Contributions regarding the testing of kneading characteristics on wheat flour dough

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ABSTRACT

This study deals with the possibility of correlating the measurements made on a Brabender farinograph in laboratory and those made on a mixer used in a bread making factory, to which it was connected a device for measurement which is made from an amperometric clamp and a data acquisition system made from an acquisition data plate (type Supco USB 6000), connected to a computer. The experimental research is based on the analysis of two types of flour FA-650, from two different mills.

1. INTRODUCTION

Nowadays, in the Romanian bread factories, the technology is expanding and it requires a stricter control of the entire bread making process. In Romania, the analysis of chemical, physical and rheological properties of flour are done in the laboratories and mills in which the flour is grinded.

The process of dough mixing is different from an usual mixing one because of its components properties, especially flour and water, which are the dough’s main components, [1]. The dough mixing process is the first step and a very important phase in bread making industry, [6].

Dough is formed through the coalescence of hydrated flour particles and their relative movement under the action of the mixer’s work mechanisms, resulting in the end, a compact and homogeny mass [2, 7].

Even if the farinograph’s curves have similar profile, these present differences because of the flour’s characteristics, the added water, the type of mixer, time of kneading, the quantity and the quality of added ingredients for the improvement of dough and final product. The rheological behaviour of dough during kneading, is fluctuating, [3, 4, 5, 10].

An aspect of great importance it represents the quantity of added water in the kneading process, in correlation with the water absorption capacity of the analysed flours and which is basically influenced by the type of mixing (intensive or normal) and by the shape of the kneading arms, more precisely by the energy introduced per time unit in the dough [J/kg], but also by the quality of the proteins found in flour [5, 9].

The image of the kneading process must be as clear as possible, because it can show the optimum dough development (if it is a good gas retainer, it has elasticity or it’s behavior in other phases of the bread making process is optimum), which will decide the quality of the final product, [8, 2, 4].

The present article draws to attention the fact that the bread making process can be can be done with a higher accuracy, if the used mixer offers the possibility to determine the quantity of water which must be added to the flour for each individual charge.

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2. MATERIALS AND METHODS

The experimental determinations for evaluating the quality of the flour in the kneading process, were made using a Brabender farinograph, version E (figure 1a). The farinograph has a capacity of 300 g of flour and the water temperature in the recirculation system was held up to 30+1 ºC.

There were also made experimental determinations on a mixer type Tecnopast BSE 300, at which was connected a device called 'Loggit' (figure 1b), used for measuring the electricity consumed by the engine of the mixer.

In order to make a correct comparison between the two measurement devices, it is necessary to establish an equivalence between the obtained results with the benchmark mixer and the ones obtained with the data acquisition device in real time, called 'Loggit'. In order to establish the right correction that must be done to the in-house device, several combined measurements have been done, to which the benchmark mixer has been connected to and the data acquisition device as well during the establishment of values.

The working principle of this method consists in connecting the measuring and data acquisition device to the mixer, where it measures the consumed electricity by the engine during the kneading, a consumption that is growing/descending depending on the opposition force of the dough at the kneading arm, more so on the torque at the mixer's working arm.

For the experimental research, were used two types of wheat flour, both F-650, but with different physico- chemical and rheological features, as it is shown in table 1.

Table 1: Physico- chemical and rheological features of different types of flour from wheat in the context of experimental research

Flour type	Moisture content, (%)	Wet gluten (%)	Ash content, (%) s.u.	Protein content, (%) s.u.	Gluten deformation (mm)	Acidity, (º)	Gluten deformation index	Falling number, (sec)	Gluten index
FA – 650 (F1)	13,7	0,65	11	26,8	4	1,8	2	350	84
FA – 650 (F2)	14,1	0,65	11,2	27,5	5	2,5	1,5	290	82
Flour type	**P, [mm]**	**G**	**L, [mm]**	**W [$10^{-4}\cdot$J]**	**P/L**	**Water absorption [%]**	**Farinograph quality number**	**Stability [min]**	**Development [min]**
FA – 650 (F1)	118	18.4	57	257	2.1	60.4	35	6	3
FA – 650 (F2)	99	18.5	68	233	1.5	57.5	40	4	4

The same type of flour (FA-650 F1) used on Brabender farinograph, was used for the tests made on an industrial mixer, type Tecnopast BSE 300, with spiral blade, planetary motion and mobile vat, with a capacity of 300 l, in order to determine the variation of the resistant torque on the spiral blade. The water temperature was 30-31 ºC, in correlation with the temperature of the water used in the tests on Brabender farinograph. The mixing time in both sets of tests, was of 20 minutes.

