Evaluation of the Possibility to Replace Conventional Rheological Wheat Flour Quality Control Instruments with the New Measurement Tool – Mixolab

Tamara DAPČEVIĆ (✉)
Miroslav HADNAĐEV
Milica POJIĆ

Summary

Because of the belief that the rheological properties of wheat flour and dough are related to the flour quality and its processing characteristics, they are of great importance in the baking and milling industries. The Farinograph, Extensograph, Amylograph and Alveograph tests are the most common empirical tests used for assessing rheological properties of wheat dough. Recently, new rheological tool for wheat flour characterization, called Mixolab, has been developed. The advantage of using Mixolab is that one can measure protein and starch characteristics in a single test.

The objective of this study was to determine the relationships between Mixolab parameters and parameters obtained using Farinograph and Amylograph among flour samples of different technological quality.

Mixolab water absorption value was significantly correlated to Farinograph water absorption value (r = 0.9816) as well as Mixolab dough formation time value (time for C1) to dough development time obtained using Farinograph (r = 0.9668), while the values which indicate dough stability have not expressed so high correlation (r = 0.7484). In addition, difference between the values of maximum torque (C1) and torque at the end of the first period of constant temperature (T = 30°C) obtained by Mixolab expressed good correlation with the Farinograph degree of softening (r = 0.8504).

A significant correlation coefficient (r = 0.8812) was determined between the Amylograph peak viscosity parameter and C3 value which is an indication of starch gelatinization.

Key words

Mixolab, correlation, dough rheology, wheat flour quality

University of Novi Sad, Institute for Food Technology,
Bul. Cara Lazara 1, 21000 Novi Sad, Serbia
✉ e-mail: tamara.dapcevic@fins.uns.ac.rs

Received: November 5, 2008 | Accepted: February 24, 2009

ACKNOWLEDGEMENTS
This work was financially supported by Ministry of Science and Technological Development, Republic of Serbia (Project No. 20066).

Introduction

One of the most commonly used techniques for testing flour quality and its suitability for specific end-uses as well as predicting the quality of baked products are empirical rheological tests (Khatkar & Schofield, 2002). The instruments utilized for investigation of flour and dough rheological behavior are Farinograph, Mixograph, Extensograph, Alveograph, and Amylograph. The working principle for the most of these instruments is based on measuring of torque raised during dough development caused by either mixing action or extensional deformation (Sahin & Sumnu, 2006). In spite of their importance, during the last few decades, a great effort was made to introduce a new rheological tool which would eliminate all the shortcomings of the previously mentioned devices. Namely, the performances of traditional, empirical rheological methods for dough testing are time-consuming (Álava et al., 2007) and do not provide information about flour quality based on complete characterization of all flour components, but only on the protein ratio and its quality (e.g. Farinograph) or starch quality (e.g. Amylograph). However, itemized analysis of these components is not sufficient, due to the interactions between them as well as the interactions with other components of wheat flour such as enzymes, lipids, fibers etc. that play a significant role of overall flour quality and its processing characteristics (Fustier et al., 2008).

The Mixolab enables the determination of properties of both, flour proteins and starch, including the other components, in a single test with less than 50 grams of sample. It measures, in real time, the torque in Nm produced by passage of dough between two kneading blades (Bonet et al., 2006). During the passage dough is subjected to dual mechanical shear stress and temperature constraint (Ozturk et al., 2008). Therefore, by using Mixolab it is possible, to simulate the conditions which are present during the bread baking process which considers subjection of the flour compounds to mechanical work and heat treatment and thus promotes changes in their physicochemical properties (Rosell et al., 2007). The data obtained from Mixolab profile gives information about the parameters, such as: water absorption, the protein strength (mixing time, kneading stability and tolerance and gluten quality) and the starch behavior (gelatinization and retrogradation). Furthermore, Mixolab can be applicable not only to wheat flour quality control, but to many other purposes including: development of gluten-free products (Marco & Rosell, 2008), whole wheat studies (Haros et al., 2006), effects of different hydrocolloids (Rosell et al., 2007) or different enzymes on the rheological behaviour of the flour (Haros et al., 2006), which represent its huge advantages over conventional rheological tests. Finally, the advantage of using Mixolab in dough rheological behavior characterization is confirmed by its insertion in ICC methods under the number N° 173.

