Effect of Malt Flour Addition on the Rheological Properties of Wheat Fermented Dough

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Abstract

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The bread-making quality of forty three wheat flour samples, divided into two groups according to the ash content (up to 0.6% and 0.7%), and its changes by fortification with malt flour were studied in the form of fermented dough. Standard analytical measurements (ash and protein contents, wet gluten, falling number, Zeleny sedimentation value), rheological investigations (amylograph, maturograph, oven rise recorder), and laboratory baking test were used for the characterisation of flour and dough. The influence of the malt flour addition on the fermented dough behaviour depends on the flour composition and was found more significant in flours with a lower ash content ("bright" type). Amylograph characteristics of flour-water suspensions were affected in the same extent by the malt addition. Maturograph behaviour changed significantly only in proofing stability (without influence by the flour type) and dough firmness was affected by malt only in the case of flours with lower ash contents. Oven rise characteristics of dough and the specific bread volume showed important changes in both sets of samples with significant differences between flours with lower and higher ash contents. A strong correlation (r = 0.62–0.75) significant at 0.01 level exists between the specific bread volume and all oven rise parameters of dough from both sets of samples.

Keywords: wheat flour; malt flour; fermented dough; maturograph; oven rise recorder; bread volume

The supplementing of wheat flour with enzyme preparations containing amylases, proteinases and lipoxygenase has been widely adopted in mills and bakeries. While the three enzymes are present in sound wheat, they normally occur in levels insufficient to produce optimal technological effects. In milling sound, mature wheat these enzyme are retained in low levels and the flour is fortified with controlled amounts of enzyme (REED 1975).

Since wheat flour contains an adequate amount of native β-amylase, the supplementation of flour with amylase aims at an increase in α-amylase activity. Originally, malted barley flour was used to this aim, than it was replaced by malted wheat flour and recently by fungal α-amylase.

Malt flours are relatively rich sources of maltose, minerals, soluble proteins, amylolytic and proteolytic enzymes, and flavour substances, which promote vigorous yeast activity, accelerate dough conditioning and contribute a distinctive flavour and aroma to the baked product (FINNEY 1985). The principal functional benefits of the malt addition include an increased gas production in the dough, an improved crust colour formation, a better crumb moisture retention, and an enhanced flavour development.

Malt α-amylases acting on damaged starch granules rectify the deficiency of fermentable sugar which is necessary for optimal yeast growth and gas production (POTUS *et al*. 1994).

According to PYLER (1988), malt syrup used at a level of 0.5%, can provide the following benefits:
– supply preformed sugars, soluble proteins and mineral salts, promote yeast activity,

– adds moderate proteolytic activity to the dough that assists in dough conditioning and gluten development during fermentation,
– insure maltose formation from susceptible starch after heat inactivation of the yeast in the oven, thus improving the loaf of bread, grain and texture, and crust colour,
– increase the moisture-retaining properties of the finished product, thus enhancing freshness and keeping quality,
– compensate the inhibitory effect of milk solids which retards the amylolytic action and increases the dough fermentation requirements when added at the 6% level,
– reduce the potential for buckiness, wildness or stickiness in dough without lowering absorption.

The influence of malt flour (addition 0.2–0.5%) on the rheological characteristics depends on its diastatic power and flour quality. Effects were usually found (Shewry & Tatham 2000; Pyler 1988; Pomeranz 1971) in:
– changes of water absorption and dough consistence during farinograph kneading,
– increase of dough stickiness and decrease of tolerance against overmixing in farinograph,
– decrease of amylograph maximum and temperature of the beginning of gelatinisation,
– decrease of elasticity and increase of extensibility in extensigraph or alveograph,
– increase of dough stability and elasticity in maturograph,
– increase of dough volume in oven spring apparatus,
– increase of bread volume,
– changes of bread shape and sensorical characteristics,
– increase of bread freshness during storage test.

The objective of this study was to describe the improving effect of malt flour on the rheological properties of full dough system during the proofing, the oven spring and the baking process.

MATERIALS AND METHODS

Forty three samples of wheat flour divided into two groups according to the ash contents were taken from a commercial mill during five month (harvest 2001). The first set contained twenty flour samples with maximum 0.60% ash content, and the second set with maximum 0.70% ash content. The effect of the malted wheat flour (with diastatic power 223 U) was evaluated by the addition of 0.5% per the flour weight.

