IMPROVING THE BROWN FLOUR QUALITY ON THE ACCOUNT OF THE RHEOLOGICAL DETERMINATIONS OBTAINED IN THE ALVEOGRAPH, RHEOFERMENTOGRAPH AND MIXOLAB♦

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Received: 21/02/2008
Accepted after revision: 25/03/2008

Abstract: The aim of the paper was to optimize the quality of the brown flour by grinding wheat at industrial level. The brown flour was obtained in intermediary extraction, besides the white flour. We have rheologically analyzed more variants of composition of the flour varieties. The optimization of the brown flour quality was made by recomposing the two flour varieties, white and brown, but also through the use of hemicellulases, α-amylases, cysteine. As the brown flour presented initially a high initial P/L report, and low energy, we proceeded to redistribute the flour fractions between the two types so that the mentioned rheological indices could be brought to the parameters closest to technological optimal standard. Between additivation, we could obtain, for the brown flour, those

♦ Paper presented at the fifth edition of: "Colloque Franco-Roumain de Chimie Appliquée – COFrRoCA 2008", 25 – 29 June 2008, Bacău, Romania.

rheological parameters in the curves registered in the Mixolab, Alveograph and Rheofermentograph that are supposed to be optimal for getting high quality bread making products.

Keywords: *brown flour, alveograph, rheofermentograph, Mixolab, quality improvement*

INTRODUCTION

The technological process of gradual grinding of the wheat grain, with the separation of the endosperm from the layer and the transformation of the endosperm through grinding into flour, leads to obtaining a great number of flour fractions.

Usually a flour variety is permanently made up of the same types of flour collected at the sieve passage. They are changed only in cases of damage when one or more sieves are broken.

In these cases, another fraction with the same quality is introduced. If none of the fractions can replace the broken one, it is finally given up, even if the product is obtained at a reduced scale, until the dysfunction is repaired. Modifications of the optimal schemes that compound the types of flour are admitted also in the case of some problems related to the quality of the raw material.

When only one variety of flour is made, the flour at all the passages is brought together in a single jet. In the content FI and FII, all the parts of the endosperm are included, the difference being given by the proportion between the parts of the endosperm and the bran parts [3].

When making two varieties of flour, FI is obtained at the first passages of break rollers and reduction, and FII is obtained at all the other passages. In the contents of FI, the central and dorsal parts of the endosperm are involved, while in FII, only the periphery parts of the endosperm are involved.

When we make three varieties of flour, they are made of:

- FS – fractions from the first grinding passages, ash contents of 0.38% – 0.5% when FS is made from the separated fractions from C1-3 or 0.40 – 0.60 when FS is made of the fractions separated at C1-5.
- FI – fractions left at break rollers and reduction passages left after separating FS, when FI is made of the fractions from B2, C3. So, the ash contents is 0.45 – 0.55%, or 0.50 – 1.15% when FI is made of the fractions from the passages C4-7 (the above sieves).
- FII – the other fractions of flour, ash contents 0.6 – 1.8%.

In the case of extractions of 80 – 82%, equal to the endosperm quantity, the ash content of the flour is of 0.9 – 1.11%, because of the content of layers.

For extractions of 70% made on extended grinding graphs, the ash content of the flour exceeds 0.60%, i.e. more than the ash content of the endosperm. However, the extraction of flour with a little content of ash is much bigger than in the case of the simple grinding.

The combination of the flour fractions is most of the times made for obtaining a maximum profit. In most of the cases, the combinations are made through subjective decisions based on the mill technician's experience and knowledge.
The purpose of this paper was to optimize the quality of brown flour obtained by grinding wheat at industrial level. The brown flour has been obtained in the intermediary extraction, besides the white flour. We have rheologically analyzed more variants of composition of the flour variants. The optimization of the quality of brown flour has been done by recombining the two varieties of flour, white and brown, but also by using hemicellulase, α-amylase and cysteine.

MATERIALS AND METHODS

The rheological determinations were done using the following equipment:

- The NG Chopin Alveograph, the AACC 54-30 method [4],
- The F3 Chopin Rheofermentometer [6]
  It measures the developing parameters of the dough (250 g flour, 7 g yeast pressed under the form of suspension, 5 g salt and water that ferment according to the parameters imposed by the Chopin protocol, 28.5ºC temperature, hydration according to the elasticity values in the alveogramme, the mass of the dough sample 315 g, 3 hour-test duration and the weight mass of 2000 g, the kneading being made in the Alveograpf kneader) and it determines the quantity of gases formed and retained by the dough.
- The Chopin Mixolab [5]
  The device settings during the determinations are those shown in table 1.

