Changes of Wheat Flour Properties during Short Term Storage

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Abstract

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Two samples of commercial wheat flour from the last year's harvest were stored for three months (in the period from November to April) under different conditions. The ambient temperature and humidity varied during the storage in the dependence on the year season. Certain analytical characteristics (moisture, wet gluten and its extensibility, acidity and falling number) and alveograph behaviour of flour were determined at regular intervals. Flour moisture, acidity, and falling number changed with the time of storage but no explicit influence of the storehouse conditions and the initial flour properties was proved. Viscoelastic properties of weaker flour samples changed during storage more markedly than those of stronger flours in the sense of a significant improvement of their quality.

Keywords: wheat flour; short term storage; temperature changes; analytical characteristics; alveograph behaviour

Wheat flour bread-making quality was estimated on the basis of the characteristics and content of protein, the condition of starch (damage) and the flour enzymatic activity. These parameters of flour which depend on the wheat variety, the year and the conditions of harvest, and the milling technology are important for the use of flour in bakery and the quality of the final products.

The storage time and conditions have an influence on the technological quality of wheat and result in modifications of the flour parameters. LUKOW and WHITE (1997) studied changes of the milling and baking parameters of US wheat during 15 months storage at temperatures in the range of –4°C and 25°C, and air humidity in the range of 28% and 73%. Four wheat properties were affected by the storage under these conditions. The yield of flour decreased mildly during laboratory milling. Farinograph stability increased and the dough handling quality improved. But the wheat strength was negatively affected as shown by a lower Zeleny sedimentation value and a higher falling number.

Flour properties change during the process of maturing. PYLER (1973) described complex biochemical changes which started 4 or 5 days after milling and lasted approximately 3 weeks. The time of maturation is important for the achievement of the optimal flour bread-making quality although this period is affected by many factors. The time required for the optimal maturation depends both on the flour characteristics and on the storage ambient conditions. Weaker flours need a longer time but flours with higher ash contents reach the optimal characteristics sooner.

The changes of the rheological dough properties are connected with the gluten quality and its alterations during maturation. Gluten extensibility mostly decreases and its elasticity increases (CENKOWSKI *et al.* 2000). As a rule, dough becomes less sticky and its ability to hold up fermentation gases increases. During the flour maturation water absorption also increases, the amylolytic activity becomes lower and the temperature of starch gelatinization increases (LINFENG-WANG & FLOTES 1999). An improved dough handling and a better quality of products are caused by the changes mentioned above (HAMPL & PŘÍHODA 1985).

Wheat flours continue to be living biological stuffs also during the ensuing storage. All processes connected with maturation work on for several days after milling and their influence on the flour quality depends on the ambient storage conditions. Flour is a very hygroscopic material and its moisture changes with the changes in temperature and humidity of the store environments. Flour moisture changes can support the acidity alterations caused by the enzymatic breaking of fytin by fytase, lipolytic fat

hydrolysis and proteolysis (HANSEN & ROSE 1996). Changes in the protein–protease complex of wheat flour as reflected in elasticity and extensibility of gluten can exert a positive or a negative influence on the dough bread-making characteristics. During a longer storage time, flour properties change by the effect of nonsaturated fatty acids which can reduce gluten swelling and water absorption, and increase starch resistence against gelatinization (CHEN & SCHOFIELD 1996). This results in a lower amylolytic activity and a lower gas production ability of flour (SRIVASTAVA & HARIDAS-RAO 1992).

Flour changes become less pronounced during storage at low temperatures. YONEYAMA *et al.* (1970) proved that during two-year storage at 0°C, flour characteristics did not change significantly.

The objective of this study was to estimated the changes in the analytical and alveographic characteristics of fine commercial wheat flours during short time storage under different conditions in industrial bakery.

MATERIALS AND METHODS

Two fine flour samples (marked M1 and M2) from a commonly grown wheat variety (harvested in year 2000) prepared in an industrial mill were obtained for this study. The storage period was three months, in the term of November–January for sample M1, and of February–April for sample M2. The flours were stored in jute sacks in two storehouses of an industrial bakery plant. The storage took place in different locations and under different ambient conditions which changed with the season. As condition P1, the location with low temperature was marked where the air temperature wavered in the range of approximately 10°C. The temperature for sample M1 dropped and that for sample M2 grew up depending on the outdoor atmosphere. Condition P2 was characterized by a higher temperature and the conditions did not change significantly during the storage term. Air humidity in both locations was also different.