The analytical flour quality was determined according to the Czech standard methods (ash content, wet gluten, protein content – ČSN 560512, Falling Number – ČSN ISO 3093 and Zeleny value – ČSN ISO 5529).

The rheological properties of flour were evaluated by means of amylograph according ICC 126 (Brabender, Germany), maturograph (Brabender, Germany), and oven rise recorder (Brabender, Germany) according to the producer recommendations.

The baking test was performed according to the Czech method and the protocol used was: flour 100%, compressed yeast 4%, salt 1.7%, sugar 1.5%, fat 1%, and water necessary for optimal consistency 600 BU (Brabender unit). The dough from 300 g of flour was prepared in farinograph (Brabender, Germany). Dough dividing and roll shaping were made by hand and after the standard proofing

Table 1. Average values of flour analytical parameters

Parameter	Ash (%)	Wet gluten (%)	Protein (%)	Falling Number (s)	Zeleny value (ml)
Flours with lower ash contents					
Average	0.55	31.1	11.4	332	39
Min.	0.47	27.7	10.3	246	34
Max.	0.60	34.8	12.9	415	44
Flours with higher ash contents					
Average	0.68	31.1	11.3	319	36
Min.	0.60	27.3	10.5	256	32
Max.	0.70	35.2	13.1	384	42

time, the pieces of dough were baked at 240°C for 14 min. Bread volume was determined after two hours of cooling by means of rape seeds.

The parameters of wheat flour quality and the results of amylograph, maturograph, oven rise recorder, and the baking test evaluation for each set without and with fortification with malt flour are presented by average, minimum, and maximum values. The dependence between rheological parameters of dough (according to maturograph and oven rise recorder results) and the results of the baking test were evaluated using correlation analysis.

RESULTS AND DISCUSSION

Flour quality parameters as determined by the standard methods are shown in Table 1. Analytical characteristics of both sample sets are very similar except for the ash content and Zeleny sedimentation value. For the production of rolls and buns, flours with lower ash contents (Czech name "bright sort") and higher protein quality are usually used, while for bread products flours with higher ash contents (Czech name "semi-bright sort") are more suitable. Average values of flour analytical parameters were typical for the Czech wheat production environment (protein 10.3–13.1%, FN 246–415 s, Zeleny value 32–44 ml). The flour samples tested appeared to be suitable for the standard manufacture of yeast leavened dough in an industrial bakery according to these characteristics, but the specific bread volume and shape ratio (Table 4) were found only on the average. A conditioning agent such as malt flour can improve both dough technological characteristics and final products.

The amylograph records the gelatinisation properties of flour–water suspension during heating and the maximum viscosity attained during the test is the results of both the α-amylase activity and the gelatinisation behaviour of flour. The evaluation of amylogram which expresses the flour suspension behaviour without and with malt addition is given in Table 2. Amylograph quality of different flour sets was indicated by the maximum viscosity which is significantly higher in the case of samples with lower ash contents. Malt addition caused in both sets of flour a decrease of maximum viscosity and temperature at this stage in nearly the same extent.

The maturograph records the fermentation behaviour of the dough after the proofing time by means of a sensing probe which touches the dough surface. With the help of an additional loading on this probe, which occurs periodically, the elasticity of the fermented dough is recorded. This cycle is repeated every 2 min which produces the typical zigzag form of the maturogram. The curve rises until maximum dough maturity is reached and drops thereafter. This action is recorded in maturograph units (MU) on the strip-chart. The evaluation of maturograms which express dough behaviour without and with malt addition during the proof period is given in Table 3. Proofing time was found to be in a similar range for both sets (range 36–48 min and 32–44 min), and after malt addition unimportant changes occurred in both sets of flours. The dough level describing the

Table 2. Average values of amylograph evaluation

Parameter	Temperature at the start of gelatinisation		Temperature at max. viscosity		Max. viscosity (BU)	
	without malt	with malt	without malt	with malt	without malt	with malt
Flours with lower ash contents						
Average	60.9	61.5	89.3	74.9	528	248.7
Min.	58.0	61.0	85.0	73.0	340	230
Max.	64.0	63.0	92.5	76.0	750	260
Flours with higher ash contents						
Average	61.4	61.4	88.5	74.8	489	248.6
Min.	56.0	59.5	83.5	71.5	320	200
Max.	64.0	64.0	92.5	79.0	620	265

