Rheological Parameters of Cereals

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Abstract. Rheology is a widely used tool in the qualification of cereals and cereal products. Maybe the most specific rheological analytical equipments were developed and used in the analysis of the dough made from flour and water. It is not a surprise as the dough is a very specific material. The moistened gluten proteins forms a three dimensional network in the dough what is a complex chemical system, and the chemical knowledge of this netwotk is hard to analyse and also hard to translate for the prediction of technological behaviour. On the other hand, the high starch content with the fiber content of the flour and the mechanical properties of the flour modify the usability of dough. The rheological analysis of this complex system is a rapid and practically useful way of qualification. The Farinograph, Alveograph, Extensigraph, Mixograph and Amylograph are specific complex equipments for the quality prediction and this paper will summarize the principles of these methods and their use in the qualification.

Keywords:

cereals,
rheology,
qualification,
wheat flour

MATERIALS AND METHODS

Rheologial methods in flour analysis

Specific rheological methods have a special emphasis in the cereal and especially in the wheat flour analysis. They can give special information about the technological suitability of flours, what depends on the starch and protein related functions of dough made from the flour. From the starch related parameters the activity of amylase enzymes and the gelatinization properties are the most important ones. Especially the high amylase activity, because it hinders the use in bakeries. The specific measurement method for the amylase activity is the Falling number. In this evaluation a flour-water suspension is stirred in hot water bath, then the rod falls down in the starch suspension. This falling slowed down due to the gelatinization of starch, but the amylases start to breakdown it. The higher amylase activity result faster starch degradation and faster decrease of viscosity, therefore the rod will be got down sooner.

The most important rheological tests of wheat flour is the ones which evaluates the behavior of dough made from water and flour. The most important tests for this are the Farinograph, Alveograph and Extensograph tests.

During the Farinograph test the dough in knead using two z-arm mixer arms. The machine continuously records the force what is required to maintain the constant deformation. As it can be seen, the resistance of dough against the kneading is

increases up to a specific point – this is the dough development time what is necessary to reach the optimal consistency for forming. The next phase is the stability when the strength of dough does not change. It can be determined by the length of the middle line of the curve measuring the time while it is horizontal, or measuring the time while the upper part of the curve is over the maximum consistency line. The next phase is the softening when the strength of dough decreases. In some countries the degree of softening after a predefined time is the last parameter. In Hungary the baking value is the most important parameter, what is calculated by the area between the maximum resistance line and the middle line of the curve. (D'Apollonia and Kunerth, 1990; Cornish et al., 2001).

