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Citation: AACC International Annual Meeting, 21 September - 24 September 2008, Honolulu, Hawaii, U.S.A.

Link:
http://www.aaccnet.org/meetings/Documents/Pre2009Abstracts/2008Abstracts/p08ma199.htm

How Dough Mixing Properties Affect Bread-Making Performance

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ABSTRACT

Flour from 58 hard wheat samples from Western and Eastern Canada were analyzed for their composition, dough rheological properties and bread- making performance. During test baking, flour samples were mixed using a National Pin Mixer and mixing curves were generated using P2M software. Seven parameters from the resulting mixing curves were defined: peak time (PT), hydration time (HY), development time (DT), peak height (PH), bandwidth at peak (BW), area of curve (A) and slope of gluten development period (S). The correlations between the mixing parameters and flour protein/wet gluten content, dough rheological properties and baking performance were compared and discussed. Strongly positive correlations were found between PH and protein content (PC, R = 0.91), and PH and wet gluten (WG, R = 0.84). Correlations between S and PC (R = 0.83), S and WG (R = 0.81) were also observed. No significant correlations between the mixing parameters PT, HY, DT, BW, A and the farinograph parameters or baking performance were found. Interestingly, a strongly positive correlation between S and loaf volume (LV, R = 0.85) was obtained. The correlations between PH and PC/WG, and S and PC/WG indicated that the amount of power used for gluten network development is largely dependent on either protein content or the wet gluten content of flour. The correlation between S and LV indicated that the loaf volume of samples mixed using the National Pin Mixer is not only positively correlated to either protein content or wet gluten content of flour but also correlated to the rate of gluten network development. The faster the gluten network developed, the larger the loaf volume. Knowledge of how dough mixing properties affect bread-making performance can provide wheat breeders, flour millers and commercial bakers with important information so that they can better understand the mechanism of gluten formation and improve bread and flour quality with respect to various wheat classes, varieties and crop conditions in the future.

INTRODUCTION

Dough mixing is the first step and a very important stage in the baking process. Dough mixing has several functions in the bread-making process (Bushuk, 1998). The first is to blend the ingredients into a reasonably homogeneous mixture (dough). It is during the early stage of mixing that the flour particles become hydrated and gradually cohere together into underdeveloped (undermixed) dough. Mixing promotes hydration by ensuring the surfaces of the flour particles interact with water. As mixing proceeds, flour particles lose their identity and the dough takes on a relatively homogeneous appearance as development continues. Dough development, reflected by a rise in dough consistency, can be monitored during mixing by recording the torque on the mixer blades (as in the farinograph or mixograph) or the power consumed by the mixer/developer. Under appropriate mixing conditions, i.e. above the critical speed (Kilborn and Tipples, 1972), the mixing curve will peak at a time characteristic for the specific wheat cultivar indicating optimum development.

The parameters of mixing time and energy input are normally used to reflect dough mixing properties. The widespread belief is that stronger dough requires longer mixing time and more energy input. However, this is not observed when using a National Pin Mixer (National Mfg Co.) by which the mixing curves are recorded using P2M software developed by the University of Manitoba, Canada. Shorter mixing time is quite often noted for a strong dough and longer mixing time and more energy input may be usually obtained for a weak dough. This outcome can create much confusion. The National Pin Mixer is quite popular for test baking all over the world. It is very important to better understand how the mixing properties of dough mixed using this equipment would affect bread-making performance. Therefore, the aim of this study is to assess correlations between dough mixing parameters and bread quality parameters and to select better mixing parameters reflecting protein quantity and quality which strongly relate to baking quality. To this end, 58 hard wheat samples were mixed using the National Pin Mixer and test baked. The correlations of the parameters for mixing and baking performance were compared and discussed.

MATERIALS AND METHODS

Materials

11 wheat samples of Canada Western Red Spring (CWRS), Canada Western Hard White Spring (CWHWS), Canada Prairie Spring Red (CPSR) and Canada Western Red Winter (CWRW) from the 2007 crop were provided by the Canadian Wheat Board. 11 wheat samples of Canada Eastern Red Spring (CERS) and Canada Eastern Hard Red Winter (CEHRW) from the 2007 crop were supplied by the Ontario Wheat Producers' Marketing Board, Canada. 36 samples of 2007 CWRW were from the University of Saskatchewan, Canada. All wheat samples were milled at the Canadian International Grains Institute (CIGI) using a Buhler Lab Mill.

Methods

Analytical Methods

Protein content (N X 5.7) was determined using Combustion Nitrogen Analysis (CNA) using the Leco analyzer calibrated using EDTA. Results are corrected to 14.0% moisture basis (mb) for flour.