Table 1. *The settings of the Mixolab during the experiments performed*

Settings	Simulator test	Chopin +
Mixing speed [rpm]	80	80
Dough weight [g]	75	75
Tank temperature [ºC]	30	30
Temperature first plateau [ºC]	30	30
Duration first plateau, until torque will be 0.90×1.1 Nm [min]	30	8
Temperature second plateau [ºC]	-	90
First temperature gradient [min - ºC/min]	-	15 - 4
Duration second plateau [min]	-	7
Second gradient temperature [min - ºC/min]		10 - 4
Temperature third plateau [ºC]	-	50
Duration third plateau [min]	-	5
Total analysis time [min]	-	45

The following parameters were recorded: water absorption, development time, stability at mixing, dough weakening (C2 and α), starch gelatinization (C3 and β), amylase activity (C4 and γ), starch gelling (C5). The typical curve recorded by the Mixolab is shown in figure 1.

C1 (Nm) – marks the peak torque of the dough; it is used to determine the water absorption;
C2 (Nm) – gives indications about the dough weakening as a function of the proteins' quality, mechanical work and temperature;
C3 (Nm) – expresses the starch gelatinization;
C4 (Nm) – indicates the stability of the starch gel formed;
C5 (Nm) – measures the starch regression during the cooling stage.
α – represents the slope of the curve between the end of the period of 30 ºC and C2; it expresses the weakening speed of proteins under the heating effect.
β – represents the slope of the curve between C2 and C3; it expresses the rate gelatinization.
γ – represents the slope of the curve between C3 and C4; it expresses the rate of enzymatic hydrolysis.

