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ESTIMATING TECHNOLOGICAL QUALITY IN WHEAT BY HAGBERG FALLING NUMBER AND AMYLOGRAPH PEAK VISCOSITY

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Summary: Amylolytic activity in 15 winter wheat cultivars has been followed by a comparative analysis of the values of peak viscosity on Brabender Amylograph (BU) and the values of falling number (FN) according to Hagberg (sec). Only one cultivar, Renesansa, had the peak viscosity below 500 BU and the FN below 250 sec. Four cultivars had the peak viscosity between 500 and 800 BU, seven cultivars between 800 and 1500 BU and three cultivars above 1500 BU. Twelve cultivars had the FN between 250 and 300 sec and only two above 300sec. The obtained values were compared against the values of bread made from the flour of these varieties. Bread quality was assessed as baking score (BS) via crumb quality, the parameter that represents the numerical expression of crumb elasticity and pore structure fineness.

Key words: amylase activity, baking score, falling number, peak viscosity, wheat

Introduction

Although the Hagberg falling number and the Brabender amylograph can satisfactorily predict the level of -amylase activity in wheat, they occasionally differ in their relative ranking of wheat cultivars (Kruger and Tipples, 1980). Falling number has been recently introduced into country elevators and mills. It gives an indication of the amount of sprout damage that has occurred within a wheat sample. Generally, a falling number value of 350 seconds or longer indicates a low enzyme activity and very sound wheat quality. As the amount of enzyme activity increases, the falling number decreases. Values below 200 seconds indicate high levels of enzyme activity.

The falling number decreases in pre-harvest sprouted wheat as enzymatic degradation of the starchy endosperm increases. Wheat with FN values below 250-275 is often discounted at the time of sale. That is because the level of impact of sprout damage is not fully realized until wheat is processed into bread or pasta. The falling number test does not measure amylase enzyme activity directly, but it measures changes in the physical properties of the starch portion of the wheat kernel caused by these enzymes during the test.

-Amylase is high in the bran, pollard and germ fractions, in which ash content was very high, whereas -amylase was low in these fractions. These observations, together with the moderate correlation of -amylase and poor correlation of -amylase to ash content, suggest that most -amylase in flour derives

from contamination with bran, pollard and germ, whereas most -amylase derives from the endosperm (Dale et al., 2002). -Amylase activity that is present in wheat flour plays an important part in determining flour peak viscosity, while it has a lesser effect on starch peak viscosity (Takahiro et al., 2003). Comparison of falling numbers and amylograph maxima indicated that these two methods could not be used as equivalent alternatives for the prediction of -amylase behavior (Cork and Spillane 2001; Hutchinson, 2006). FN is a relevant quality parameter for the crop processing industry, therefore, breeders should use FN to select for PHS resistance (Zanetti et al., 2000).

The aim of the present investigation was to assess the effect of genotype on amylase activity and bread quality.

Materials and Methods

Grain samples were obtained from 15 winter wheat cultivars grown at three locations in the Vojvodina Province: Novi Sad (NS, N 45º 33', E 19º 85') Indjija (IN, N 45º 03', E 20º 06') and Sremska Mitrovica (SM, N 44º 033', E 20º 93'). Amylolytic activity has been comparatively tested peak viscosity (BU) on the amylograph (Brabender, Duisburg, Germany) and by the Hagberg falling number test (Falling Number 1800, Stockholm, Sweden) (Standard ICC Method, 107/1).

Bread making properties were evaluated using the standard 350-g pup loaf procedure, a straight–dough procedure with a fermentation time of 3 hr. The baking formula included flour, water, salt (2.0%), and yeast (2.0%). The baking score (BS) (0-7, where 7 is excellent) was determined as a numerical expression based on the sensory assessment of crumb values representing the sum of points for elasticity (0.0-4.5, where 4.5 is excellent) and pore structure fineness (0.0-2.5, 2.5 is extremely fine). LSD test was used to determine the significance of the differences among the average values for the indicators under study.

Results and Discussion

Although the peak viscosity varied from 160 BU (in Renesansa) to 2275 BU (in Pesma), while the FN varied from 158s (in Renesansa) to 352s (in NSR-5), the variations among the locations were not significant for most of the tested cultivars (Figures 1a and 1b; $LSD_{0.05}$= 660 and $LSD_{0.0}5$= 68, respectively).