Since the conventional empirical rheological instruments are still worldwide used for wheat flour quality determination, the aim of this study was to determine the relationships between Mixolab parameters and parameters obtained using Farinograph and Amylograph among flour samples of different technological quality. The reason of selecting Farinograph and Amylograph is that the first one is traditionally used for determining the quality of protein-protease complex, and the second one for carbohydrate-amylase complex.

Materials and methods

Materials

Nineteen different samples of mercantile wheat were obtained during wheat harvest 2007. The samples were milled by Bühler MLU 202 laboratory mill in order to obtain the samples with similar particle size distribution. Average flour particle size distribution, obtained by sieving method (Bühler sieving machine) is shown in Fig. 1. The moisture, protein, wet gluten and ash content of the samples were in the range 11.50 – 12.57 %, 8.15 – 15.10 %, 18.0 – 42.0 % and 0.42 – 0.55 % (d.m.), respectively. These parameters were determined according to the approved method of ICC (ICC Standard No. 109/1; ICC Standard No. 105/2; ICC Standard No. 106/2; ICC Standard No. 104/1; 1996).

Farinograph studies

Farinograph studies (Brabender Farinograph) were carried out as approved by ICC 115/1 (1996). 300 g of flour, on 14% moisture basis, was kept in the Farinograph bowl and, during mixing, water was added from the burette to give a dough consistency of 500 BU. The following parameters were determined from the resulting Farinogram: % absorption of water, dough development time, dough stability and degree of softening.

Amylograph studies

Amylograph studies (Brabender Amylograph) were carried out by following the method of ICC 126/1 (1996). The 80 g of flour, on 14 % moisture basis, was slurried in 450 ml of distilled water by using a glass rod. The slurry was then

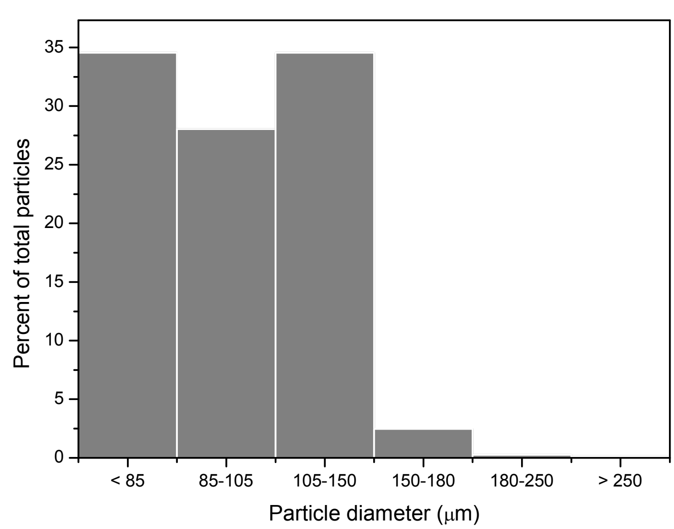

Figure 1. Average flour particle size distribution

Table 1. Instrumental settings defined in "Chopin+" protocol

Settings	Values
Mixing speed	80 rpm
Dough weight	75 g
Tank temperature	30 °C
Temperature 1st step	30 °C
Duration 1st step	8 min
1st temperature gradient	15 min – 4 °C/min
Temperature 2nd step	90 °C
Duration 2nd step	7 min
2nd temperature gradient	10 min – 4 °C/min
Temperature 3rd step	50 °C
Duration 3rd step	5 min
Total analysis time	45 min

transferred to the amylograph bowl and heated from 25 °C, at a rate of 1.5 °C/min until it reached maximum viscosity. From the resulting amylogram, the peak viscosity was noted.

Mixolab studies

Mixing and pasting behaviour of wheat flour dough was studied using the Mixolab (Chopin, Tripette et Renaud, Paris, France). The appropriate amount of flour (calculated using Mixolab software) was placed into the Mixolab bowl and subjected to hydration, mixing and heating according to standard "Chopin+" protocol. The settings used in the protocol are presented in Table 1.

Parameters obtained from the recorded curve were: water absorption (%) or water uptake required for the dough to obtain a torque of 1.1 ± 0.07 Nm, dough development time (min) or time to reach the maximum torque at 30 °C (time for C1), stability (min) or elapsed time at which the torque produced is kept at 1.1 Nm (± 11 %), degree of softening (Nm) or the torque difference between the maximum torque at 30°C and the torque at the end of the holding time at 30 °C, and peak torque (Nm) or the maximum torque produced during the heating stage (C3).

Statistical analyses

All the measurements were done in triplicates. Correlation coefficients between parameters obtained by Farinograph/Amylograph and Mixolab were calculated using Origin Lab software.