Table 3. Average values of maturograph evaluation

Parameter	Final proof time (min)		Dough level (MU)		Dough elasticity (MU)		Proofing stability (min)	
	without malt	with malt	without malt	with malt	without malt	with malt	without malt	with malt
Flours with lower ash contents								
Average	42	42	669	691	194	198	7	10
Min.	36	38	480	630	160	170	4	8
Max.	48	46	770	800	220	230	10	12
Flours with higher ash contents								
Average	39	40	673	701	196	204	7	10
Min.	32	34	580	650	180	190	2	8
Max.	44	46	780	780	220	230	12	14

Table 4. Average value of OTG evaluation

Parameter	Dough volume (OU)		Baking volume (OU)		Final rise (OU)		Oven rise (OU)	
	without malt	with malt	without malt	with malt	without malt	with malt	without malt	with malt
Flours with lower ash contents								
Average	396	438	547	573	564	614	151	135
Min.	330	380	470	500	460	510	100	100
Max.	450	490	640	640	670	690	260	180
Flours with higher ash contents								
Average	398	420	555	576	567	615	157	156
Min.	340	390	460	500	470	520	100	100
Max.	450	470	656	660	670	710	255	230

dough resistance against mechanical stress was slightly higher in the case of flours with lower ash contents and with malt fortification it increased significantly in both sets (about 18 MU or 21 MU). The dough firmness (expressed as elasticity) of fermented dough from both sets of flour was similar and was increased by malt addition, in the same range (approximately about 2%). Proofing stability which reflects the time tolerance of optimal proofing ensuring the highest volume of the final product changed in same range (6–8 min). The increase caused by malt was more significant in the dough samples with a very low value of proofing stability (from 4 to 6 min) in both sets as described in Figure 1.

The oven rise recorder describes the change in the volume of dough (at the point of maximum maturity) during baking in the oil bath. Due to the exact heat transfer, the temperature and the dough volume can be determined at any point of the process. The volume of the dough increases as does the oil temperature (from 30°C to 100°C) and the piece ascends in the bath. The action is recorded in oven rise units (OU) on the strip-chart. The evaluation of the oven rise diagrams of the dough without and with malt addition is shown in Table 4. The dough volume, which is indicated as the volume of the dough at the start of the baking period, was found similar in both sets of sample. After malt addition, the dough volume changed in a wider range for flours with lower ash contents (380–490 OU against 390–470 OU). The baking volume (indicating the final volume of the baked goods) and its changes after malt addition was