Wet gluten content was determined following AACC Method 38-12A and corrected to a 14.0% mb for flour.

Farinograph was performed according to AACC Method 54-2, constant flour weight procedure using a 300 g bowl.

No Time Dough (NTD)Test Baking

Formulation used: fresh yeast 4%, sugar 4%, salt 2%, whey powder 4%, shortening 3%, ammonium phosphate 0.1%, diastatic malt syrup 0.2% and ascorbic acid 60 ppm. The dough was mixed using a pin-type mixer (National Mfg. Co., Fig. 1) to 10% past peak as measured by P2M software developed by the University of Manitoba, Canada (Fig. 2) followed by resting for 20 min, sheeting and molding, proofing for about 60 min (37°C, 85% relative humidity) and baking for 20 min (190°C).

Long Time Fermentation (LTF)Test Baking

Formulation used: fresh yeast 1.5%, sugar 6%, salt 1.5%, whey powder 4%, shortening 3%, ammonium phosphate 0.1%, diastatic malt syrup 0.2% and ascorbic acid 20 ppm. The dough was mixed to 10% past peak as measured by the P2M software, followed by fermenting for 3 hours (35°C, 85% relative humidity), sheeting and molding, proofing for about 75 min (35°C, 85% relative humidity) and baking for 20 min (190°C).

Bread volume was measured using a bread volumeter (National Mfg. Co.).

Bread was evaluated using the CIGI Bread Scoring Standard with a total bread score of 100, including external properties (40: symmetry - 10, crust character - 10, crust colour - 10, break and shred - 10) and internal properties (60: crumb colour - 20, crumb structure - 20, cell wall thickness - 5, cell size - 5, cell shape - 5, cell distribution - 5).

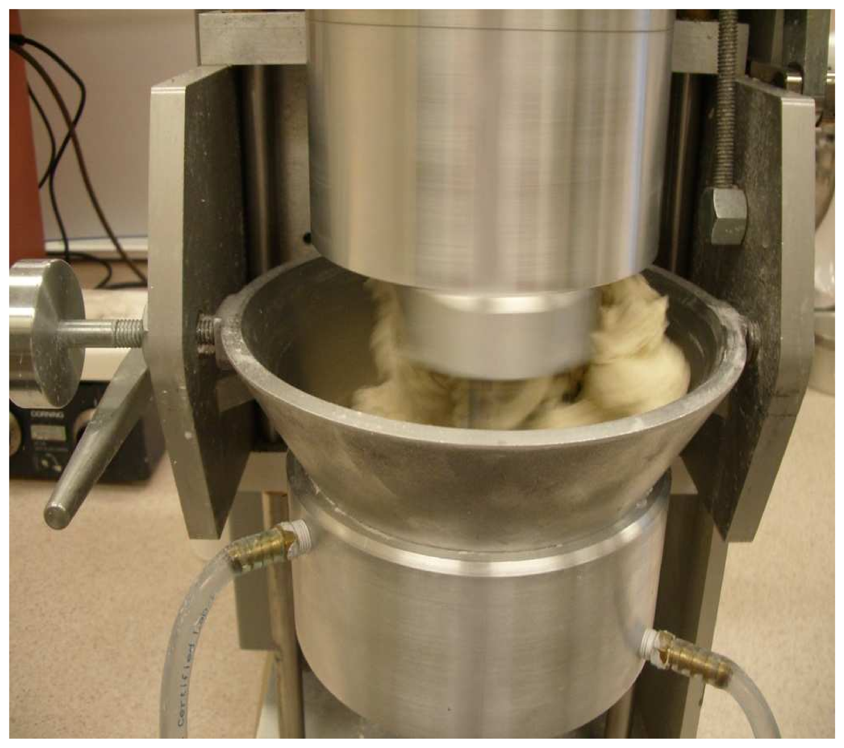

Fig. 1 National Pin Mixer

RESULTS AND DISCUSSION

Parameters of Mixing Curve

A typical mixing curve is shown in Fig. 2. All parameters were evaluated based on the centre of the mixing curve. The definitions of the parameters are summarized as follows:

- Peak time (PT): the time when mixing starts until the curve reaches the peak, also called mixing time.
- Hydration time (HT): the time when mixing starts until the curve begins to go up.
- Development time (DT): the time when the curve starts to go up until the curve reaches the peak; DT = MT – HT.
- Peak height (PH): the Y value at the peak.
- Area of curve (A): the area covered at the centre of the mixing curve, also called energy input.
- Band width (BW): the band width at the peak.
- Slope (S): the slope of the gluten development period.

