The effects of different doses of gluten on Rheological behaviour of dough and bread quality

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Abstract

The aim of this study was checking the effect of vital gluten, which was added in different doses into the type of flour with a medium quality, referring to its improvement potential. The rheological experiments have been carried out on the Chopin alveograph (for doses of 1%, 2%, 3%, 4%, 5% added vital gluten) and on the mixolab (for doses of 1%, 2%, 3% added vital gluten). The mixolab has registered an increase of the moment opposed by the dough during mixing, with 8.4% and of dough stability with 9.4%, in relation to the quantity of added gluten. Moreover, an increase of the C2 value with 18.4% has been registered in the first step of dough warming. The alveograph has shown a decrease of parameter L and an increase of parameters P and W. From the baking samples point of view, the best results have been obtained for a dose of 2% addition of vital gluten with an increase of 48,8% for the loaf volume value. The descriptive sensory analysis of the bread baked with added gluten has shown some improvements in terms of external aspect, crust aspect, firmness and flavor, the sample with 2% gluten obtaining a score of 17 points compared to the 11 points registered by the control sample.

Keywords: vital gluten, mixolab, alveograph, baking test

Introduction

Wheat is one of the three major cereals dominating world agriculture today. The importance of wheat is attributed to the gluten storage proteins present in the endosperm, conferring unique viscous-elastic properties of the dough [9]. Gluten is the insoluble proteinaceous mass left, when wheat dough is washed to remove starch and soluble proteins. Its unusual physical properties, a combination of elasticity and extensibility, are responsible for the ability to bake wheat flour into leavened bread. Studies of gluten protein structure are therefore, important in relation to understanding its role in bread making and other functional properties of dough [4].

Gluten is a large complex constituting mainly of glutenine (polymeric) and gliadine (monomeric) proteins. Gluten has a high percentage of amide nitrogen mainly from glutamine, a high percentage of proline, intro- and intermolecular disulfide bonding, and many amino acids with hydrophobic side chains. Intra- and intermolecular disulfide bonding caused by cysteine can be found mainly in glutenins; much of the intramolecular disulfide bonding is in gliadins [13].

The differences in rheological behavior between glutenin and gliadin are partly attributable to a difference in molecular size. The glutenins consist of a HMW group and a LMW group of polypeptides, able to form disulfide linked polymeric networks. Gluten proteins affect dough mixing time and rheological properties. It has been demonstrated that gliadin behaves as a viscous liquid [1, 5] and glutenin behaves as cohesive elastic solid when hydrated [6, 7, 8, 12]. Because of the specific viscoelastic properties of wheat flour dough, gas cells are retained in the dough during the bread-making process. It is this property that allows wheat flour to be used for production of a wide range of leavened food products.

The technological potential of the flours obtained from Romanian wheat need to be increased by using diversified improvement additives [10]. The basic principle of gluten usage in bakery derives from its ability to fit in perfectly with the glutenic proteins in flour, which has been improved with additives, resulting into a perfectly homogenous and stable gluten network. The addition of vital gluten increases the technological potential of wheat flours up to a certain dose.

Therefore, we have regarded as useful the development of an experimental study on the rheological behavior of the dough, with different doses of vital gluten addition, using the mixolab and the alveograph devices. The rheological experiments have been carried out through baking samples.

Materials and Methods

Commercial wheat flour (harvest 2006) was milled on an experimental Buhler mill from Mopan S.A. (Suceava, Romania) and vital gluten was provided by MelPro Ingredients B.V. Netherlands. Deionised water was used in all experiments. The effect of vital gluten was evalueted by the addition of 1%, 2%, 3%, 4%, 5%, related to the flour weight.

The chemical composition of the flour was determined according to Romanian, or international standard methods: moisture (ICC Standard No. 202), wet gluten content and gluten deformation index (STAS 90 - 88), protein content (ICC Standard No. 202), ash content (AACC Standard No. 08 – 21), falling number (ICC Standard No. 107)

Rheological properties of wheat flour were determined by a Chopin alveograph (according ISO Standard 5530/4) and Mixolab (Chopin, Tripette & Renaud). Each alveograph chart was analyzed for four factors: P - the maximum over pressure needed to blow the dough bubble, expresses dough resistance, L- the average abscisa at bubble rupture, expresses dough extensibility, P/L - alveograph ratio, W- the deformation energy.