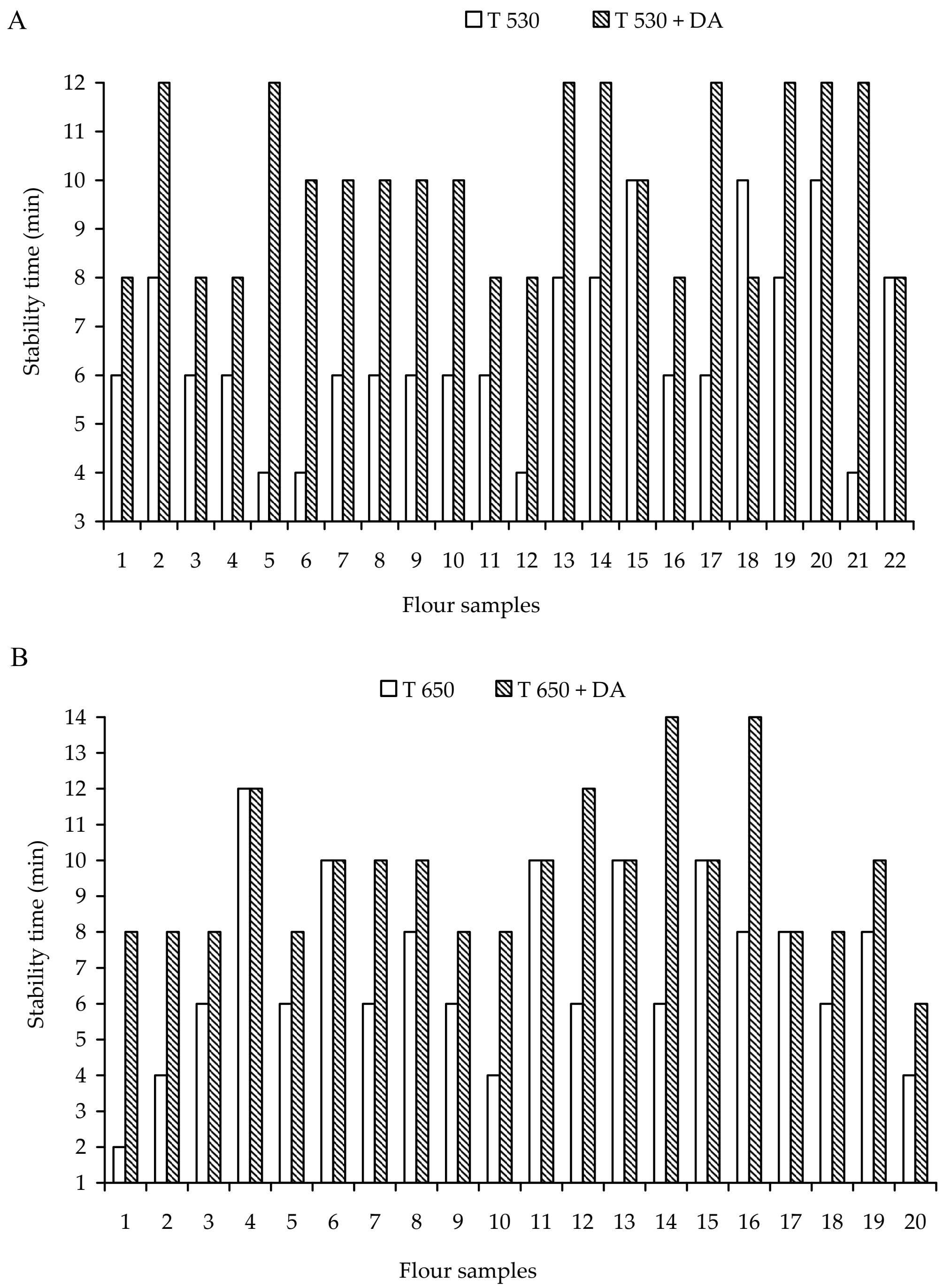

Figure 1. Influence of malt flour on proofing stability – flour with lower (A) and higher (B) ash contents

slightly higher with flour samples with higher ash contents. The effect of malt showed only, with the samples with small original volumes (increase about 10%). From these results, it is apparent that, the oven rise (the difference between the final bread and the dough volumes) was lower in the set with lower ash contents and, after the malt addition, the average value was significantly lower in this set of flour only. The final rise (represents the volume of the baked goods after 11 min from the test beginning) described the shrinkage of volume mostly by the malt action (about 8%).

As a result, nearly the same specific bread volumes were obtained in the laboratory baking test (Table 5) with both sets of flours (average 359 or 345 ml/100 g). In the case of malt addition, com-

Table 5. Average values of baking test evaluation

Parameter	Specific bread volume (ml/100 g)		Bread shape ratio	
	without malt	with malt	without malt	with malt
Flours with lower ash content				
Average	359	389	0.61	0.62
Min.	320	346	0.57	0.57
Max.	424	428	0.66	0.66
Flours with higher ash content				
Average	345	369	0.61	0.62
Min.	309	335	0.58	0.59
Max.	384	413	0.68	0.66