The stored flours were analysed two or three times every week for moisture, wet gluten content and its extensibility, acidity, and falling number (according Czech methods, respectively ISO 3093). The rheological properties of the flours were evaluated by means of alveograph MA 95 (Tripette, France) according to ISO 5530-4. The results obtained are summarized and averaged at ten days intervals for the evaluation of the changes**.** The relations between single flour quality characteristics were evaluated by *F*- and *t*-tests.

RESULTS AND DISCUSSION

Flour quality parameters (analytical and alveograph) before storage as determined by standard methods are reported in Table 1. They corresponded to the Czech standard as fine type for bakery products. According to the characteristics obtained, flour M2 was evaluated as weaker with a lower wet gluten content and alveographic energy. Doughs prepared from these flours before storage had optimal viscoelastic behaviour as identified by a well-balanced ratio of gluten elasticity and extensibility.

Table 1. Evaluation of wheat flours quality

Analytical properties	Units	Flour M1	Flour M2
Moisture	(%)	14.1	14.1
Ash	(%)	0.5	0.5
Wet gluten	(%)	32.3	29.1
Gluten extensibility	(cm)	12	12
Acidity	(mmol/kg)	33.4	32
Falling number	(s)	217	215
Alveograph properties			
Elasticity	(mm)	70	66
Extensibility	(mm)	73	52
Ratio P/L		1	1.3
Energy	(10E-4 J)	190	140

The storage conditions (marked as P1 and P2) characterized by the temperature and humidity of the ambient air of the bakery storehouse were different for flour samples M1 and M2. While the highest temperature under condition P1 was 15.6°C and it varied in the dependence on the season during both storage tests, the temperature in location P2 changed only a little; during both tests, however, it was higher than it has been recommended for flour storage.

The analytical and alveographic properties of flours stored under conditions P1 and P2 are shown in Tables 2 and 3, respectively. The results of the appurtenant determinations expressed by average for each storage decade (approximately 5 tests) varied, as expected, with the storage conditions, which applies especially to moisture, acidity, and falling number. Different extents of their dependence were proved by *F*- and *t*-tests. The content of moisture increased under condition P1 by approx. 1.1% and 1.2%, respectively, in samples M1 and M2. Storage under condition P2 resulted in a loss of the flour moisture, the content of moisture being lower in flour M1. The changes in the moisture contents depended on the short time storage conditions and had a different time course in the individual locations. Wet gluten content tended to decrease with time but the differences did not seem significant for the flour quality. Gluten extensibility had the same tendency; a more marked decrease was found in the weaker flour M2 in agreement with LUKOW and WHITE (1997). The acidity of both flours significantly increased with time regard less of the storage locations; differences were

Table 2. Flour M1 – average air and flour properties during storage time

Periods (decade)	Storage condition		Flour analytical properties					Flour alveograph characteristics			
	temperature (°C)	humidity (%)	moisture (%)	wet gluten (%)	extensibility (cm)	acidity (mmol/kg)	FN (s)	elasticity (mm)	extensiblity (mm)	ratio P/L	energy 10E-4 J
P1											
I.	14.5	71	14.1	32.1	12	32.9	206	68	91	0.75	208
II.	13.8	70	14.2	32.1	11	32.5	210	66	92	0.72	209
III.	12.5		14.3	31.6	10	32.2	214	64	83	0.77	195
IV.	11.2	70	14.7	32.1	10	32.3	222	70	86	0.81	208
V.	8.3	72	14.8	31.5	11	34.4	223	73	85	0.85	209
VI.	4.1		14.9	31.3	11	34.1	226	73	74	0.98	200
VII.	2.7	70	15.3	31.8	11	36.3	233	72	91	0.79	206
VIII.	2.6		15.1	31.9	10	36.5	232	69	84	0.82	207
IX.	2.3	71	15.2	30.8	10	37.1	234	64	85	0.75	210
P2											
I.	19.6	55	13.9	31.9	12	31.9	224	73	84	0.87	215
II.	18.4	53	13.6	31.2	12	31.3	229	74	90	0.82	214
III.	18.4	58	13.5	32.3	12	32.4	225	64	91	0.7	196
IV.	18.1	51	13.5	33.5	11	32.8	234	70	86	0.81	203
V.	18.3		13.4	33.5	11	33.9	238	91	64	1.41	210
VI.	17.3	51	13.2	33	11	33.9	236	93	61	1.52	217
VII.	17.1		12.5	32.5	10	35.8	233	70	76	0.92	195
VIII.	18.2	51	12.7	32	10	36.5	231	74	71	1.04	184
IX.	20.1		11.5	31.4	10	37.3	236	72	70	1.02	179
***t*-tests – P1 vs. P2**											
t-value	–5.9597	14.4229	5.7113	–2.145	–0.8944	0.2892	–2.5129	–1.9892	2.08	–2.1562	0.882
P (T ≤ *t*)	0.0003	0	0.0001	0.053	0.3849	0.07762	0.028	0.0745	0.0603	0.0587	0.3984

