations.

Technological quality of wheat for the milling and baking use is determined by the protein quantity and quality and the state of the carbohydrate-amylase complex, thus the degree of starch damage and amylase content. The determination of these features in both the cultivation process and manufacture is carried out by common standardised methods, the results of which are the main indicators of wheat quality – protein content, sedimentation values (SDS and Zeleny test) and falling number. These parameters influence the qualities of mill and baker's products in a decisive way. In order to achieve their standard quality in established continuous manufacturing processes in mills and bakeries the stable quality of input commodities, i.e. of wheat and its flour, is preferably required.

Quality characteristics of wheat flour significantly correlate with corresponding wheat characteristics, nevertheless the milling process affects their absolute values. For example Fencík (2002) quoted the

falling number values of wheat from 2001 harvest to be by more than 30 s lower than those of its flours and they varied in dependence on the variety composition. Moot and Every (1990) found differences in the effect of amylases in various mill intermediates and he explained the higher falling number values of wheat flour in comparison with wholemeal groats to be due to the absence of covering particles and a sprout in the mill products. Differences in the determinations of SDS and Zeleny tests that describe the quality of gluten proteins according to their ability to swell and settle in a slightly acidic medium also resulted from different composition and granulation of tested components.

Food wheat is a subject of biochemical changes during the storage time that also affect the values of technological quality indicators. Changes depend on time and storage conditions and especially on wheat moisture. In a short-term wheat storage experiment (4 months at temperatures 4°C, 27°C and 37°C) a decrease in sedimentation value depending on the storage temperature was found (Srivastava & Haridas Rao 1991) while amylase activity did not practically change. Falling number increase from 407s to 412s corresponds to the accuracy of the determination method. After 15-month storage of 2 wheat varieties Lukow *et al.* (1995) found a decrease of sedimentation value and an increase of falling number regardless of the temperature of storage boxes that ranged from –4° to 25°C. At long-term wheat storage (4 years in closed containers at 20°C and RH 74%) (Warchalewski *et al.* 1985) the protein content decrease (from 12.5% to 12.0%) and falling number decrease (from 360 s to 307 s) were found, but wheat moisture (13.7%) did not change. During wheat storage the viscoelastic qualities of its flour are also changed, e.g. the farinograph water-binding capacity decreases and the dough stability increases (Srivastava & Haridas Rao 1991; Every 2002), the maximum amylograph viscosity decreases, etc. Bell *et al.* (1979) found a decline of the baking quality of wheat flour documented by the bread volume decrease in a long-term storage experiment.

The aim of this paper was to study the quality of commercial wheat manufactured in an industrial mill over the years 2001 and 2002 by measuring sedimentation values and falling numbers, changes of these parameters in the course of one-year storage in agricultural operations and their mutual relations.

MATERIALS AND METHODS

The samples of commercial wheat were taken ten times a month during the process of intake into an industrial mill so that each delivery coming from five producers would be represented twice. Wheat came from 2001 and 2002 harvests produced in Central Bohemian localities that belong to the beet-producing region. Variety specification of the samples corresponded to the wheat of quality classes A and B and was not studied. Wheat after harvest was stored in the agricultural operations generally in indoor storehouses at the temperature from 20°C to 25°C and samples from each harvest were taken continuously from October to August, thus 110 samples a year.

Wheat quality was evaluated according to protein content that was assessed using the Inframatic 8600 (Perten, Sweden) and protein quality was determined by SDS test (according to ČSN 46 10 21) and Zeleny test (according to ISO 55 29). Both sedimentation tests were carried out on SEDI Tester (Strakonice, CR). The samples of wholemeal groats were prepared on the grinder ZM 1000 (Retsch, Germany) and smooth flours on the laboratory mill FQC 109 (Hungary).

Each analysis was carried out at least twice and average values for the whole month were used for the wheat quality evaluation. Relations between individual characteristics were described by the correlation analysis. The influence of storage time on wheat parameters is evident from the regression equations. Statistical evaluation results from the data processing by means of MS Excel tools.

RESULTS AND DISCUSSION

Wheat quality studied in single months varied in dependence on the supplier (thus sample origin), as obvious from Tables 1 and 2 that show as an example the results of the analyses of ten samples taken from the mill in November 2001 and 2002. The analyses obviously show that wheat quality delivered to the mill varied according to the deliveries, nevertheless the variation range was comparable during the two months. For instance, the protein content ranged from 11.8 to 14.6% in 2001 and from 11.6 to 14.1% in 2002, average values were higher in November 2002 (12.8% compared to 12.5% in 2001). The protein quality according to Zeleny test was slightly higher for the wheat from November 2001 (average 58 ml compared