Before starting the kneading process, an amperometric clamp was connected to the power supply of the engine which trains the kneading arm. The amperometric clamp was also connected to a data acquisition device (Supco type), which downloads real time information on a computer. The registered signals were filtered based on the electrical current variation, and the variation curves for the dough consistency during kneading, were drawn.

In order to filter the obtained data, functions like max, min, average, count and others in the Excell program were used. The next step was to correlate the measuring unit between the one used for Brabender farinograph (Nm), and the one on the results obtained by the consumption at the kneading arm.

At first, the mixer was left working without load (out-current), in order to establish the energy losses of the mixer, which were decreased from the final calculation of the torque (Nm) consumed by the spiral blade, in relation with the opposing force of the dough.

Considering the general relation for calculating the necessary driving power on the working arm, it can be written:

$$P_m = M_m \frac{\pi .n}{30} \qquad (1),$$

where: M_m is the resisting torque at the kneading arm, maximum, respectively medium and Pm is the corresponding power, [11].

For finding the power consumed by the mixer's engine, the following relation was used:

$$P_m = \sqrt{3} * U\, I \cos\varphi \qquad (2),$$

where: U is force of the current, I is the intensity of the current and which is the value measured by the amperometric clamp and cos φ is the power factor.

In order to establish the consumed power by the kneading process, without the energy losses, the next relation was used:

$$P_{mf} = P_m - P_{mg} \qquad (3),$$

where: P_{mf} is the consumed power only for the kneading process, P_m is the total power consumed by the mixer's engine and P_{mg} is the consumed power of the engine, on out-current.

Knowing the consumed power for the kneading process and the angular speed described by the kneading arm, it is possible to calculate the medium torque:

$$M = \frac{Pm}{\omega m} \qquad (4),$$

where: M is the medium torque of opposition by the dough at the kneading arm, P_m is the power consumed by the engine only for the kneading process and ω_m is the angular speed of the arm when kneading.

a. b.

Figure 1: a. Brabender farinograph; b. Portable device used for measuring the consumed current when kneading dough

3. RESULTS AND DISCUSSIONS

The experimental research was structured in four stages:

- In the first stage of research, the experimental data was processed, resulting in drawing the variation curves of the resistant torque on the kneading arm, as it can be observed in figure 2:

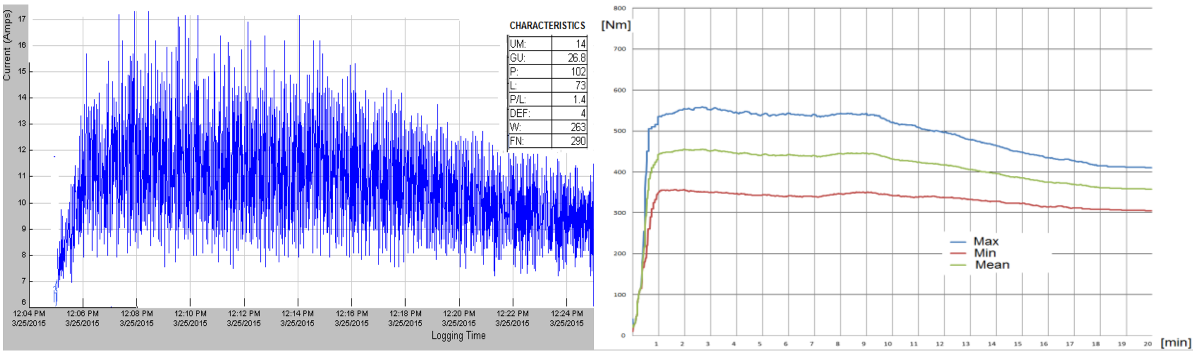

Figure 2: Data registered by Loggit device before and after processing it

- The second part of research focuses on the comparative analysis of the results obtained by the two devices that were used for the same charge of dough, kneaded by the Brabender farinograph. It was drawn the resulting farinogram with the Brabender device and simultaneously with it, was drawn the variation curve of the electrical current consumed in the kneading process, with the Loggit device, as it can be seen in figure 3.