Table 3. Flour M2 – average air and flour properties during storage time

Periods	Storage condition		Flour analytical properties					Flour alveograph characteristics			
(decade)	temperature (°C)	humidity (%)	moisture (%)	wet gluten (%)	extensibility (cm)	acidity (mmol/kg)	FN (s)	elasticity (mm)	extensiblity (mm)	ratio P/L	energy 10E-4 J
P1											
I.	14.5	71	14.1	32.1	12	32.9	206	68	91	0.75	208
I.	6		14.6	29.5	11	32.3	210	68	57	1.19	149
II.	7.3	34	15	28.8	10	33	218	67	88	0.76	194
III.	8.6		15.1	28.8	10	33	218	63	84	0.75	194
IV.	10.4	34	15.1	27.5	11	33.6	219	61	91	0.67	178
V.	10.1	35	15.5	27.2	10	32.3	224	56	107	0.52	184
VI.	12.4		15.1	28.1	10	32.7	215	55	85	0.64	160
VII.	12.9	32	15.4	29.5	10	37.2	217	58	102	0.57	191
VIII.	10.5	30	15.1	26.7	10	41.3	219	57	100	0.57	186
IX.	10.5	30	15.8	26.8	10	41.1	227	52	133	0.39	198
P2											
I.	20	38	13.2	28.1	11	32.3	213	71	69	1.03	144
II.	19.7	38	12.6	28.3	11	32.3	214	76	77	0.99	196
III.	18.2	35	13.1	28.7	11	32.8	229	67	102	0.65	209
IV.	18.2	38	13.8	27.8	11	32.5	223	60	91	0.66	182
V.	19.1		13.1	26.6	12	32.2	234	58	99	0.59	185
VI.	21	33	12.9	26.9	11	36.2	227	62	92	0.67	183
VII.	18.3		12.9	26.8	11	38.5	221	59	94	0.63	186
VIII.	19.2	33	12.7	26.5	11	40.2	223	58	97	0.6	184
IX.	20		12.5	27	11	39.9	225	54	120	0.45	190
***t*-tests – P1 vs. P2**											
t-value	–11.6397	–2.4769	12.8121	1.5048	–4.8242	–0.0261	–1.6857	–1.039	0.0793	–0.2377	–0.3458
P (T ≤ t)	0	0.0331	0	0.1534	0.0002	0.9795	0.1131	0.3153	0.9379	0.8152	0.734

Table 4. Coefficients of correlation for air and flour properties during storage time

Correlation coefficient*	Days of storage	Wet gluten	Extensibility	Acidity	FN	Alveograph			
						elasticity	extensibility	ratio P/L	energy
M1									
Wet gluten	–0.18								
Extensibility	–0.73	0.13							
Acidity	0.94	–0.23	–0.64						
FN	0.7	0.22	–0.3	0.44					
Alv. elasticity	0.12	0.52	0.12	0.01	0.5				
Alv. extensiblity	–0.49	–0.34	0.35	–0.31	–0.57	–0.76			
Alv. ratio P/L	0.29	0.49	–0.09	0.15	0.54	0.95	–0.92		
Alv. energy	–0.44	0.13	0.48	–0.37	–0.12	0.3	0.24	0.08	
M2									
Wet gluten	–0.66								
Extensibility	–0.19	–0.27							
Acidity	0.85	–0.54	–0.21						
FN	0.48	–0.6	0.34	0.23					
Alv. elasticity	–0.85	0.55	0.27	–0.58	–0.48				
Alv. extensibility	0.81	–0.54	–0.21	0.63	0.71	–0.74			
Alv. ratio P/L	–0.86	0.58	0.24	–0.58	–0.7	0.86	–0.93		
Alv. energy	0.36	–0.14	–0.15	0.3	0.57	–0.16	0.64	–0.58	