The mixolab, developed by Chopin, is used to characterize the rheological behaviour of dough, subjected to a dual mixing and temperature constraint. It measures in real time the torque (expresses in Nm) produced by passage of the dough between the two kneading arms, thus allowing study of rheological and enzymatic parameters: dough rheologic characteristics (hydration capacity, development time, etc.), protein reduction, enzymatic activity, gelatinistaion and gelling of starch. Figure 1 shows a typical Mixolab curve, in which five different stages can be distinguished (1-development, 2-protein reduction, 3-starch gelatinisation, 4-amylasic activity and 5-starch gelling).

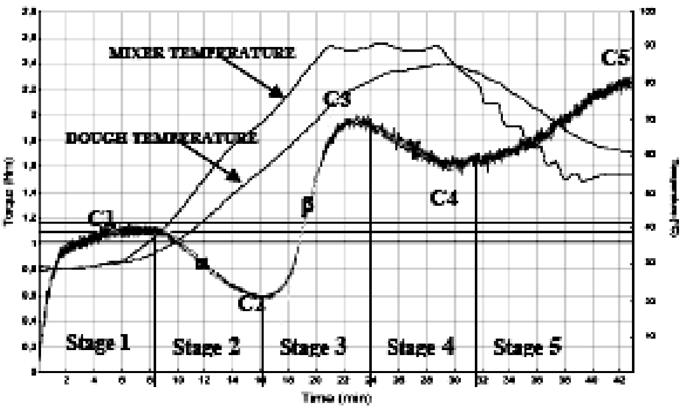

Figure 1. Rheological behaviour of wheat flour in the Mixolab

The procedure followed for the analysis of the mixing and pasting behaviour to the mixolab, is the following: mixing speed 80 rpm, tank temperature 30˚C, heating rate 2˚C/min, total analysis time 45 minute.

The baking test was performed according to the Romanian method (STAS 90/1977) and the protocol used was: 2100g flour, 63g yeast, 31.5g salt, vital gluten in different doses (0%- control sample, 1%, 2%, 3%, 4%, 5%) and water - 1176 ml to 29-30˚C. Bread volume was determined after two hours of cooling by means of rape seeds (STA S 91/1983). The elasticity and porosity parameters of bread have also been determined according to the methods described by STAS 91/1983.

In the case of bread supplied with gluten additives, which has shown the best quality parameters in terms of volume, porosity and elasticity, as well as in the case of bread obtained from the control sample, a sensorial analysis has been carried out, in conformity with the method described by STAS 91/1983 – the Romanian diagram of evaluation for determining bread quality up to 20 points [2, 3].

Results and Discussion

Analytical characteristics. The chemical composition of the flour, indicated the following values: 0.64 ± 0.05 (%) ash content, 14.3 ± 0.02 (%) water content, 12.42 ± 0.03 (%) crude protein, 8 ± 0.01 (mm) deformation index, 2.2 ± 0.01 (%) for acidity and 296 (s) for falling number.

Rheological characteristics for mixolab. The mixolab was used for the tests carried out on flour with 1%, 2%, 3% vital gluten addition (all values shown, are the means of duplicate analysis). The results are displayed in table 1.

Table 1. The mixolab parameters for doughs improved with different quantities of vital gluten

Characteristics / Samples		Control sample	1%	2%	3%
WA (%)		58%			
Dough Development (C1)	C1 (Nm)	1.07	1.12	1.14	1.16
	Dough temperature (°C)	27.5	27.3	27.3	27.2
	Stability min:s	09.36	09.54	10.12	10.24
Protein Break-down (C2)	Formation time C2 (min:s)	19.03	18.31	17.56	17.51
	C2 (Nm)	0.38	0.40	0.42	0.45
	Dough temperature (°C)	56	56	56.1	56.1
Starch Gelatinization (C3)	Formation time C3 (min:s)	24.26	24.22	23.92	23.48
	C3 (Nm)	1.51	1.53	1.52	1.53
	Dough temperature (°C)	77.2	77.3	77.5	77.9
Amylase activity (C4)	Formation time C4 (min:s)	35.04	34.51	34.07	33.57
	C4 (Nm)	0.97	0.98	0.96	0.96
	Dough temperature (°C)	77.5	78	78.3	78.7
Starch gelling (C5)	Formation time C5 (min:s)	45.03	45.02	45.03	45.03
	C5 (Nm)	1.31	1.38	1.38	1.37
	Dough temperature (°C)	55.1	54.9	53.4	53.7