Results and discussion

In order to better understand parameters obtained by Mixolab one of the measured Mixolab profile is presented in Fig. 2.

Water absorption is an amount of water needed for adequate dough consistency (Mixolab 1.1 Nm). Dough development time refers to time at which the maximum torque of 1.1 Nm (C1) is reached. Dough stability presents its resistance to kneading while in the case of Mixolab measurement it is a time until the torque at the point C1 decreases in 11 %. The degree of softening was obtained by measuring the difference

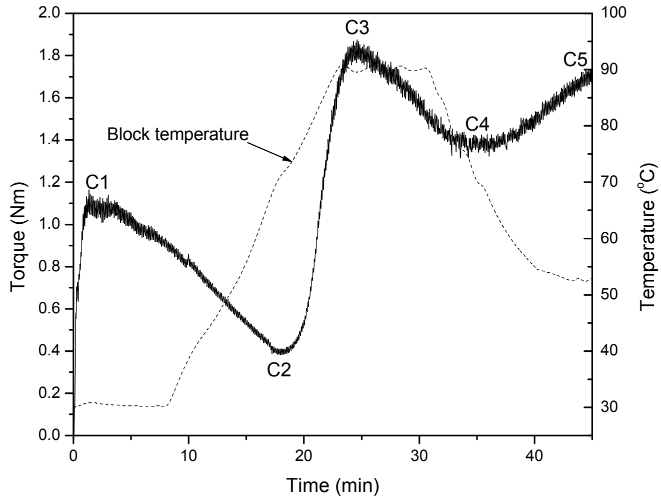

Figure 2. Mixolab profile

between the torque at the end of the period of constant temperature (30 °C) and the torque at C1.

As it was mentioned above, the main advantage of using Mixolab is the possibility to measure both the protein and starch properties in a single test. Starch properties can be analyzed in the second segment of Mixolab profile curve. The first segment of Mixolab curve, obtained with the constant heating rate, corresponds to Farinograph measurements, while the second segment of the curve obtained with the temperature increase corresponds to Amylograph measurements. Hence, the value of the torque at the second maximum of the curve (C3) is due to starch gelatinization and it can be compared to the peak viscosity of Amylograph curve.

Correlation between results obtained by Brabender Farinograph and Chopin Mixolab

Water absorption

Water absorption of wheat flour is influenced by different factors such as the protein (gluten) quality, starch properties (damaged starch, enzymatically treated starch etc.), type, flour particle size etc. In order to avoid the influences of different flour particle size on water absorption, only flours with similar distribution of particle sizes were used. Thus, the recorded parameters were solely influenced by protein and starch properties of the selected wheat flours. The increase of protein (gluten) content is in good agreement with the increase of water absorption. Starch absorbs through capillary action only about 0.3 % of water on its mass but in the case of damaged starch, which can arise in milling process, it can be increased up to 10 times more (Catteral, 1995; Rasper & Walker, 2000).

Correlation between water absorption obtained by using Chopin Mixolab and Brabender Farinograph is given in Fig. 3.

As it is shown (Fig. 3) strong correlation with the calculated correlation coefficient of r = 0.9816 (P<0.0001) was obtained. That gives a significant opportunity to use this data reliably in future trends of dough measurements.

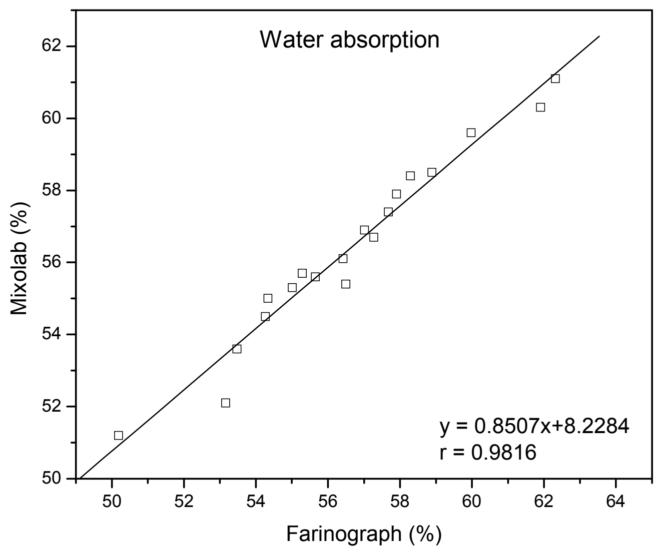

Figure 3. Correlation between water absorption obtained by Mixolab and Farinograph