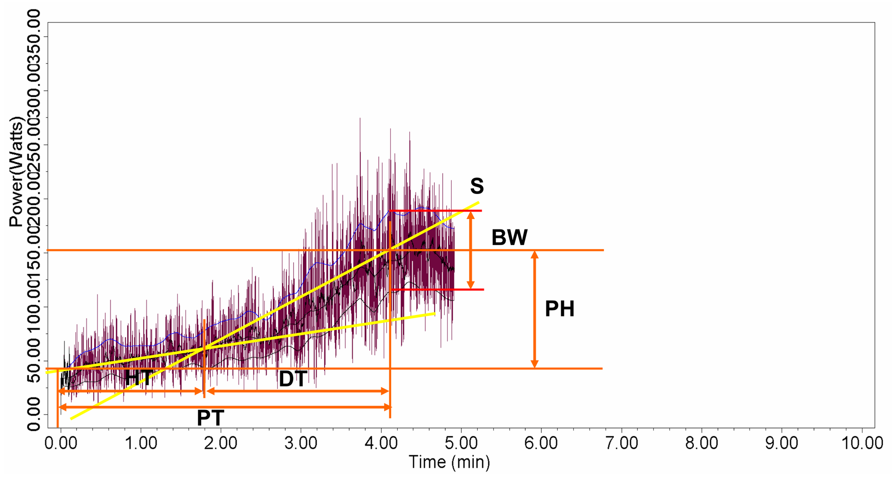

Fig. 2 Typical Mixing Curve

Correlations between Mixing Parameters, Dough Rheological Properties and Baking Quality of Canadian Wheat

The results from the 11 Canada Western wheat samples showed strongly positive correlations between PH and PC, PH and WG, PH and FA, PH and DDT, PH and BA, BW and PC, BW and WG, S and PC, S and WG, S and LV for both NTD and LTF baking processes (data not shown).

The results from the 11 Canada Eastern wheat samples confirmed the strongly positive correlations between PH and PC, PH and WG, S and PC, S and WG, S and LV for both NTD and LTF baking processes (data not shown).

The results from the 36 Canada Western hard winter wheat samples again confirmed the strongly positive correlations between PH and PC, PH and WG, S and PC, S and WG, S and LV under the NTD baking process (data not shown).

Strongly positive correlations (Table 1) between PH and PC (Fig. 3, R = 0.91), PH and WG (R = 0.84), S and PC (R = 0.83), S and WG (R = 0.81) and S and LV (Fig. 4, R = 0.85) under the NTD baking process were obtained when the 58 wheat samples were plotted together.

Our results indicated that loaf volume of the samples mixed using the National Pin Mixer is not only positively correlated to either protein content or wet gluten content of flour but may reflect a positive correlation to the rate of gluten network development. The faster the gluten network developed, the larger the loaf volume.

Table 1. Correlations (R) between Mixing Parameters, Dough Rheological Properties and NTD Baking Quality of 58 Wheat Samples

			Farinograph				Baking Test			
	PC	**WG**	**FA**	**DDT**	**ST**	**MTI**	**BA**	**LV**	**TBS**	**BF**
PT	-0.17	-0.30	-0.14	0.30	0.27	-0.32	-0.10	-0.22	0.22	0.10
HT	0.10	-0.17	0.10	-0.14	0.32	-0.30	0.10	0.10	0.22	0.10
DT	-0.25	-0.32	-0.22	-0.28	0.14	-0.22	-0.25	-0.32	0.10	0.10
PH	**0.91**	**0.84**	0.50	0.71	0.57	-0.48	0.37	0.71	0.60	0.76
A	0.27	0.10	0.10	0.14	0.49	-0.45	-0.14	0.10	0.33	-0.42
BW	0.70	0.63	0.17	0.60	0.58	0.48	0.10	0.52	0.50	0.64
S	**0.83**	**0.81**	0.51	0.68	0.40	-0.30	0.48	**0.85**	0.50	0.47

PC = protein content, WG = wet gluten, FA = Farinograph absorption, DDT = dough development time, ST = stability, MTI = mixing tolerance index, BA = baking absorption, LV = loaf volume, TBS = total bread score, BF = baking factor (LV/PC)