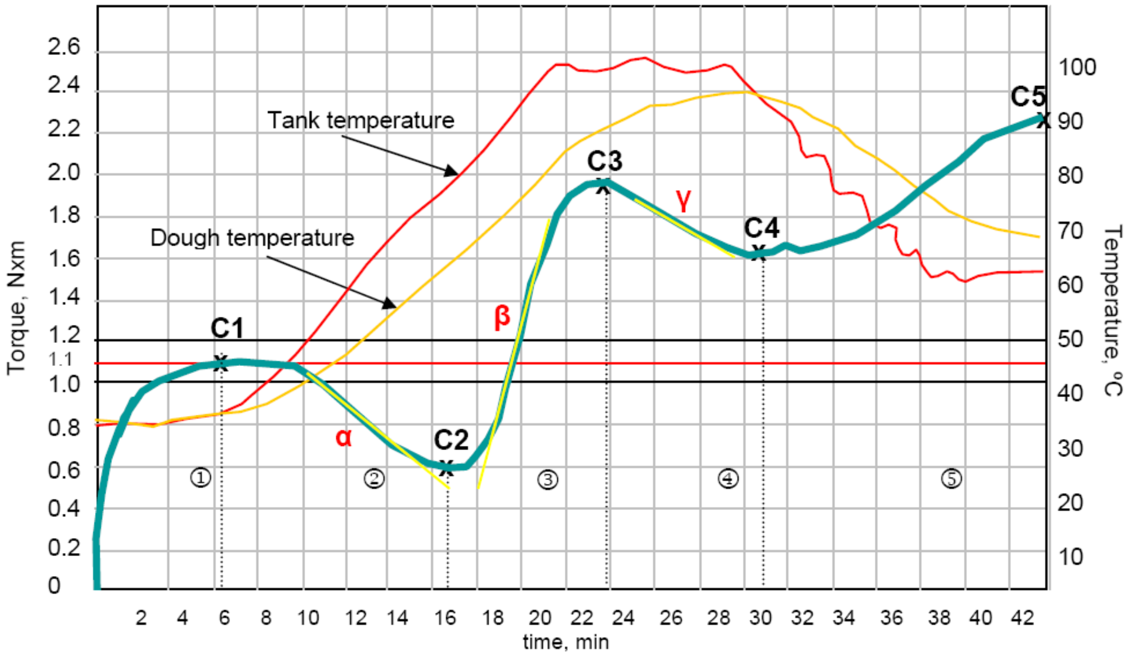

Figure 1. *The typical curve recorded by the Mixolab*

The wheat grinding was done in an industrial mill with the capacity of 80 t/24 h. The wheat was conditioned so that at the first break rollers passage, the humidity was of 16.3% after 12 hours of repose (out of which 7.5 hours at the stage I, the difference being at the stage II), the water being distributed in proportion of 2/3 at the first stage, and 1/3 at the second. The wheat at B1 had 27.8% gluten, a glutenic index of 92.44%, and the falling figure of 435 s.
The milling is made with modern equipment – rollers with two stages (MDDO, with a length of 800 mm) and rollers with a stage (MDDM, with lengths of 800 and 1000 mm) of grinding. The total length of grinding is of 1000 cm, the ratio between the grinding length at break rollers and that at the grinding is 2/3. The grinding process is completed

with impact detacher MJZE and MJZF, and drum detacher MDLA, which finally leads to a specific charge of 100 kg/cm, 24 h.
The sieving is ensured by plane sieves MPAJ-824 NOVA, the specific charge being of 100 kg/m^2, 24 h. The final step in separating the endosperm from the layer is made with the help of bran finisher MKLA 30/80. The recovery of the sieved product without particles which is obtained at the bran finisher is made trough sieving with vibrocentrifugal MKVA 36/10 M. The characteristics of the break rollers and the sieving diagram ensure an efficient granulometric separation that replaces the presence of the purifying and classifying semolinas machine in the grinding diagram.
We have analyzed the flour obtained by grinding wheat in two technological variants, presented in table 2.

Table 2. *The composition of the flour varieties in the analyzed technological variants*

Flour	Componentes fractions
Variant A	
White flour ✓ ash content 0.55%, ✓ extraction 44.4%.	C2/C3I, C2/C3III, C4I, C5I, C7I, B1/B2, FD
Brown flour ✓ ash content 1.06%, ✓ extraction 38%.	C1I, C1II, C1III, C2/C3II, C6I, C9I, C9II, B3, B4, B5f, Div
Variant B	
White flour ✓ ash content 0.64%, ✓ extraction 45%.	C2/C3I, C2/C3II, C2/C3III, C5I, C7I, B1/B2
Brown flour ✓ ash content 0.96%, ✓ extraction 37.4%.	C1I, C1II, C1III, C4I, C6I, C9I, C9II, B3, B4, B5f, Div, FD

In order to optimize the quality of brown flour, we have used enzymes - fungic α-amylase (Clarase Gplus, from *Aspergillus oryzae*) 1 g/100 kg flour, fungic hemicellulase (Belpan Hemi C, from *Aspergillus oryzae*) 5 g/100 kg flour and microbian cysteine (Citoplus 50) 1 g/100 kg flour.

RESULTS AND DISCUSSION

The rheological determinations made for the flour varieties obtained in the first variant of composition indicated an unsatisfactory quality for the brown flour and one that is satisfactory for the white flour. Thus, for the brown flour we have obtained a high P/L ratio of 3.29, and an energy of $77 \cdot 10^{-4}$ J, and for the white flour the P/L ratio was 0.62, and the energy was $263 \cdot 10^{-4}$ J.
Analyzing the alveogrammes of the composing flour fractions we have decided to transfer the separated fractions at FD and at C4I from the white flour to the brown one, and of the fraction C2/C3II from the brown flour to the white one. The main alveogramme parameters for the flour fractions at FD, C4I and C2/C3II are shown in

table 3. Through this transfer we wanted to reduce the P/L ratio and to raise the energy of the brown flour. Thus, for the brown flour the P/L ratio was reduced to 2.73 and the energy raised to $95 \cdot 10^{-4}$ J, while for the white flour the P/L ratio raised to 0.68 and the energy to $252 \cdot 10^{-4}$ J.

Table 3. *The alveogramme parameters of some flour fractions*

Flour fractions	Extraction, %	P/L	$W \cdot 10^{-4}$ J
FD	1.43	0.5	121
C4I	3.58	1.4	277
C2/C3II	6.43	3.1	175

We proceeded to the optimization of the brown flour quality through additivation. We analyzed three variants of additivation. The parameters of the alveogrammes and of the rheofermentograms for the variants with the brown flour additivation are shown in table 4.