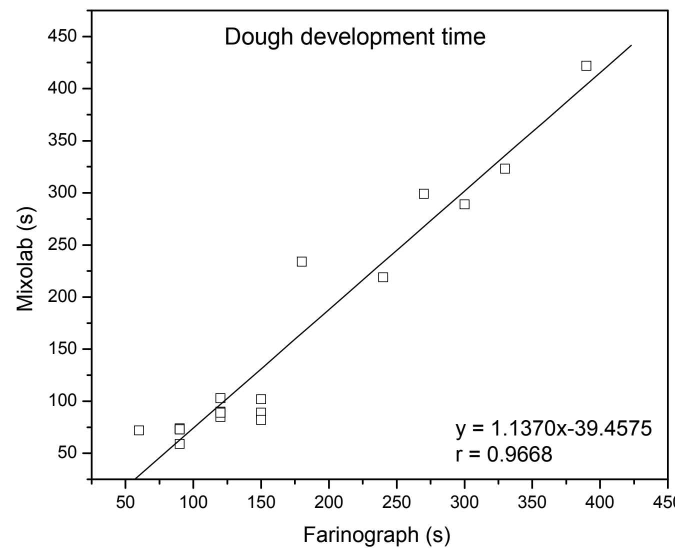

Figure 4. Correlation between dough development time obtained by Mixolab and Farinograph

Dough development time

Dough development time is strongly influenced, as in previous case, by protein and starch properties, type and flour particle size of used flours. Omitting the influences of type and flour particle size, predominantly protein, as well as starch characteristics on dough development time were observed. In the case of good gluten quality dough development time is longer than in the case of poor gluten quality. Starch properties do not significantly influence the dough development time as it is the case of gluten properties (Catteral, 1995; Rasper & Walker, 2000). Correlation between the dough development time obtained by using Chopin Mixolab and Brabender Farinograph is given in Fig. 4.

Very strong correlation between dough development time obtained by Mixolab and Farinograph was obtained, too, with correlation coefficient of r = 0.9668 (P<0.0001) (Fig. 4).

Dough stability

Dough stability is influenced mainly by gluten quality and its resistance to the kneading forces. Gluten properties can be governed by different factors such as wheat variety, agroecological conditions during wheat growing, protease activity, milling conditions etc. (Catteral, 1995; Rasper & Walker, 2000). Correlation between dough stability obtained by Chopin Mixolab and Brabender Farinograph is given in Fig. 5.

By measuring dough stability using Mixolab and Farinograph acceptable correlation coefficient of r = 0.7484 (P<0.0001) was obtained. The calculated result is not as good as it was in the cases of water absorption and dough development time. Presumably this is caused by different geometries of mixing elements and different speed of rotation having impact on investigated dough stability.

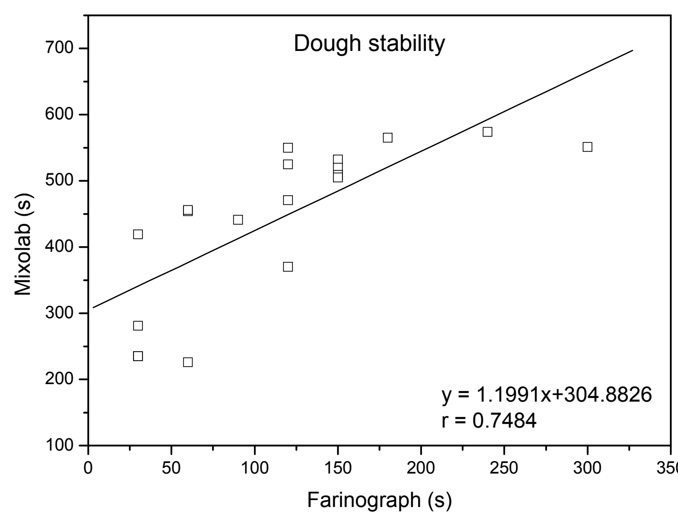

Figure 5. Correlation between dough stability obtained by Mixolab and Farinograph

Degree of softening

Degree of softening is predominantly influenced, as it was for the dough stability, by the amount and quality of gluten. The correlation between degrees of softening obtained by these two instruments is presented in Fig. 6.

Good correlation coefficient of r = 0.8504 (P<0.0001), even better than in the case of dough stability (r = 0.7484), using Mixolab and Farinograph was obtained. It can be concluded that degree of softening is not so dependent on the geometry of mixing blades and its rotating speed as it was in the case of measuring dough stability.

