INFLUENCE OF WHEAT FLOUR DOUGH HYDRATION LEVELS ON GAS PRODUCTION DURING DOUGH FERMENTATION AND BREAD QUALITY

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Abstract: *The purpose of this study was to investigate the influence of different dough hydration levels on gas production during dough fermentation and on the quality of the finished bakery products. Experiments were performed using like row materials wheat flour with an average quality for bread-making and a compressed yeast Saccharomyces cerevisiae type. The hydration level of dough analyzed was equal to the wheat flour water absorption optimum value determined by a Farinograph device and values lower and higher than the 10% of this. A Fermentograph SJA device was used to analyze gas production during 10, 20, 30, 45, 60, 75 and 90 minutes fermentation times. Like finished bakery products investigated in this study was loaf volume, height, length, height/ length ratio and bread humidity. A series of graphical representation was made using a STATISTICA 6.0 software between dough gas production at 90 minutes of fermentation time, the different hydration levels used and some parameters of the bakery products obtained. Once with the increase of water content in dough, the fermentative activity of yeast and the quality of bread obtained through baking tests is stimulated. So, the gas production level increase in all fermentation times analyzed, the bread loaf volume is enhanced, the parameters height and height/ length ratio decrease and the bread parameters length and dough humidity increase.*

Key words: *wheat flour, fermentation time, water content, gas production, bread quality*

1. Introduction

For a *Saccharomyces cerevisiae* type with a given biochemical composition, the conditions of the dough medium such as temperature, osmotic pressure, pH, level of water, sugar, salt, affect the fermentation rate of yeast. Generally, dough's with low water content take longer to ferment as compared to that's with high water content. With additional water, the soluble solids are diluted and the osmotic pressure on the yeast cells is reduced. This causes an increase in yeast activity and the overall of fermentation rate [1]. Although numerous factors have a bearing on the fermentative activity of yeast, we should remember that the baker judges this activity by the rising of the dough. This is the result of the force exerted by the increase in internal pressure (impermeability plus carbon dioxide production) and the resistance of the dough to deformation [2]. So, the carbon dioxide causes the gluten proteins to stretch, and some escape, but most of the gas is retained and is trapped within the matrix. This process is known as dough leavening [3].
We can say that the gas production is the most important effect of fermentation process because it creates the foam like structure of dough that is the prerequisite for a rapid heat flow through the dough's. Heat applied to

dough's permits the gas and water vapor to be expelled from the dough while starch gelatinization causes the frothy structure of the dough to set, thus producing the bread crumb [4]. Various methods based on monitoring gas production have been used to characterize the physical properties of dough fermentation process [5-8]. Fermentograph SJA (Sweden) or advanced type Rheofermentomenter (Chopin, France) can describe this dough behavior [9].

The objective of this study was to study the influence of dough hydration level on the yeast fermentative activity during 90 minutes of fermentation time and bread quality.

2. Materials and methods

2.1. Materials. Commercial wheat flour (harvest 2008) was milled on an experimental Buhler mill from S.C. Vel Pitar S.A. Valcea. Flour quality tests were accomplished according to Romanian standard methods: ash content (SR EN ISO 2171:2002), moisture content (SR EN ISO 711:1999), wet gluten content (SR EN ISO 21415-1:2007), gluten deformation (SR 90/2007), protein content (SR EN ISO 20483:2007), fat content (SR 90/2007), sugar content (SR 90/2007), falling number (SR EN ISO 3093:2007) and the viscoelastic parameters, specific for the farinograph method (SR ISO 5530-1:1999) and for the alveograph method (SR ISO 5530-4:2005).

The yeast used in this study was *Saccharomyces cerevisiae* type made by S.C. Rompak S.A Romania in compressed yeast commercial form. Yeast quality tests were accomplished according to Romanian standard methods: humidity (STAS 985-79), protein content (SR ISO 1871:2002), yeast dough gas leavening ability release using a Fermentograph SJA (Sweden).

The dough fermentation behavior was analyzed at different hydration levels using the SJA Fermentograph (Sweden). The amount of water used in dough was equal to the wheat flour water absorption optimum value determined by a Farinograph device and values lower and higher than the 10% of this. The dough for the Fermentograph test is prepared in Farinograph (Brabender, Germany). After 5 minutes of mixing the dough sample is placed into the temperate Fermentograph chamber at 35˚C. Fermentograph plotter registers the changes in the increase volume of gas production at different fermentation time (10, 20, 30, 45, 60, 75 and 90 minutes).