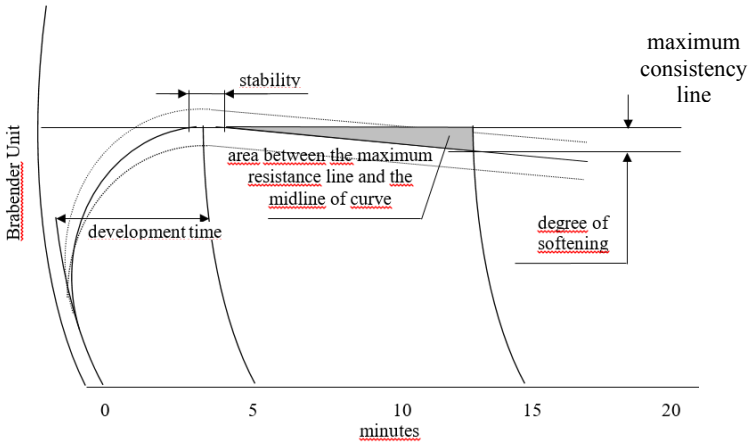

Figure 1
Representative Farinograph diagram

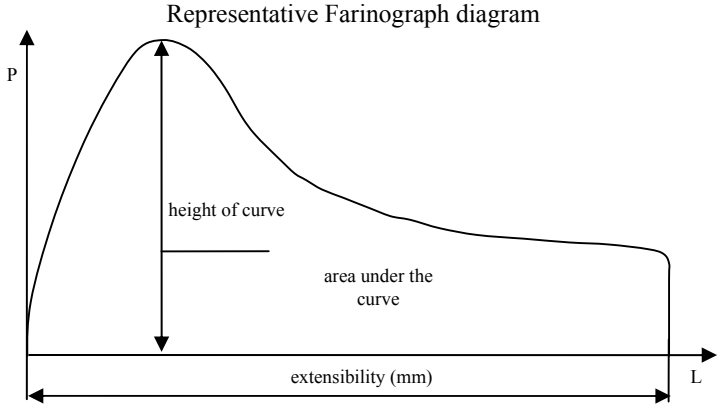

Figure 2
Representative Alveograph diagram

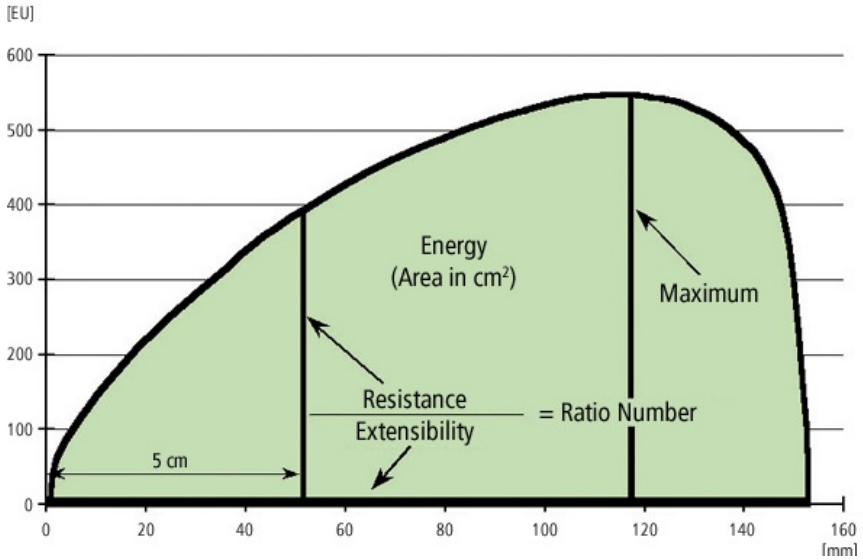

Figure 3
Representative Extensigraph diagram

The Alveograph test is the evaluation of dough made from salt solution and flour and formed into a disc. This disc is inflated until it gets torn and the equipment records the changes of pressure during the evaluation time (Figure 2). The higher pressure value (P value) is due to the stronger dough structure and the longer time to torn (L value) means more extensible dough. The quality parameter is the quotient of them (P/L value) and the deformation work (W value) what is the area under the curve from the beginning of inflation to the torn. (Rasper et al, 1986; Faridi and Rasper, 1987; Schöggl, 1998).

The Extensograph test is more or less similar to the Alveograph test; a dough formed into a rod and it is exposed to deformation until it stretches. The equipment records the resistance of dough against the pulling deformation and measure the resistance of dough (what is the maximum force measured during the pulling), the extensibility (what is the length of the curve) and the energy (the deformation work, determined by the measurement of the area under the curve) (Figure 3) (Müller and Hlynka, 1964).

Although these tests are different, there are some similarities in the properties. All of them evaluates the strength and the extensibility of the dough, therefore they characterize similar parameters. In this study we have evaluated the similarities and differences amongst them.

The evaluated samples

In the University of Debrecen the rheological parameters of winter wheat flours have been analysed for decades. In this study we have evaluated that how these parameters are changes under the same effects and is there any connection between the parameters of different methods. For this comparison we have

evaluated the effect of different flour additives (flour treatment agents and salts) on the Farinograph (MSZ ISO 5530-3:1995), Alveograph (AACC 54-30.02) and Extensograph (AACC 54-10.01) parameters and we made statistical analysis (correlation and regression analysis) to reveal the connections amongst the parameters and to try to estimate the different parameters from each others.