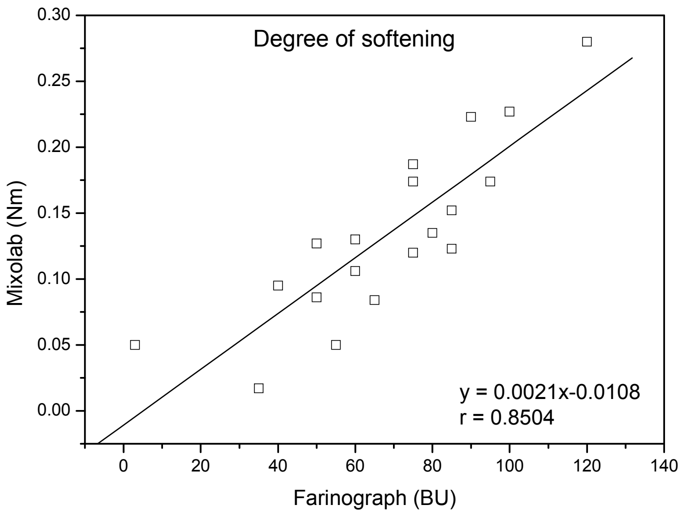

Figure 6. Correlation between degree of softening obtained by Mixolab and Farinograph

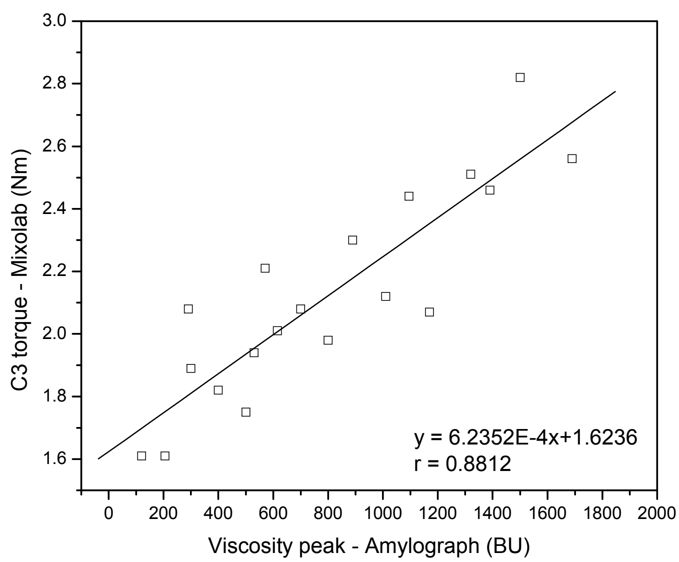

Figure 7. Correlation between peak viscosity (Amylograph) and maximum torque during the period of heating (Mixolab)

Correlation between Brabender Amylograph and Chopin Mixolab

Peak viscosity

Amylograph peak viscosity is the flour property that is mainly governed by starch properties of used wheat flour. The temperature increase leads to protein denaturation and all the resulting properties are influenced by present starch characteristics in the investigated systems. In Amylograph tests, peak viscosities of heated wheat flour suspensions were observed, while in the case of Mixolab tests, the maximum torque C3 obtained during heating with a constant heating rate and mixing of wheat dough was followed. The value of maximum torque C3, as well as the value of peak viscosity, can be influenced by starch content, amylolytic activity, starch damage, wheat variety, agro-ecological conditions during wheat growing etc. (Cornell & Hoveling, 1998). In Fig. 7 correlation of the measured peak viscosity obtained by Brabender Amylograph and maximum torque during the period of heating C3, obtained by Chopin Mixolab is presented.

From the Fig. 7 it can be concluded that very good coefficient of correlation of r = 0.8812 ($P<0.0001$) between tested properties was obtained. Regardless of different investigating systems (in Mixolab tests the object was dough, while in Amylograph tests it was wheat flour suspension) very good correlation between the two tests was proved.

Conclusion

Comparison between the conventional rheological tests (Farinograph, Amylograph) and Mixolab (used with "Chopin+" protocol) has shown the existing of very strong correlation concerning water absorption and dough development. Stability and degree of softening as well as peak viscosity has shown the existing of good correlation between selected methods for flour quality determination. In general, Mixolab method could be used for monitoring as well as for wheat and flour quality control with high level of reliability offering a number of important advantages over traditional rheological methods.

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