Bread recipe comprised flour, water (accord. different WA, %), 2% compressed yeast (% flour basis) and 1.5% salt (% flour basis). Baking tests were done and bread characteristics (loaf volume, height, length and ratio height/length) were analyzed according Romanian standard method (STAS 91:1983).

2.2. Data analysis. All determinations were performed at least in triplicate. Values of parameters were expressed as the mean ± standard deviation to a confidence interval for mean of 95%. Treatment of data was analyzed using STATISTICA 6.0 software.

3. Results and discussion

3.1. Analytical characteristics. The characteristics of the flour samples are shown in Table 1. According to the table 1 data the flour used like row material has a good to average quality for bread - making. The compressed yeast sample used has the humidity of 67.48%, protein content of 40% and the gas leavening ability during 60 minutes, 120 minutes and total gas release of 740/1190/1930.

The yeast fermentative activity expressed by the gas production obtained with the Fermentograph SJA device on different dough hydration levels is shown in Table 2. By changing the dough hydration level its consistency changes, affecting the bakery yeast fermentation rate.

Table 1
Physicochemical and rheological properties of flours

Analytical characteristics	Mean value ± Std. deviation	Rheological characteristics	Mean value ± Std. deviation
Parameter		**Parameter**	
Ash content (%)	0.65 ± 0.02	Water absorption (%)	57.1 ± 0.5
Moisture content (%)	14.6 ± 0.06	Development time (min)	1.7 ± 0.08
Wet gluten (%)	27.2 ± 0.4	Stability (min)	2.4 ± 0.05
Gluten deformation (mm)	6 ± 1	Weakening (B.U.)	83 ± 0.7
Protein content (%)	11.46 ± 0.22	Tenacity (mm H_2O)	65 ±0.2
Falling number (sec.)	354 ± 2	Extensibility (mm)	62 ± 0.8
-	-	Baking strength (10^{-4} J)	121 ± 1.2
-	-	Configuration ratio	1.05 ± 0.05

Comparing the samples with 51.4% water content to the samples with 62.8% and 57.1% water content, the highest values of gas production was obtained for the samples with a level of 51.4% water content for all the fermentation times taken into account. So, the highest quantity of dough gas production was obtained when the level of water content in dough increase. These results are in agreement with those obtained by Potus J. *et al.* (1994). This is to be explained because the increase of environment humidity leads to an increase in enzyme mobility and the possibility to react with the substratum. As a consequence, sugar hydrolysis intensifies and leads to an increase of the quantity of fermentable sugars which are metabolized by yeasts that form carbon dioxide.

From the point of view of bread characteristics (Table 3) obtained from wheat flour dough with different hydration levels, an improvement in the bread quality is to be noticed in proportion with the increase of the water content used for bread making.

Table 2
Gas production (cm^3) during dough fermentation time at different dough hydration levels
(mean value ± std. deviation)

Water content (%)	Fermentation time (min)						
	10	20	30	45	60	75	90
51.4	70 ± 1	185 ± 1.2	325 ± 1.3	530 ± 1	735 ± 2	1025 ± 2.2	1270 ± 2
57.1	80 ± 1.4	195± 1.3	335 ± 1.9	560 ± 2	785 ± 2.2	1125 ± 1	1410 ± 2
62.8	100 ± 0.9	205 ± 1.7	370 ± 1.9	595 ± 1.2	825 ± 2	1157 ± 2.5	1433 ± 2.2

Table 3
Bread characteristics at different dough hydration levels

Characteristics	Abbreviation	Range		Mean ± Std. Deviation
		Minimum	Maximum	
Loaf volume (cm^3)	V	312.00	370.00	341.33 ± 20.00
Height (cm)	H	5.10	5.50	5.30 ± 0.20
Length (cm)	L	11.50	14.10	13.03 ± 1.36
Height/Length	H/L	0.36	0.48	0.47 ± 0.06
Bread humidity (%)	DH	41.08	44.83	42.98 ± 1.87
Water content (%)	WA	51.40	62.80	57.10 ± 5.70
Gas production (cm^3)	GP	1270.00	1433.00	1371.00 ± 88.22