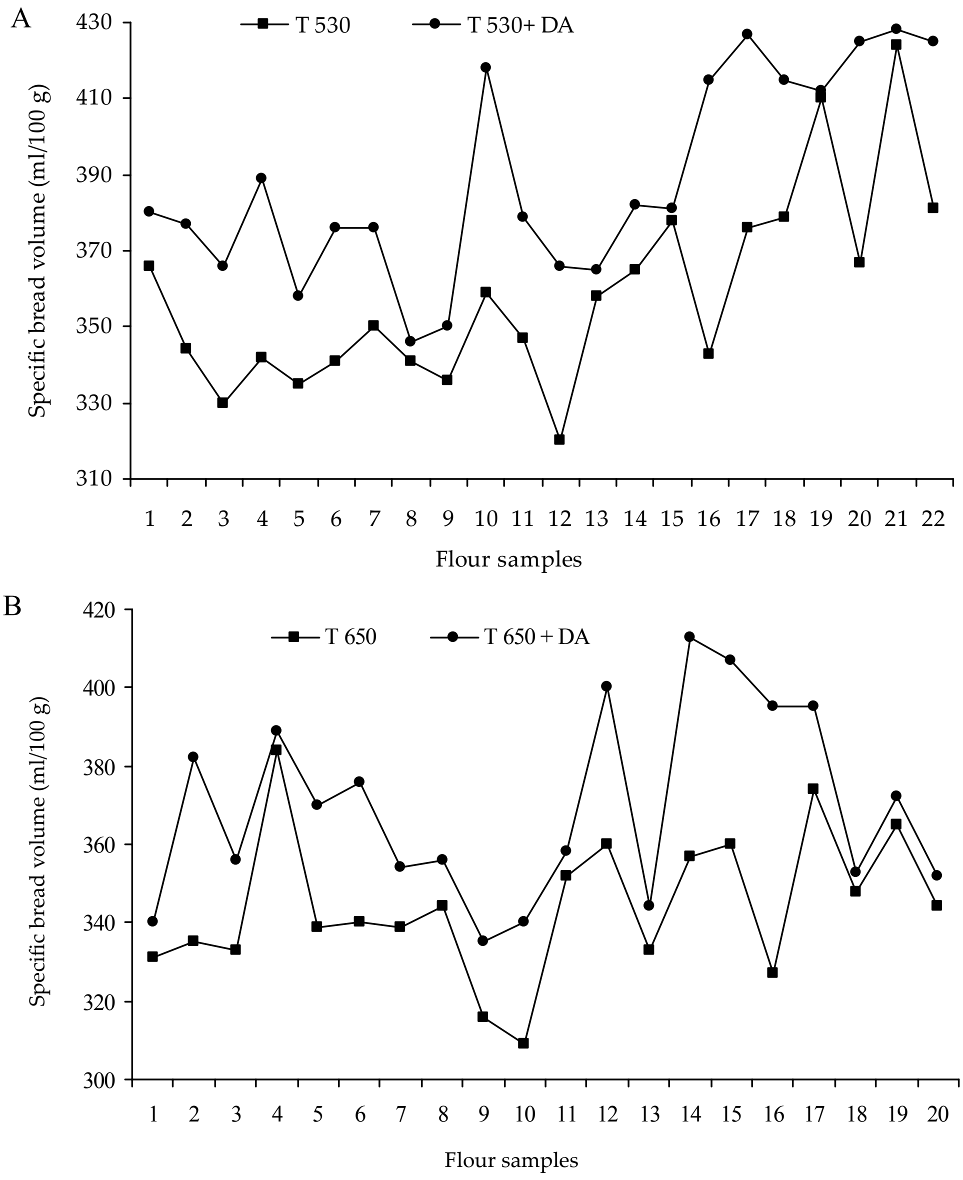

Figure 2. Influence of malt flour on specific bread volume – flour with lower (A) and higher (B) ash contents