The cultivar Renesansa had the lowest values of peak viscosity and FN in all three locations. Zanetti et al. (2000) found that the FN was more variable per year than per location. The cultivars Renesansa and Pobeda, which had highest average enzymatic activities (313 and 560 BU, respectively) according to the amylograph but different activities according to the FN (205 and 268 sec), had average baking scores of 4.3 and 5.5 respectively (Figure 1c). Quite satisfactory baking performance was shown by flours with falling numbers 220–250 s, but poor results were obtained using flours with falling numbers below 120 s (Ingver and Koppel, 1998; Veskus and Kann, 1997; Anjum and Walker). Therefore, differences in FN might mainly reflect differences in starch quality rather than in starch degradation (Zanetti et al., 2000). Wheat grain with a Hagberg falling number below 250 sec is unsuitable for use in baking (Major and Kettlewell, 1999). Negative relationship was found between the falling number and the total amount of gliadins and glutenins (Johannson, 2002). All cultivars in our research

unanimously showed a high BS when their peak viscosity and falling number had maximum values (Figures 1a and 1b). Depending on the carbohydrate type and concentration, the measured -amylase activity can be 75% lower than the actual -amylase activity (Tim et al., 2006; Takahiro et al., 2003; Zanetti et al., 2000).

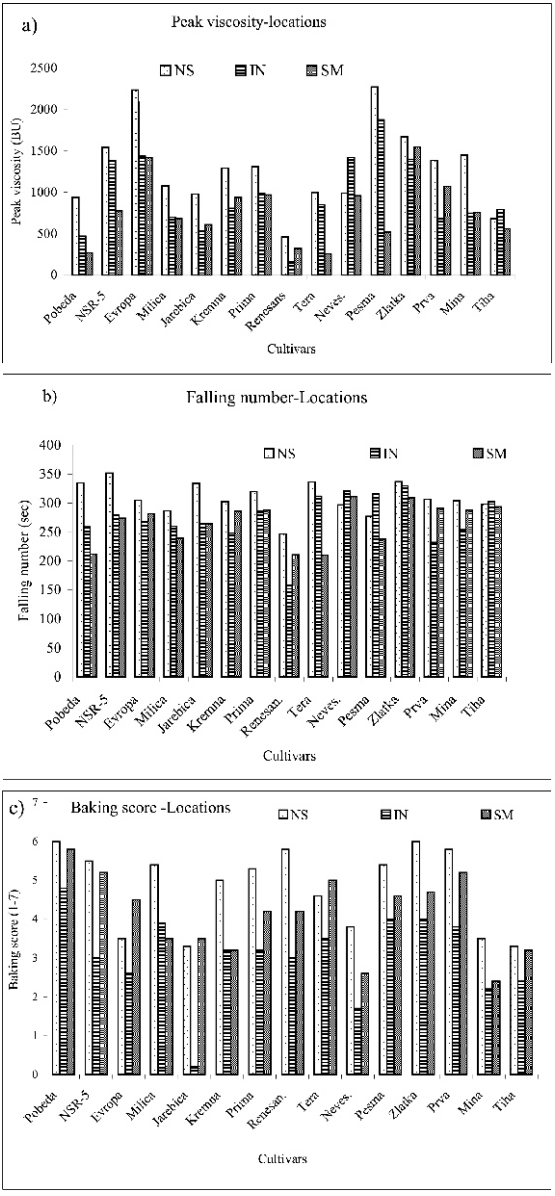

Fig. 1. Comparison of different parameters for 15 wheat cultivars at three localities in the Vojvodina Province during 2005. a) peak viscosity, b) falling number, c) baking score

Based on average values of peak viscosity and FN in three locations (results are not shown), the tested cultivars were divided in 6 groups regarding their amylolytic activity (Table 1).

With the exception of Renesansa, all analyzed cultivars had the average values of peak viscosity above 500 BU. The medium late cultivars, which have high amylolytic activity as a varietal characteristic, had highest increases in the amylolytic activity in response to the unfavorable weather conditions at harvest (Djurić et al., 1999; Szilágyi and Györi, 1999). Previously, Loney et al. (1974) found that genetic factors (i.e., difference among cultivars) were a significant source of variation for peak viscosity.