The graphics for medium quality flour, both control sample and those improved with different quantities of vital gluten (1%, 2% and 3%) were studied. By comparing the data from table 1, regarding dough development (C1 zone), it is visible that there is an increase in the C1 value by 8.4 %, and also in dough stability by 9.4%, proportionally with the added quantity of vital gluten.

The increase in dough consistency (and also the increase of C1 value) is a consequence of the decrease in the quantity of free water, as a result of vital gluten addition.

The largest part of free water of normal bread dough (about 40%) is bonded with gluten and starch. As a result, the increase of protein substances, leads to a larger amount of water absorbed by the dough during kneading, thus increasing dough consistency. This has a positive influence on dough stability and quality of bread.

The value increase for C2 by 18.4% in the first step of dough warming is due to the state of the carrier. After the vital gluten addition, the proteins become more compact, the enzymatic attaching points are less in number and this leads to a reduced dough softening tendency. For zones 3, 4, and 5, of the mixolab curve no significant changes were observed.

Alveograph rheological characteristics. The alveograph measurements of dough are presented in table 2 (all values shown are the means of duplicate analysis, error±2% of the mean).

Table 2. The dough parameters resulted on the alveograph

Characteristics	Control	1%	2%	3%	4%	5%
Resistance (P), mm	76	93	99	103	111	116
Extensibility (L), mm	85	84	83	80	73	72
Swelling Index (G)	20.5	20.5	20.2	19.8	18.9	18.8
Energy $W \cdot 10^{-4}$ J	211	251	272	300	327	341
Ratio P/L	0.89	1.09	1.19	1.28	1.52	1.61

By comparing the data in table 2, it can be observed a decrease of L parameter and an increase of P and W parameters (linked to dough resistance and the energy required for swelling up to breaking point of the dough, respectively) in the same time with an increase of the gluten dose. This variation of the rheological parameters can be attributed to the water redistribution process between the system components, because of the higher protein content that retain a larger amount of water, meaning a decrease in the mobility of the dough system. Consequently, an increase of dough viscosity was observed. From the alveographic point of view a decrease of the L parameter and extensibility index G was noticed. The addition of vital gluten increases the quantity of gluten in the dough, forming a much more arranged gluten network, which better holds all the other dough components, and leads to an increase of the energy absorbed by the dough, when being stretched (W) and in dough resistance (P).

Baking tests. Figure 2 shows the variation of the volume of bread from average quality flour, depending on the different quantities of vital gluten added. It can be noted an increase of the protein dose, up to a certain level and also an increase in the bread volume, caused by the change of the gliadins/glutenins ratio, that reflects in the elasticity and extensibility of the gluten.

By increasing the level of vital gluten over the optimal dose, for the specific conditions of the baking test, the bread volume decreases because of the excessive elasticity of the dough, which makes the growth of the bread in the oven, very difficult.

A similar behavior with the variation of the volume up to one point, followed by a drop, is also recorded for the other physical characteristics of the bread: porosity and elasticity, as shown in figure 2.

The addition of vital gluten increases the quantity of gluten in the dough, forming a gluten network much more arranged, which better holds all the other dough components. Because of this, the CO_2 retention is improved and the bread has a higher porosity. The increased protein content makes the bread loaf more elastic.

Sensorial test. For the sensorial test, the bread with vital gluten addition, that had the best score for the physical characteristics, compared with control sample, was selected. The characterization of the quality indices for determining the sensorial characteristics of the samples analyzed is shown in table 3.