RESULTS AND DISCUSSION

The different flour additives significantly influenced the theological properties of the evaluated fine wheat flour (BL55 type), but their effects were different on the behaviour of the dough. The control flour had the highest Alveographic W value, relatively high Farinograph baking value and the second highest Extensographic energy value. However, when the flour was completed by 10% artichoke flour, the baking value showed a very slight decrease in the baking value (about 2%), while the Extensigraph energy value increased by almost 50% while the W value decreased to the third of the data of control flour. Other flour additives had similar effects on the different rheological parameters, for example one developed for biscuit making resulted almost the lowest baking value and W value and the dough was so soft that the Extensograph parameters were not evaluable. A classic Hungarian flour improver resulted the lowest baking value, but the Alveograph and Extensigraph readings proved that the dough became stronger by its use.

In the second experiment the effect of sodium chloride was evaluated on the rheological parameters. The sodium addition influences the water absorption capacity, increases the development time and stability while making the dough more strength by the slight rise of pH, which decreases the number of positive ions and helps the formation of cross-bindings (Preston, 1981; Danno and Hoseney, 1982). These references were proved in several cases as the addition of sodium chloride in increasing ratios increased the baking value, W value and Extensograph energy value of winter wheat flours, but it has no effect on the water absorption capacity and the Extensofraph extensibility. The increasing sodium chloride addition did not influenced the bread crumb hardness measured by texture analyser measured a day after baking, but its effect could be seen 3 days later when significantly lower hardness values were measured in the breads containing more salt.

When correlation analysis was performed on the results it was not a surprise that the connection between the baking value and the Extensograph energy value was moderate only (r=0,40), but it was much more stronger with the W value (r=0,71). Similarly there is only a moderate strong connection between the Extensograph energy and W value (r=0,43). It is much more interesting that the correlation coefficient is only 0,2 between the L value and the Extensograph extensibility and 2,21 between the P value and the Extensograph resistance value. Based on these connection it is also not a surprise that the stepwise regression analysis did not resulted good estimations for one rheological parameter based on the readings of the other quality data.

CONCLUSIONS

Rheological methods used in the cereal qualification are suitable for the prediction

of technological quality, but the different methods based on similar principle result different result. All the methods are suitable for the differentiation amongst the different samples, but their results are not comparable to each others. The prediction of rheological data using other quality parameters do not result reliable result.

REFERENCES

D'Apollonia, B.L., Kunerth, W.H. (1990). The Farinograph Handbook. Third edition, revised and expanded, AACC Inc., St. Paul, Minnesota, USA, 31-32

Danno, G., Hoseney, R. C. (1982). Effect of sodium chloride and sodium dodecyl sulfate on mixograph properties. Cereal Chemistry, 59, 202-204.

Faridi, H., Rasper, V. F. (1987). The Alveograph Handbook. American Association of Cereal Chemists, St. Paul, MN

Müller, H.G., Hlynka, I. (1964). Brabender Extensigraph Techniques. Cereal Sci. Today, 9, 422

Preston, K. R. (1981). Effect of neutral salts upon wheat gluten protein properties. I. Relationship between the hydrophobic properties of gluten proteins and their extractability and turbidity in neutral salts. Cereal Chemistry, 58, 317-324.

Rasper, V. F., Pico, M. L., Fulcher, R. G. (1986). Alveography in quality assessment of soft white winter wheat cultivars. Cereal Chemistry, 63, 395-400

Rasper, V. F., Preston, K.R. (1991). The Extensigraph Handbook. American Association of Cereal Chemists, St. Paul, MN

Schöggl, G. (1998). Überprüfung der technologischen Aussagefähigkeit von Alveogrammwerten zur Weizenbeurteilung. Getreide Mehl und Brot, 52, 218-223