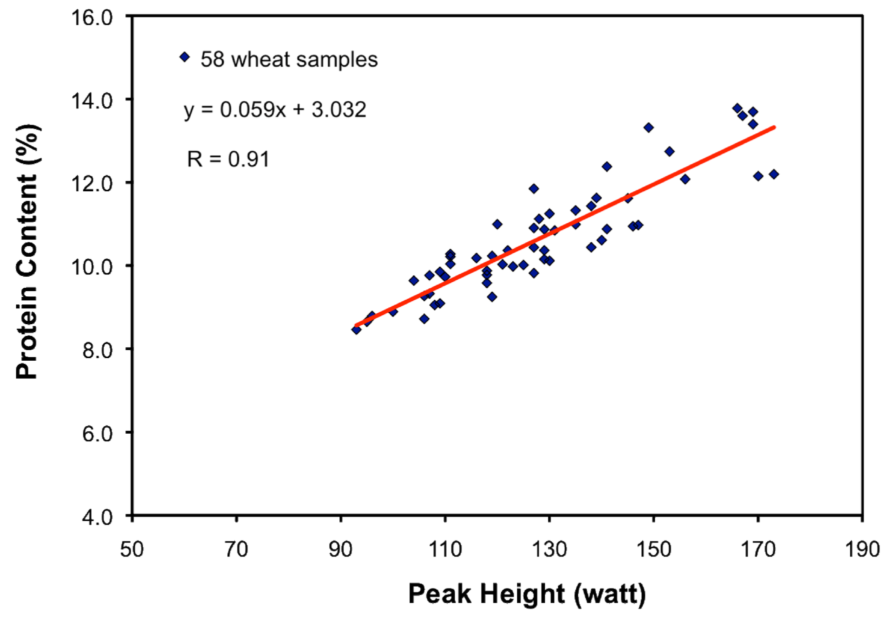

Fig. 3 Correlation between Peak Height and Protein Content

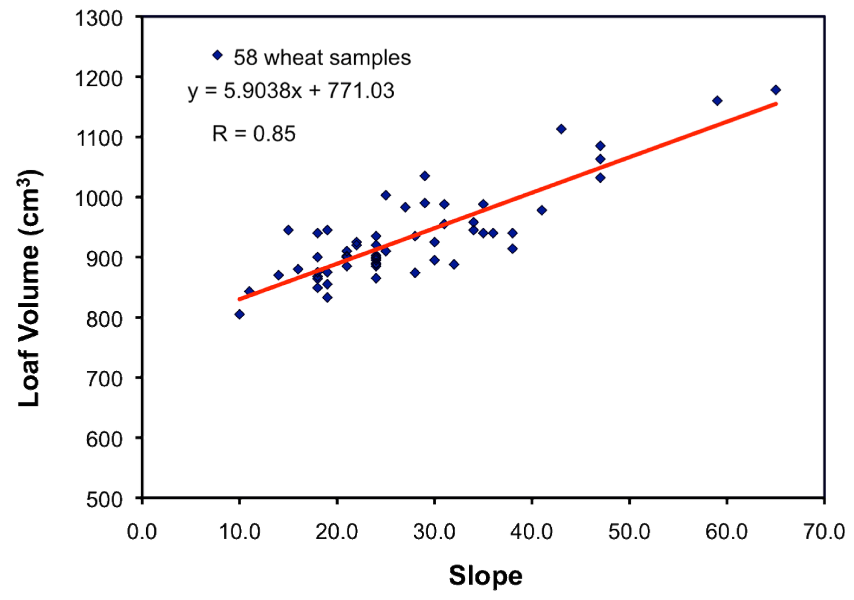

Fig. 4 Correlation between Slope and Loaf Volume

CONCLUSIONS

No significant correlations between the mixing parameters PT, HT, DT, BW, A and the dough rheological properties as measured by Farinograph or baking performance of the 58 Canadian wheat samples were found when the National Pin Mixer was used for mixing. However, strongly positive correlations between PH and PC/WG, S and PC/WG and S and LV were obtained which indicated that the amount of power used for gluten network development is largely dependent on either protein content or the wet gluten content of flour. Loaf volume is not only positively correlated to either protein content or wet gluten content of flour but may also be correlated to the rate of gluten network development. The faster the gluten network developed, the larger the loaf volume. Knowledge of how dough mixing properties affect bread-making performance can provide wheat breeders, flour millers and commercial bakers with important information so that they can better understand the mechanism of gluten formation and improve bread and flour quality with respect to various wheat classes, varieties and crop conditions in the future.

ACKNOWLEDGMENTS

The supply of wheat samples from the Canadian Wheat Board, the Ontario Wheat Producers' Marketing Board, and the University of Saskatchewan and the technical support from colleagues are gratefully acknowledged.

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