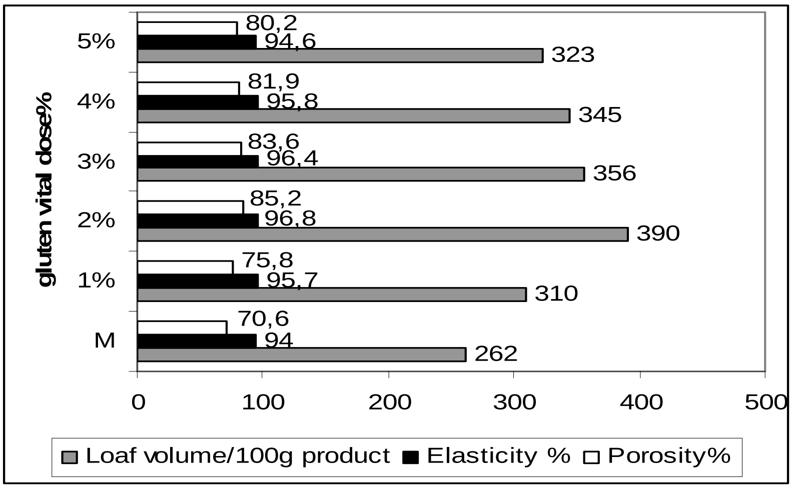

Figure 2. The variation of the bread volume, porosity and elasticity depending on the different quantities of vital gluten added

Table 3. Sensory evaluation of bread

Sensorial characteristics	Control sample	2% Gluten Bread
Shape	The product does not have the established shape, it is slightly asymmetric.	The product has the right, the regular shape
Volume	Insufficiently developed volume	Well developed volume
Crust colour	Rich golden brown, even	Moderately dark brown
Crust character	Soft tender, moderately thick	Slightly soft, moderately tender, slightly rubbery
Crumb colour	Cream white	Creamish white, moderate bright
Crumb State and Aspect	Tender, soft, moist	Slightly touch and dry
Pore Structure and Porosity	Compact, mostly fine cells, slightly coarse	Fine cells, evenly distributed
Flavor	Slightly off flavor	Excellent
Taste and acidity	Pleasant, suitable to the type	Pleasant, suitable to the type

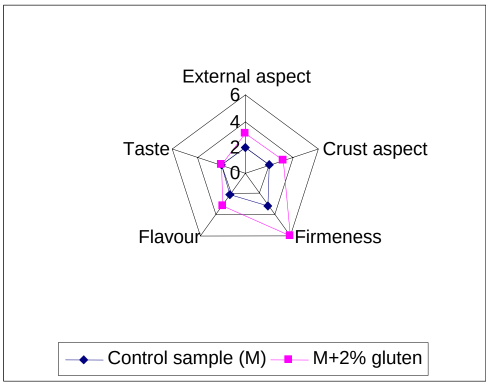

Figure 3. Sensorial characteristics of the 2% gluten added bread comparing with control sample

According to the Romanian diagram of evaluation, the bread with 2% vital gluten addition (figure 3) had obtained 17 points, as opposed to 11 points for the control sample. In the case of its external aspect, firmness and crumb structure, the improvement is linked to the increase in support quantity, which held the dough. As for the crust aspect and bread flavor improvement, there was an increase in substratum quantity for proteases, which determines the formation of a larger amount of free amino acids. Increased amounts of free amino acids has a significant role for bread flavor [11, 12]. It seems that the reaction Maillard aminoacids-glucides is the most important way for forming the color of the crust and bread flavor [13].

Conclusions

For the types of flour with an average potential for bread making, vital gluten addition promotes a substantial improvement, both in the sensorial (external aspect, crust aspect, firmness, flavor) and in the physical characteristics (a significant increase of the volume with 48,8%) of bread.

These improvements represent a consequence of the improvement of the rheological properties of the dough. It strengthens doughs by increasing the proteic network (the parameters P and W increase).

On the mixolab, vital gluten addition led especially to an increase in dough consistency and stability and also an increase of the momentum opposed by the dough (C2).

All the results from baking tests, regarding the rheological aspect and the quality of the finished product have shown that for the medium-quality flour like starting material the optimal dosage for the vital gluten is 2%.

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