Table 4. *The alveogramme and rheofermentograms parameters for the additived brown flour (FN)*

Parameters	FN (P0)	FN + 1 g α-amylase and 1 g cisteine (P1)	FN + 1 g α-amylase, 1 g cysteine and 5 g hemicellulase (P2)
Falling number [s]	479	245	255
Alveorgramme parameters			
Dough elasticity (P) [mm]	82	67	72
Dough extensibility (L) [mm]	30	40	43
P/L	2.73	1.67	1.67
Energy (W) [$Jx10^{-4}$]	95	93	110
Flexibility index (Ie)	0	24.5	28.5
Dough blowing index (G)	12.2	14.1	14.6
Rheofermentogram parameters			
Dough permeability by time when gas starts to escape from the dough (Tx) [h]	1.18	1.31	1.34
Maximum time for gas production (T'1) [h]	2.15	2.57	2.55
Total gas production [mL]	1768	1804	1804
Volume of the gas lost [mL]	49	49	47
Retention volume [mL]	1719	1755	1817
Retention coefficient [%]	97.2	97.3	97.5

Through additivation we have achieved a substantial reduction of the falling number, from 479 to 245 s. The parameters in the alveogram also show a tendency to modify the elasticity through its diminution with 20% and a rise in the extensibility with 10, respectively 13 mm compared to the witness sample. In exchange, the energy is slightly diminished for the α-amylase and the cysteine samples, but slightly raised for the sample additivated with hemicellulases. Compared to the witness sample we can see the

occurrence of the elasticity index - 24.5 mm, respectively 28.5 mm for the two additivated samples (Table 4).
The effect of the α-amylase adding is obvious in the total volume rise of gas with 2% (36 mL) compared to the witness, while the gas retention, influenced by the action of cysteine is increased from 1719 to 1755 mL, which is transposed in values in keeping with the 0.1 rise of the retention coefficient. It is o be remarked the occurrence of the moment when gas is lost after a longer lapse of time (13 minutes later). The dough has the tendency of decreasing the gas developing curve height in the case of the samples P0 and P1, while once the gas is lost, their production is continued but in a different way. While the dough at P0 reaches a maximum of development after 135 minutes corresponding to a height of 79.2 mm, at the sample P1 the production of gas is continued in the same time with its lost, but the moment when the maximum development is reached is after 177 minutes at a height of 85.4 mm.
For P1, the moment T'1, when the bread maximal volume is reached, is decisive for the period of the dough processing, until being placed into the oven.
Figure 2 comparatively shows the curves recorded in the Mixolab for P0, P1 and P2.
The α-amylase adding determines for P1 a reduction of the dough developing time compared to P0, from 3.36 min to 2.54 min. For P2, to which beside the α-amylase hemicellulases are also added, it is recorded a rise in the time of the dough development compared to P1. On the plateau that is also at constant temperature (30 ºC), after reaching the value Cmax (1.1 Nm) we noticed the stability of the dough at deformations of a certain type. The period when the couple and the temperature are constant determine the dough stability. By additivation, the dough stability improves – it rises from 5.02 for P0 to 5.22 for P1 and 5.44 for P2.
After the dough stability period we recorded the reduction of the couple, rendered by the mechanical softening of the dough and explained in fact by the unfolding of the proteic chain under the action of the mechanic force. The minimal couple of the force in the point C2 inscribed in the Mixolab curve (Figure 2) shows smaller values for the additivated samples, 0.32 Nm, compared to 0.42 Nm for the witness; this leads to higher values for the α slope.
The activity of the proteolytical enzymes is neatly characterized by the α slope in the mixolab. Previous studies showed that the reduction of the C2 couple size is correlated with the rise of the bread volume [7].
The temperature rise of the dough in the mixolab determines the proteins' coagulation accompanied by the release of the largest quantity of water bound to proteins at kneading [2]. The β slope that characterizes the starch gelling has smaller values in the additivated samples, 0.332 Nm/min for P1 and 0.360 Nm/min for P2, compared to 0.420 Nm/min for P0. The enzyme adding determines the reduction of the C3 couple size, from1.85 Nm/min for P0, to 1.36 – 1.39 Nm/min, for P1 and P2.
C4, that characterizes the beginning of the period of cooling the starch gel, diminishes for the additivated samples compared to the witness sample (1.12 – 1.16 Nm/min at P1 and P2, 1.75 at P0). The starch retrogradation is characterized by the C5 couple value and had smaller values at the additivated samples: 1.66 – 1.69 Nm/min, compared to the witness, 2.42 Nm/min. Practically, the α-amylase adding allows a decrease of the retrogradation [1]. Smaller values of the couples C4 and C5 for the additivated samples are correlated with higher volumes of the bread.