Table 6. Dough characteristics correlation

	Final proof	Dough level	Dough elasticity	Dough stability	Dough volume	Baking volume	Final rise	Oven rise	Specific bread volume	Shape ratio
Flour with ash content lower than 0.6% ($r_{0.01}$ = 0.536)										
Final proof	1									
Dough level	–0.0711	1								
Dough elasticity	–0.1497	0.6047	1							
Dough stability	0.0000	0.0941	–0.1638	1						
Dough volume	0.2820	0.5611	0.6141	–0.1666	1					
Baking volume	–0.0452	0.7201	0.7389	–0.1423	0.7935	1				
Final rise	–0.2279	0.6424	0.7647	–0.1674	0.7730	0.8277	1			
Oven rise	–0.4677	0.3937	0.3505	0.0000	–0.0992	0.5269	0.2736	1		
Specific bread volume	0.0763	0.5612	0.6357	0.0796	0.7109	0.7516	0.7108	0.2361	1	
Shape ratio	0.2862	0.5449	0.0896	0.0645	0.2885	0.3271	–0.0013	0.1320	0.2183	1
Flour with ash content lower than 0.7% ($r_{0.01}$ = 0.5614)										
Final proof	1									
Dough level	0.3261	1								
Dough elasticity	0.2365	0.8334	1							
Dough stability	0.1757	–0.3342	–0.4000	1						
Dough volume	0.2299	–0.0594	–0.0506	0.2275	1					
Baking volume	0.5650	0.5416	0.5103	–0.0093	0.5474	1				
Final rise	0.6718	0.1749	0.1106	0.2671	0.6457	0.7015	1			
Oven rise	0.2937	0.6884	0.6448	–0.1742	–0.0644	0.7999	0.3734	1		
Specific bread volume	0.5069	0.0879	0.0213	0.6363	0.6169	0.6202	0.6593	0.2971	1	
Shape ratio	0.1391	0.5315	0.3682	–0.3757	0.1479	0.4678	0.2988	0.4518	–0.1293	1

parable average increases of volume were found (about 10%), but as for separate samples, individual values of increase were detected (Figure 2). The bread shape ratio increased insignificantly in both sets. As it is known, the influence of malt was assessed to be more important for flours with a lower α-amylase activity.

The correlation between the fermented dough characteristics as measured by the maturograph and the oven rise recorder, and the bread characteristics evaluated by a laboratory baking test (Table 6) depends on the flour quality. In both sets of flour, a significant correlation between the specific bread volume and all oven spring parameters was found. The relationship between the baking volume and the dough level and elasticity was proved with the set of flour with lower ash contents, but its relation to the proofing stability was statistically important only with flours with higher ash contents. It confirmed, the baking characteristics relation to the maturograph parameters were highly influenced by both the ash content and the protein quality.

Conclusion

Technological quality of two sorts of white wheat flours with different protein and ash contents were described by means of rheological methods (using the amylograph, the maturograph and the oven rise recorder) including a laboratory baking test. The influence of small amounts of malt flour on the proofing stability was significant. The increase was about 40% for both sets of flour. The proofing time was not prolonged as significantly as the dough elasticity in all samples. The dough behaviour during oil baking in the oven rise tests was influenced by the addition of malt at an important level, similarly as the specific bread volume in the baking test, but individual differences were found between separate flour samples in accordance with Dogan (2003). The bread shape ratio increased insignificantly by the malt fortification. A significant correlation was obtained between the oven spring parameters and the baking test results, but as far as the maturograph characteristics are concerned, their relationships to the bread volume depends on flour quality.

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Souhrn

Hrušková M., Švec I., Kučerová I. (2003): **Vliv přídavků sladové mouky na reologické vlastnosti fermentovaného těsta.** Czech J. Food Sci., **21**: 210–218.

Pekařská kvalita 43 vzorků pšeničné mouky rozdělených podle obsahu popela do dvou skupin – do 0,6 % a 0,7 % a její změny přídavkem sladové mouky byly sledovány ve formě fermentovaného těsta. Analytické znaky (obsah popela, bílkovin, mokrého lepku, číslo poklesu a Zelenyho sedimentační hodnota), reologické hodnocení (amylograf, maturograf, OTG přístroj) a pokusné pečení byly použity pro hodnocení vlastností mouk a těst. Vliv sladové mouky na fermentografické chování těsta závisí na jejím složení a byl zjištěn významnější v souboru mouk s nižším obsahem popela („světlé" mouky). Amylografické vlastnosti suspenze mouka–voda byly v obou souborech ovlivněny stejným způsobem (pokles maxima viskozity a snížení teploty v tomto stavu). Stabilita kynutí se také významně prodloužila ve vzorcích obou souborů, avšak pružnost těsta při maturogafické zkoušce se změnila pouze u světlých mouk. Charakteristiky OTG a měrný objem pečiva vykázaly výrazné změny s individuálním rozdílem pro jednotlivé mouky obou souborů. Významné korelace (99 %) byly zjištěny mezi měrným objemem výrobků a parametry při zapékání, zjištěnými na OTG přístroji.

Klíčová slova: pšeničné mouky; sladová mouka; fermentované těsto; maturograf; OTG; měrný objem pečiva

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