Table 1. Sedimentation value of wheat and flour – monthly analyses

November 2001				November 2002			
Sample	protein (%)	SDS test (ml)	Zeleny test (ml)	Sample	protein (%)	SDS test (ml)	Zeleny test (ml)
1	12.2	84	47	1	14.1	86	60
2	11.8	85	58	2	12.3	82	54
3	13.3	87	64	3	13.9	79	60
4	11.8	84	50	4	11.7	70	39
5	12.5	88	52	5	13.7	95	68
6	12.3	88	63	6	13.8	84	56
7	12.0	88	60	7	11.6	82	44
8	13.0	88	61	8	12.2	79	50
9	11.8	86	54	9	12.0	85	52
10	14.6	87	70	10	12.4	80	50
Average	12.5	87	58	Average	12.8	82	53
Min.	11.8	84	47	Min.	11.6	70	39
Max.	14.6	88	70	Max.	14.1	95	68
S.D.	0.85	1.57	6.74	S.D.	0.94	6.03	7.93
Variation (%)	6.74	1.81	11.65	Variation (%)	7.33	7.34	14.87

S.D. – standard deviation

Table 2. Falling number of wheat and flour – monthly analyses

November 2001			November 2002		
Sample	FN wheat (s)	FN flour (s)	Sample	FN wheat (s)	FN flour (s)
1	254	364	1	341	402
2	260	328	2	227	306
3	245	313	3	329	328
4	311	318	4	316	363
5	327	304	5	175	221
6	317	338	6	299	305
7	326	335	7	331	378
8	283	334	8	255	323
9	126	158	9	258	324
10	244	262	10	400	380
Average	269	305	Average	293	333
Min.	126	158	Min.	175	221
Max.	327	364	Max.	400	402
S.D.	57.30	55.25	S.D.	61.65	49.15
Variation (%)	21.28	18.09	Variation (%)	21.03	14.76

FN – falling number; S.D. – standard deviation

Table 3. Average value of sedimentation tests

Harvest 2001				Harvest 2002			
Months	SDS test (ml)	Zeleny test (ml)	protein (%)	Months	SDS test (ml)	Zeleny test (ml)	protein (%)
October	70	59	12.6	October	81	55	12.4
November	87	58	12.5	November	82	55	12.8
December	80	50	12.5	December	81	53	12.5
January	76	47	12.2	January	81	55	12.4
February	79	52	12.4	February	82	58	12.8
March	78	51	12.2	March	83	60	12.9
April	78	51	12.4	April	81	57	12.8
May	78	52	12.3	May	74	42	12.5
June	77	53	12.6	June	76	58	12.6
July	76	50	12.5	July	77	59	12.7
August	79	55	12.5	August	71	49	12.5
Average	78	52	12.4	Average	79	55	12.6

to 53 ml from 2002 harvest) but the values for the single deliveries were determined in a comparable range. Amylase activity in both sets strongly varied, average falling number values were optimal for milling in both sets but higher values for wheat from 2001 harvest were found (269 s compared to 293 s from 2002).

Average quality characteristics of the wheat received in the mill during the months of October to August 2001 and 2002 are shown in Tables 3 and 4. It is assumed that the stabilisation of quality characteristics takes place at this time (approximately in 3 months after harvest) and according to the experiment methodology the changes of the

Table 4. Average value of falling number of wheat and flour

Harvest 2001			Harvest 2002		
Months	wheat (s)	flour (s)	Months	wheat (s)	flour (s)
October	288	333	October	289	298
November	269	305	November	293	333
December	329	333	December	332	330
January	312	340	January	301	299
February	314	346	February	301	311
March	333	339	March	289	298
April	334	347	April	272	299
May	348	357	May	280	307
June	348	350	June	255	284
July	340	351	July	245	286
August	312	335	August	302	330
Average	321	340	Average	287	307

average values are related to storage time. Average monthly quality characteristics also correspond to the actually ground wheat because the mill prepares a wheat batch by mixing single quality parts for the longest possible time. Storage conditions were not taken into account because the processor is unable to influence them and the aim of the paper was to study the real wheat quality during the processing time.

Wheat quality from the Central Bohemian region was medium in both harvest years, there was no need to generally adjust the quality of basic flours for the baker's production after the mill processing. The protein content was comparable in both sets (average 12.4 and 12.6%) and single months differences did not exceed 0.5%. Proteins from the 2002 harvest were of slightly higher quality according to SDS and Zeleny tests. Monthly variations of the SDS test values were comparable in both sets (11 and 12 ml), differences in Zeleny test values were larger (range of 12 ml for 2001 and 18 ml for 2002). Amylase activity studied by the falling number was found to be higher for the harvest 2002 wheat by 11% on average. Within a comparable difference (10%) average falling number values correspond to those of the light wheat flours (average 340 s for 2001 and 307 s for 2002). The amylase activity of flour from the 2001 harvest did not reach an optimal value in the period since March (falling number values over 330 s) and it was adjusted by malt preparations for some baker's products.