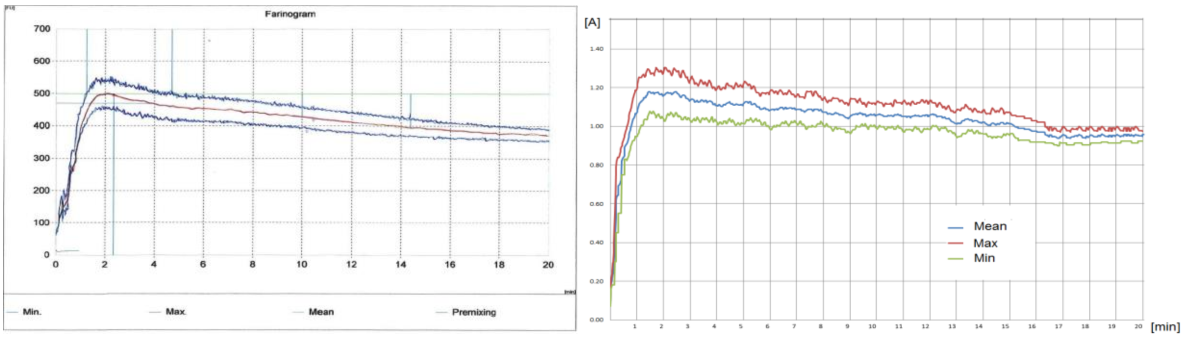

Figure 3: Flour type F1 -650, analyzed with the Brabender farinograph and the variation curves of dough consistency from FA-650 (F1) flour, drawing based on data registered by the Loggit device

- The third part of the experimental research focuses on establishing a correlation between the optimum value of dough consistency, of 500 UB (5 N·m), value indicated by the farinograph and the value indicated by the Loggit device. In order to obtain this result, there were tests made in parallel, on the Tecnopast BSE 300 mixer and on the Brabender farinograph.

For one test was used F1-650 flour type, with 58% added water in reference with the flour and one test with 60% added water, value corrected by the farinograph after the test with 58% added water. The variation curves of the torque on the kneading arm for FA-650 (F1) flour with 58% and 60% added water can be observed in figure 5.

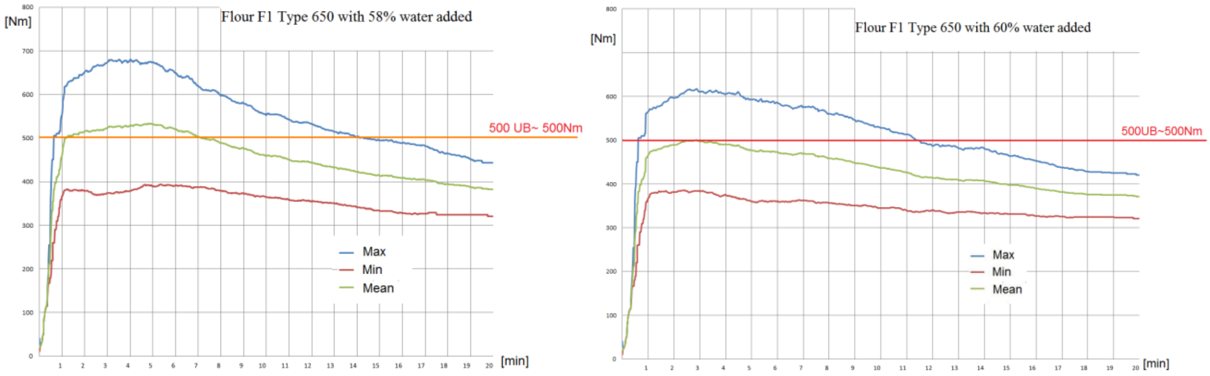

Figure 5: The variation curves of the torque on the kneading arm for FA-650 (F1) flour with 58% and 60% added water

After analyzing the farinographic parameters and taking as standard the correction indicated by the Brabender farinograph (60% added water for FA 650 F1 flour), the medium torque on the kneading arm reaches a maximum around 500 Nm (similarly to the standard value established by the farinograph, of 500UB at 60% added water for the same flour). As a result, the two values, 500UB and 500Nm can be correlated. The value of 500Nm applies only to this type of mixer.