This is to be explained because an increase in dough water content leads to an increase of the quantity of starch hydrolyzed in the fermentation process. This leads to an increase of maltose quantity and implicitly to an increase of the quantity of gas production. It is known that the bread loaf volume can be directly related to the quantity of sugars in the flour, including those sugars produced from starch by diastatic action [10]. As the flour taken into account presents an optimum water content of 57.1%, we can state notice that reaching a level of water content of 62.8% does not worsen the rheological properties of the dough significantly. As a consequence, a higher loaf volume of the bread obtained will be the result of a higher quantity of gas relieved in dough capable to retain the gas produced.

It was found that using a low amount of water content leads to bakery products with low loaf volume and humidity. Loaf volume of the bakery products increase gradually with the increase of water content in dough respectively with the decrease of dough consistency which is consistent with the gas production at different hydration levels of dough as it shown in Figure 1.

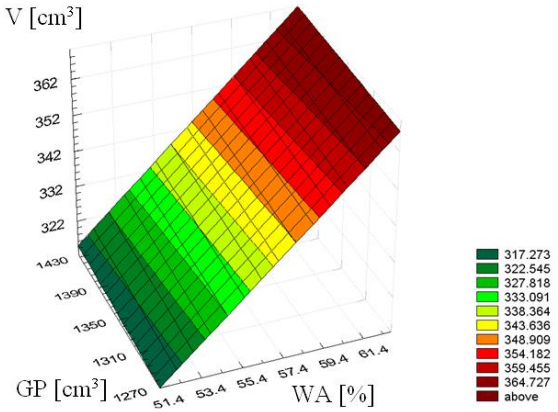

Figure 1. Variation of loaf volume (V) with gas production (GP) and water content (WA): spatial representation

As the water content used in dough will be increase the bakery products result will have higher loaf volume and humidity as it shown in Figure 2.

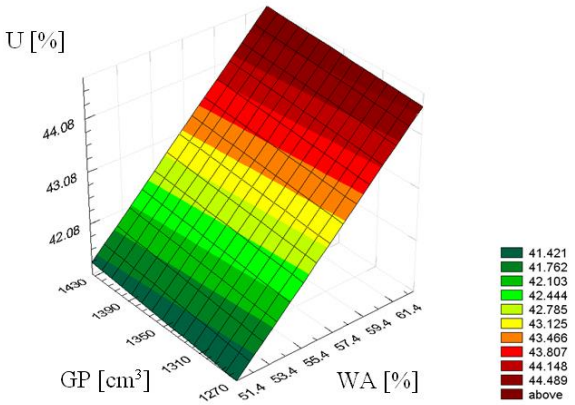

Figure 2. Variation of bread humidity (U) with gas production (GP) and water content (WA): spatial representation

It should be taking into account that bread humidity should not be very high because it could have negative influence on bakery products preservation. The H/L ratio variation is shown in Figure 3.

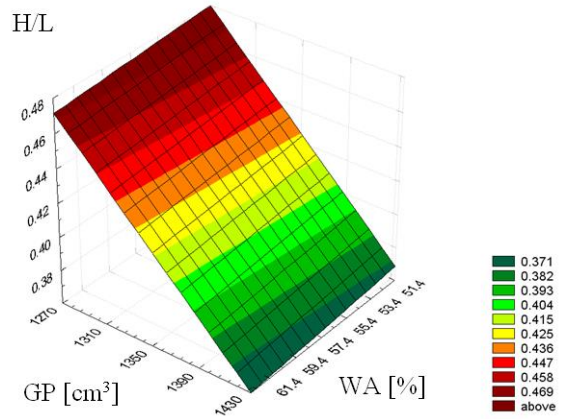

Figure 3. Variation of height/length (H/L) ratio with gas production (GP) and water content (WA): spatial representation

It could be noticed that its value decreases with the increase of the amount of water used in dough which it could be explained by an increased of the dough length as it shown in Figure 4. From the point of view of dough height this presents a maximum to an optimum wheat flour hydration level as is shown in Figure 5.