Relations between the quality characteristics of wheat and its flour were described in both sets by the correlation analysis (Table 5). There was a statistically significant correlation between the wheat and its flour falling number value, the higher correlation coefficient (0.852) was found for the samples from the 2002 crop year. The closeness of the relation was comparable with the results found for commercial wheats from the 1994 harvest where the relation between the wheat and its flour falling number value was described by the correlation coefficient 0.779 (Hrušková 1995). Zeleny test significantly correlated with the protein content; correlation coefficients were comparable for both sets (0.661 and 0.613) and with SDS test where the relation was described by a higher correlation coefficient for the 2002 set (0.787 compared to 0.531 for 2001 harvest). A closer relation described by the correlation coefficient 0.940 (Finney & Bains 1999) was found for the set of 59 wheat varieties.

Table 5. Result of correlation analyses harvest 2001 and 2002 ($r_{0.01}$ = 0.1946)

Parameters	Correlation coefficient	
	2001	2002
FN wheat and FN flour	0.556	0.825
SDS and Zeleny test	0.531	0.787
Protein and Zeleny test	0.661	0.613

FN – falling number

The influence of storage time on the quality of wheat from the two harvests was displayed in the variation of quality characteristics but there was not found any clear trend in the changes of either set. Variations in the average protein content were very small in both sets and they approached the

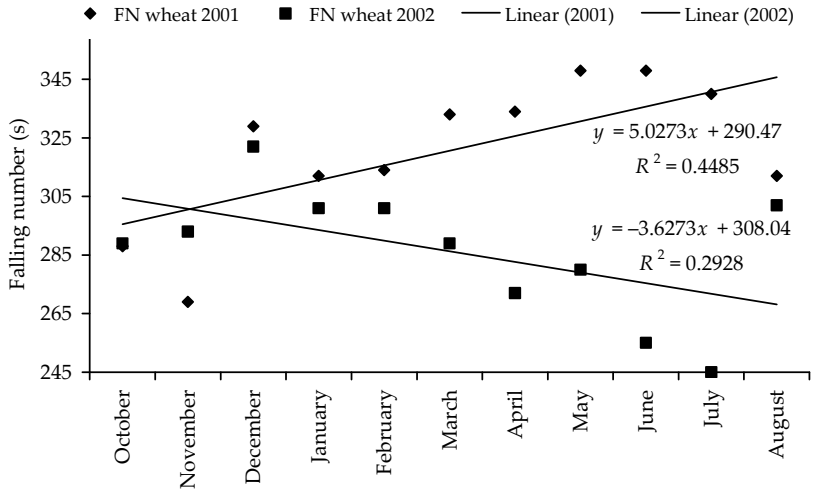

Figure 1. Falling number of wheat from 2001 and 2002 harvest

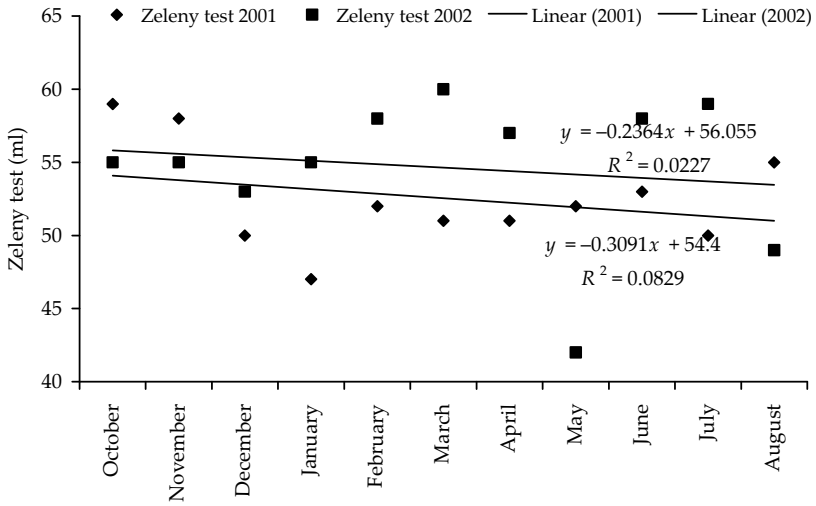

Figure 2. Zeleny test of wheat from 2001 and 2002 harvest

accuracy of the determination. The falling number of wheat evidently increased in 2001, the differences between single months in 2002 were small and the trend was rather reverse (Figure 1). Zeleny test values showed a strong variance in time and a trend of slight decline was evident in both sets (Figure 2). The ambiguity of the influence of storage time on wheat quality in comparison with other studies (Srivastava & Haridas Rao 1991; Lukow *et al*. 1995) may be related to the variety non-homogeneity of partial samples in single monthly takings, different storage conditions of wheat in agricultural operations and short-term study time that was chosen to agree with practical needs. However, it was confirmed that the variations in wheat quality between the harvests were different each year and the strong quality decrease did not generally occur.