*$P \leq 0.01$ and 0.05; $r \geq 0.47$ and 0.59

greater in samples M2. However, this process had no negative effect on sensoric value of flours according to the storage tests. The falling number indicationg the starch damage as well as the enzymatic activity increased over the storage period. An increase of about 28 s and 17 s for samples M1 and M2, respectively, were found under condition P1. In the case of the location with a higher storage temperature, lower differences occurred in the values of the flour falling number. The changes in acidity and in falling number were marked as significant on 99% statistical level (Table 4). The correlation between these flour parameters and the storage temperature was mentioned by SRIVASTAVA and HARDIS-RAO (1992).

Wheat dough rheological properties changed during a short term storage in the dependence on the initial characteristics of flour. Alveograph behaviour of the stronger flour M1 stored under the colder condition (P1) did not change significantly but in the case of storehouse with a

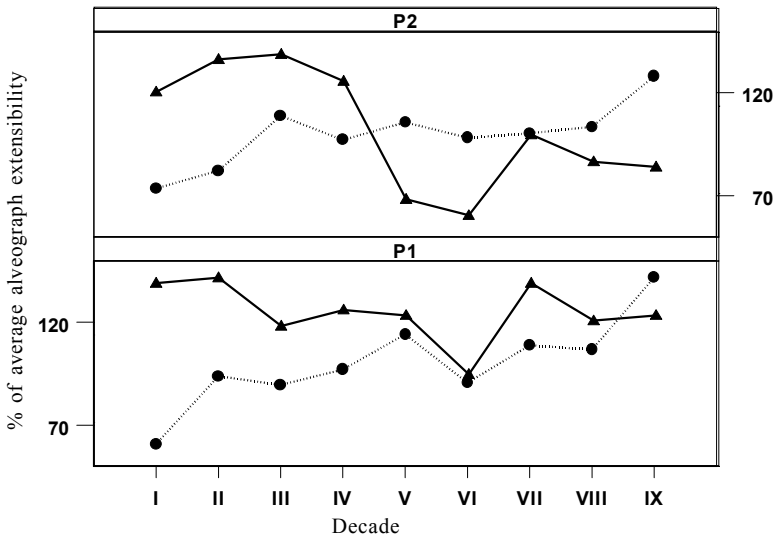

Fig. 1. Changes of relative average alveograph extensibility in two storages

higher temperature a slight decrease of alveograph extensibility and energy was found. On the other hand, alveograph extensibility of the weaker flour M2 increased (Fig. 1) and its breadmaking quality improved as judged by aveograph energy. Properties of dough from weaker flours stored for several months were reported by LINFENG-WANG and FLOTES (1999) and CENKOWSKI *et al.* (2000).

Conclusion

Wheat flour analytic and alveographic parameters were influenced by short term storage under real conditions of industrial bakery in the dependence on their initial characteristics and the ambient environments. The moisture of flour samples depended significantly on the temperature course during the storage period. Wet gluten content changed only a little and differences in its extensibility were not proved statistically. Flour acidity and falling number values increased markedly but the influence of the storage conditions was not unambiguous. Dough alveographic characteristics of the weaker flour indicated an improvement of the bread-making properties depending on the duration and the conditions of storage.

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Souhrn

HRUŠKOVÁ M., MACHOVÁ D. (2002): **Změny vlastností pšeničné mouky při krátkodobém skladování**. Czech J. Food Sci., **20**: 125–130.

Dva vzorky pšeničné mouky hladké průmyslově vyrobené z potravinářské pšenice ze sklizně roku 2000 byly skladovány po dobu tří měsíců v období listopad–duben za podmínek prostředí s různými teplotami a relativní vlhkostí vzduchu. V pravidelných intervalech byly sledovány změny analytických vlastností (vlhkost, mokrý lepek a jeho tažnost, kyselost a číslo poklesu) a reologických znaků pomocí alveografu. Vlhkost, kyselost a číslo poklesu mouk se výrazně mění dobou skladování, ale vliv změn podmínek prostředí a vstupních parametrů mouky nebyl jednoznačný. Viskoealastické vlastnosti pšeničných těst se skladováním mění výrazněji u pekařsky slabší mouky ve smyslu zlepšení kvality.

Klíčová slova: pšeničná mouka; krátkodobé skladování; změny teploty; analytické vlastnosti; alveografické charakteristiky

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