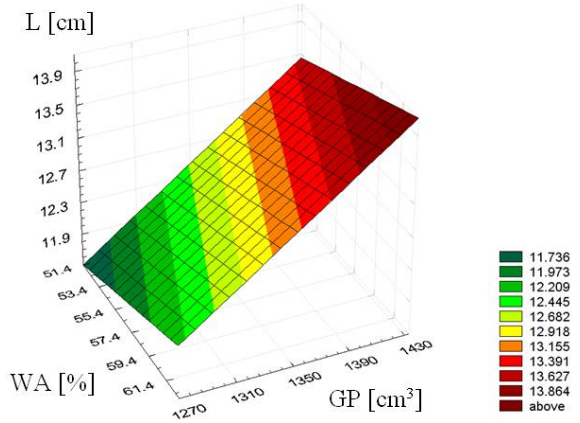

Figure 4. Variation of length (L) with gas production (GP) and water content (WA): spatial representation

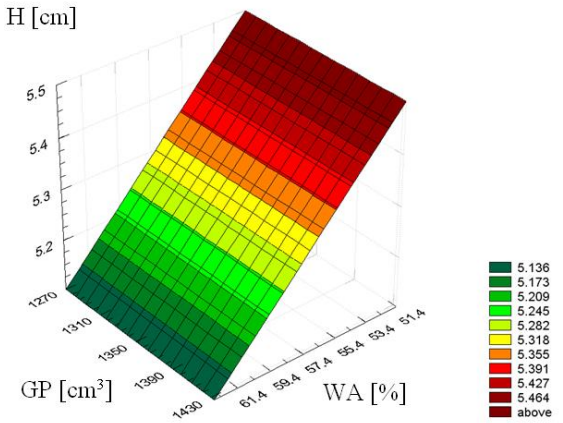

Figure 5. Variation of height (H) with gas production (GP) and water content (WA): spatial representation

4. Conclusions

The water content in the dough influences both the fermentative activity of yeast and the quality of the finish bakery products. The carbon dioxide relieved during dough fermentation presents higher values in samples with 57.1% and 62.8% water content than in samples with 51.4% water content due to the increase of the quantity of free water in the system, which ensures the mobility of molecules, necessary for the development of biochemical processes in the dough. Regarding the volume of the samples obtained, the best results were registered for the 62.8 % dough water content. Also, the bread parameters height, length, height/length ratio and bread humidity vary with the increase of dough hydration level in the way of the decrease of bread parameters height and height/length ratio and the increase of bread parameters length and dough humidity.

5. References

1. POTUS J., POIFFAIT A., DRAPRON, R., Influence of dough-making conditions on the concentration of individual sugars and their utilization fermentation, *Cereal Chem.*, 71. 505-508, (1994)
2. POITRENAUD B., Yeast in Handbook of Food Science, Technology and Engineering, vol. II, editated Y.H.Hui, USA, chapter 69, (2006)
3. HUTKINS R.W., Microbiology and Technology of Fermented Foods, Blackwell Publishing, chapter 8, p.281, (2006)
4. MEUSER F., VALENTIN M., Fermented dough in bread production, in Handbook of Food and Beverage Fermentation Technology, editated Y.H.Hui, USA, chapter 42, (2004)
5. SHUEY W.C., Practical instruments for rheological measurements of wheat products. *Cereal Chem.,* 52. 42-81, (1975)
6. RUBENTHALES G.L., FINNEY P.L., DEMARAY, D.E., FINNEY, K.F., Gasograph: Design, construction, and reproductibility of a sensity 12-channel gas recording instrument, *Cereal Chem.,* 57. 212-216, (1980)
7. MERT B., A new instrumental setup for determination of small amplitude viscoelastic properties of dough during fermentation, *Eu. Food Res Technol.*, 227. 151-157, (2007)
8. KTENIOUDAKI A., BUTLER F., GALLAGHER E., Dough characteristics of Irish wheat varieties II. Aeration profile and baking quality, *LWT-Food Sci Technol.,* 44. 602-610, (2011)
9. SVEC I., HRUSKOVA M., Wheat flour fermentation study, *Czech J. Food Science*, 22. 17-23, (2004)
10. HENRY R.J., SAINI H.S., Characterization of cereal sugars and oligosaccharides. *Cereal Chem.,* 66. 362-365, (1989)