Table 1 shows the levels of amylolytic activity of the cultivars tested in three locations.

Tab. 1. Cultivar ranking according to peak viscosity and falling number

Levels	Peak viscosity Brabender units (BU)		FN (sec)	
1	<200		< 225	1
2	200-300	-	225-250	-
3	300-500	1 cultivar	250-300	12 cultivars
4	500-800	4	300-340	2
5	800-1500	7	340-380	
6	>1500	3	> 380	

The fourth level (peak viscosity 500-800 BU) included the cultivars Pobeda, Jarebica, Tera and Tiha, whose BS varied between 2.3 and 5.5. The fifth level included the cultivars with the average peak viscosity from 800 to 1500 BU, whose BS varied between 2.7 and 4.9: NSR-5, Milica, Kremna, Prima, Nevesinjka, Prva, and Mina. The sixth level included the cultivars with low amylolytic activity, peak viscosity above 1500 BU and BS between 3.5 and 4.9: Evropa 90, Pesma and Zlatka. Twelve of the tested varieties had the falling number above 250 sec, third level activity and largest BS range (2.9-5.5). Gelling properties at maximum temperatures were found to influence amylograph maxima. Thus, starch susceptibility to enzyme attack in the early gelatinization stages was responsible for differences in falling numbers (Cork and Spillane, 2006; Salmenkallio and Hovinen, 2005).

The low amylolytic activity determined by the amylograph (1670 BU) and the high Hagberg falling number (337s) in the case of the high-quality cultivar Zlatka (BS=6.0) grown in NS, and a satisfactory amylolytic activity of the bread cultivars Jarebica and Tera grown in IN cannot be considered as reliable parameters for evaluation of -amylase activity and breadmaking quality. Neither the viscosity maximum nor a decrease in viscosity maximum was a reliable indicator of amylolytic activity (Šebečić, 1989).

The correlation coefficient (r= 0.58*) was a good indication for the relation FN/BU (Table 2). The Brabender amylograph (Hutchinson, 1966; D'Appolonia et al., 1982) and falling number (Hutchinson, 1966; D'Appolonia et al., 1982; Perten, 1964; Finney, 1985; Moot and Every, 1990) has long been used to estimate -amylase activity in studies on the relationship between this activity and wheat flour's viscometric properties. High correlation was observed by compar-

ing the falling number parameters and those obtained with the amylograph (Komlenic et al., 2002).

The low correlation (r= 0.12; r=0.20) between these values and BS may be associated with the total technological quality of bread varieties. Flour with high falling number (more than 300 sec) yields a relatively stable dough, but the bread structure will be dense and its consistency hard. Although the falling number is considered as a varietal property, weather conditions have a marked effect on this grain quality characteristic (Tohver et al., 2005). If wheat flour has low -amylase activity, its viscosity is assumed to be reflected by the viscosity of starch itself but not by this activity. The decrease in viscosity maximum due to the activity of -amylase was associated with the amount of hydrolyzed starch (r = 0.986) and it depended on both physicochemical properties of starch and concentration of -amylase (Takahiro et al., 2003).

Tab. 2. Correlation coefficients (r) for properties flours

	Viscosity BU	FN	BS
BU	1	0,58*	0,12
FN			0,20

* Correlation coefficient larger than 0.5

It is generally accepted that the long-term solution to the problem of assessing amylolytic activity lies in the development of cultivars which are able to tolerate or resist the damaging effects of rain during the period of harvest (Barnard, 2001).

Conclusion

The comparison of FN and amylograph peak viscosity BU indicated that these two methods could be used as equivalent alternatives for the prediction of -amylase behavior, providing that correspondence is established between the activity levels measured by the two methods. The above results indicate that other, indirect indicators of technological quality must be taken into account when ranking wheats.

By using the data generated from this study, it will be possible to select for more tolerant types which can be used in the development of cultivars with an inherently higher falling number and amylograph peak viscosity.

Literature

Anjum, F. M. Walker C. E. (2000): Grain, flour and bread-making properties of eight Pakistani hard white spring wheat cultivars grown at three different locations for 2 years International Journal of Food Science & Technology 35 (4): 407–416.

Barnard, A. (2001): Genetic diversity of South African winter wheat cultivars in relation to preharvest sprouting and falling number. Euphytica 119:107-110.