- The forth part of the research focuses on the comparative analysis of the results obtained on tests made on the mixer Tecnopast BSE 300 for two different types of flour FA 650 (F1, F2), in similar conditions of: added water, temperatures for environment, flour and water, kneading time. The variation curves obtained for the two studied flour types FA 650 (F1, F2), in the same conditions of added water (58%), can be observed in figure 6.

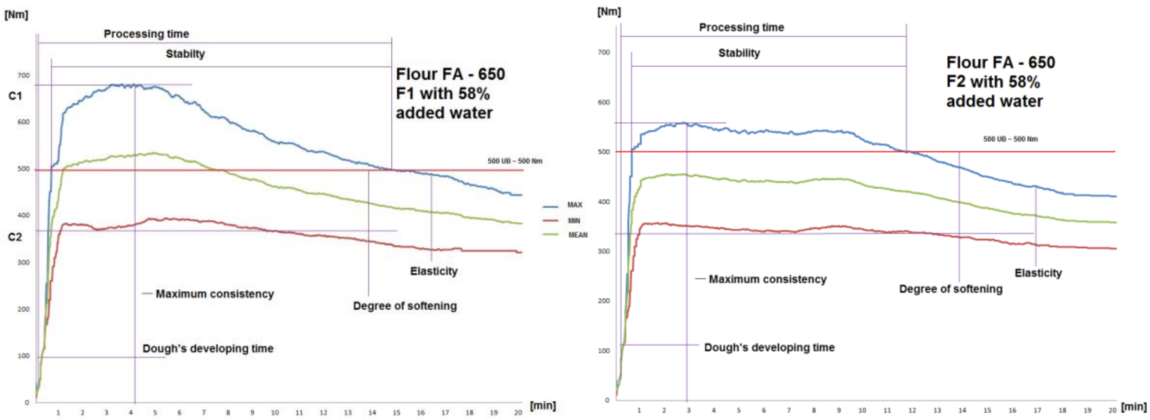

Figure 6: The variation curves obtained for the two studied flour types FA 650 (F1, F2), in the same conditions of added water (58%)

Table 2: Rheological values based on the variation curves presented in figure 6

Flour type	Processing time [min]	Stability [min]	Elasticity [N·m]	Degree of softening [N·m]	Maximum consistency [N·m]	Dough's developing time[min]
F1	15	14,2	150	120	685	4,5
F2	11,2	11,5	90	140	560	2,9

4. CONCLUSIONS:

The documentary study and the experimental results presented in this paper have led to the following conclusions:

It is imperative to estimate the final moment of the kneading process, so as to obtain a dough with the best possible characteristics, for the ulterior processing (dividing and modeling), as well for the final proofing and baking. The image registered in real time by the Loggit device can help the operators to obtain charges of dough with the same consistency, stopping the kneading process when the optimum value shown on the monitor is reached.

The Loggit device can measure with high accuracy any modification in the kneading process, a conclusion drawn after comparing the kneading diagrams obtained by the two measuring devices used simultaneously on the same process.

The diagrams obtained on an industrial mixer are different from the ones obtained on the Brabender farinograph, but these diagrams have a repeatability character, so diagrams can be drawn for each type of mixer.

For the Tecnopast BSE 300 mixer, it has been established an equivalence between the measured value on the Brabender farinograph, of 500 UB (5 N·m) and the value of 500 N·m measured with the device proposed by the author.

The amount of added water in the kneading process modifies the position of the variation curve on the torque, as well as the specific curve.

The Loggit device can offer a clear image over the kneading process, a fact that highly contributes to its utility, for the technological engineers that work in bread making factories (making it possible to work easier with any kind of flour), as well for the operators, who can follow in real time the development of the dough and its optimum consistency.

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