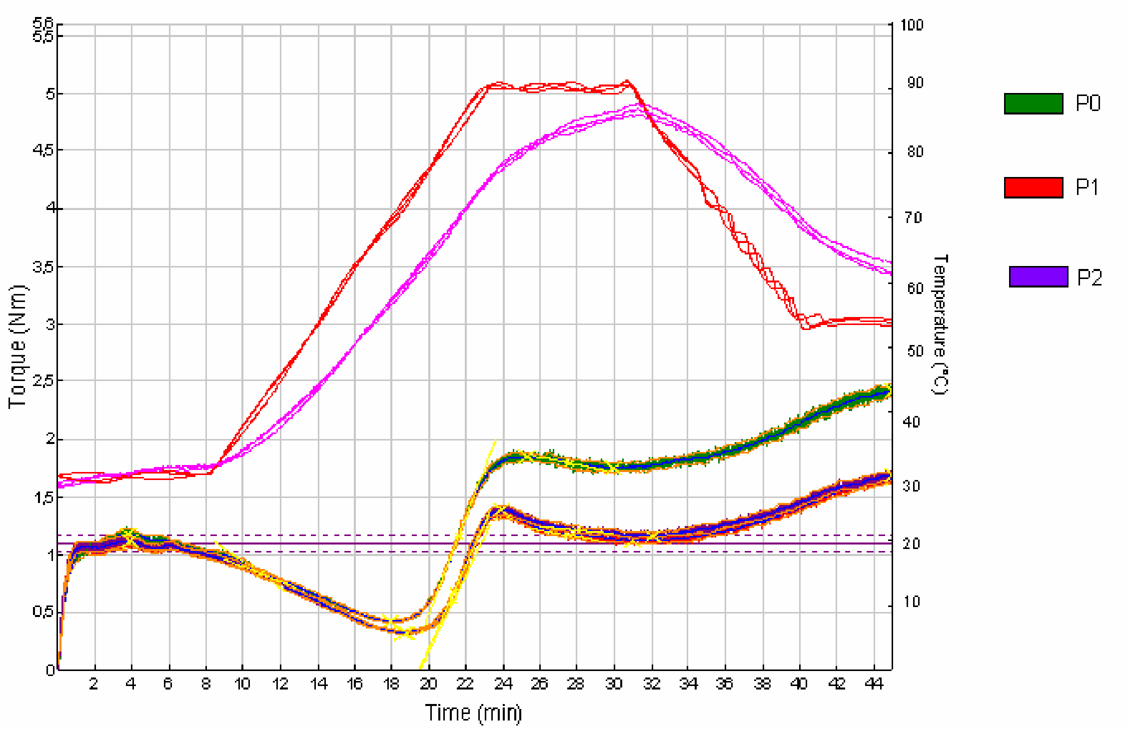

Figure 2. *The curves recorded at Mixolab for P0 – brown flour, P1 – brown flour with α-amylase and cysteine adding, P2 – brown flour with α-amylase, cysteine and hemicellulase adding*

CONCLUSIONS

The purpose of the paper was to optimize the quality of the brown flour by grinding wheat at industrial level. The brown flour was obtained in intermediary extraction, besides the white flour. We have rheologically analyzed more variants of composition of the flour varieties. The optimization of the brown flour quality was made by recomposing the two flour varieties, white and brown, but also through the use of hemicellulases, α-amylase, cysteine. As the brown flour presented initially a high initial P/L ratio, and low energy, we proceeded to redistribute the flour fractions between the two assortments so that the mentioned rheological indices could be brought to the parameters closest to technological optimal standard. Between additivation, we could obtain, for the brown flour, those rheological parameters in the curves registered in the Mixolab, alveograph and rheofermentograph that are supposed to be optimal for getting high quality bread making products.

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