Cork, J.G., Spillane, P.A. (2001): Some factors affecting amylolytic behaviour in Irish flours. Journal of the Science of Food and Agriculture 20: 638-641.

D'Appolonia, B.L., MacArthur, L.A., Pisesookbunterng, W. and Ciacco, C.F. (1982): Comparison of the grain amylase analyzer with the amylograph and falling number methods. Cereal Chem. 59: 254– 257.

Dale Every, Lyall Simmons, Jafar Al-Hakkak, Sarah Hawkins and Marcela Ross (2002): Amylase, falling number, polysaccharide, protein and ash relationships in wheat millstreams. Euphytica 126: 135-142.

Đurić, V., Vukobratović, R., Malešević, M. (1999): Variation of amylolytic activity in some wheat varieties in different production years. Second Croatian Congress of Cereal Technologists "BRAŠNO-KRUH "99" 52-58.

Finney, P.L. (1985): Effect of wheat variety on the relationship between falling numbers and alpha-amylase activity. Cereal Chem. 62: 258–262.

Hutchinson, J.B. (2006): The paste viscosities of wheat starch and flour-water mixtures on cooking. I. - An intercomparison of the Hagberg falling number, Brabender amylograph and -amylase activities of Australian and English flours. J. Sci. Food Agric. 17: 198 – 201.

Ingver, A. and Koppel, R. (1998): -Amylase content and its influence on grain quality of spring wheat. In: Genetics and Breeding of Cereal Crops, Estonian Agricultural University, 89–96.

Johansson, E. (2002): Effect of two wheat genotypes and Swedish environment on falling number, amylase activities, and protein concentration and composition. Euphytica 126: 143-149.

Komlenic, D.C., Ugarcic-Hardi, Z., Hackenberger, D., 2002. Impact of pectin and carboxymethylcellulose on rheological properties of wheat flour. Dtsch. Lebensm.-Rundsch. vol. 98, n 9, 332-338.

Kruger, J. E. Tipples, K. H. (1980): Relationships between falling number, amylograph viscosity and -amylase activity in Canadian wheat, Cereal Res. Commun. 8(1): 97-105.

Lallemand Baking Update, 1996. Volume 1/Number 15.

Loney, D. P. Meredith, P. (1974): Note on amylograph viscosities of wheat flours and their starches during storage. Cereal Chem. 51: 702-705.

Major, B.J. & P.S. Kettlewell (1999): The effectiveness of a terpenoid polymer in preserving the Hagberg falling number of winter wheat. Ann. Appl. Biol. 134: 38–39.

Marjatta Salmenkallio-Marttila, Simo Hovinen (2005): Enzyme activities, dietary fibre components and rheological properties of wholemeal flours from rye cultivars grown in Finland. J. Sci. Food Agric. 85: 1350 – 1356

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

Perten, H. (1964): Application of the falling number method for evaluating alpha-amylase activity. Cereal Chem. 41: 127–140.

Šebečić, B. (1989): Factors Affecting Wheat Flour Amylographic Maximum Viscosity. Journal of Food Science 54 (3): 610–617.

Szilágyi, Sz., Györi, Z. (1999): Effect of different factors on the falling number of Hungarian wheat varietes. Second Croatian Congress of Cereal Technologists "BRAŠNO-KRUH "99". 58-64.

Takahiro Noda, Yasunori Ichinose, Shigenobu Takigawa, Chie Matsuura-Endo, Hideyuki Abe, Katsuichi Saito, Naoto Hashimoto and Hiroaki Yamauchi (2003): The Pasting Properties of Flour and Starch in Wheat Grain Damaged by -Amylase. Food Sci. Technol. Res. 9 (4): 387–391.

Tohver, M. Kann, A. Täht, R. Mihhalevski A. and Hakman, J. (2005): Quality of triticale cultivars suitable for growing and bread-making in northern conditions, Food Chemistry, 89,125-132.

Veskus, T. Kann, A. (1997): Falling number as a suitability factor for determining the baking quality of rye flour. Tallinn Technical University: Estonia, Food and nutrition, 4: 95–104.

Zanetti S., Winzeler, M., Keller, M,. Keller, B., and Messmer, M. (2000): Genetic Analysis of Pre-Harvest Sprouting Resistance in a Wheat x Spelt Cross, Crop Science, 40:1406-1417