Conclusions

The quality of wheat from 2001 and 2002 harvests grown in the Central Bohemian region was studied during the delivery process into the industrial mill for a period of 11 months (always from October to August) and was evaluated according to protein content, sedimentation tests (SDS and Zeleny) and falling number. The results of analyses show that:

– harvest year differently affects the wheat quality characteristics and the largest differences in monthly average values (correspond to milling batch) were found for the falling number value
– falling numbers of wheat and its flour significantly correlate with each other
– Zeleny test significantly correlates with protein content as well as with SDS test
– storage time of wheat between the harvests was reflected in a slight falling number increase only in wheat from 2001, a slight trend of Zeleny test decrease was evident in both sets.

References

Bell B.M., Norman C., Hylton C., Daniela D.G., Matnan F. (1979): The composition, rheological properties and breadmaking behaviour of stored flours. J. Sci. Food. Agric., **30**: 1111–1128.

Every D. (2002): Amylase, falling number, polysaccharide, protein and ash relationships in wheat millstreams. Euphytica, **126**: 135–142.

Fencík R. (2002): Číslo poklesu pšenice v roku 2001 v troch lokalitách Slovenska. In: Sbor. Sem. 100. zasedání KJRP, Pobočka ČZS č. 3106-0665, Praha: 15–18.

Finney P.L, Bains G.S. (1999): Protein functionality differences in eastern US soft wheat cultivars and interrelation with end-use quality tests. Lebensmit.-Wiss. Technol., **32**: 406–415.

Hrušková M. (1995): Číslo poklesu pšeničných mouk. Mlyn. Nov., **6**: 3–4.

Lukow O.M., White N.D.G., Sinha R.N. (1995): Influence of ambient storage conditions on the breadmaking quality of two HRS wheats. J. Stored Products Res., **31**: 279–289.

Moot D.J., Every D. (1990): A comparison of bread baking, falling number, amylase essay and visual methods for assessment of pre-harvest sprouting in wheat. J. Cereal Sci., **11**: 225–234.

Srivastava A.K., Haridas Rao P. (1991): Changes in the pasting, rheological and baking qualities of flour during short term storage. J. Food. Sci. Technol., **28**: 153–156.

Warchalewski J.R., Klockiewicz-Kaminska E., Madaj D. (1985): Changes in amylase activity in wheat and malted wheat grain after long storage. Acta Alim. Pol., **11**: 379–384.

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Souhrn

Hrušková M., Škodová V., Blažek J. (2004): **Sedimentační hodnoty a číslo poklesu potravinářské pšenice**. Czech J. Food Sci., **22**: 51–57.

Technologická jakost potravinářské pšenice ze sklizní roku 2001 a 2002 a její změny během ročního skladování byly hodnoceny obsahem bílkovin, SDS a Zelenyho testy a číslem poklesu. Průměrné hodnoty z analýz 10 dílčích vzorků odebíraných v průběhu měsíců říjen až srpen z každého ročníku sklizně od pěti pěstitelů z oblasti středních Čech (řepařská výrobní oblast) charakterizují standardní jakost pšenice pro mlýnské zpracování a jejich rozdíly lze při srovnatelné odrůdové skladbě vysvětlit vlivem daného ročníku. Vzhledem k podobným klimatickým podmínkám let 2001 a 2002 nebyly zjištěny výrazné rozdíly v obsahu bílkovin (2001 – průměr 12,4 %, 2002 – průměr 12,8 %) a Zelenyho testu (2001 – průměr 52 ml, 2002 – průměr 55 ml), ale číslo poklesu bylo průkazně rozdílné (2001 – průměr 321 s, 2002 – průměr 287 s). Během doby skladování v prvovýrobě nebyly zjištěny průkazné změny v obsahu bílkovin, jejich kvalita však podle hodnot SDS a Zelenyho testu mírně klesá. Hodnoty čísla poklesu pšenice ze sklizně 2001 se mírně zvyšují, což nebylo průkazně prokázáno pro soubor vzorků ze sklizně 2002. Mezi hodnotou čísla poklesu pšenice a z ní laboratorně vyrobené mouky byly zjištěny statisticky významné korelace pro oba ročníky sklizně (r = 0,556 pro 2001, r = 0,825 pro 2002). Hodnota Zelenyho testu průkazně koreluje s SDS testem (r = 0,531 pro 201, r = 0,787 pro 2002) stejně jako s obsahem bílkovin pšenice.

Klíčová slova: pšenice; SDS test; Zeleny test; číslo poklesu; skladování

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