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Journal of Agroalimentary Processes and Technologies 2009, *15*(2), 211-215

Journal of Agroalimentary Processes and Technologies

A study of wheat flour fermentation

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Abstract

This paper aims to study the dough behaviour when fermenting, by means of the Chopin rheofermentometer. For the tests, a flour of weaker/average quality for bread making was considered, as well as a type of compressed yeast Saccharomyces cerevisiae. The flour quality was appreciated through physicochemical and rheological methods using the Chopin alveograph and Brabender farinograph. Throughout the fermentation process the gas volume and dough height were monitored at 30, 60, 90, 120, and 180 minute intervals into the fermentation process. The results obtained were correlated with the quality of the analyzed flour.

Keywords: wheat flour, fermentation, yeast, rheofermentometer

1. Introduction

Saccharomyces cerevisiae is major yeast in dough fermentation and has an important effect on dough rheological properties. [1] The rheological properties of fermenting dough are caused by many factors such as mixing, hydration, gluten network formation, swelling of starch granules, and enzymatic activities. [2]. Furthermore, changes in pH level caused by the production of lactic acid and production of CO_2 also affect the rheological behaviour of dough. The increasing amount of CO_2 in the dough leads to the formation of bubbles. [3] Their size, distribution, growth, and failure during the baking process will have a major impact on the final quality of the bread, both in terms of its appearance (texture) and final volume. [4]

The accumulation of carbon dioxide in the dough after mixing occurs in two phases: as dissolved bicarbonate, and as gaseous CO_2 in bubbles. The rising of the dough during proofing results from the growth of these bubbles; carbon dioxide is only slightly soluble, and as more is produced by the fermenting yeast, bicarbonate is forced out of solution. Some of the gas may escape through the surface of the dough, but the majority is trapped in the body of the dough piece and is forced into pre-existing bubbles. It is the growth of these bubbles that produces the increased volume of proofed dough. [5] It is important that CO_2 develop immediately after dough preparation and proceed at an adequate intensity. In addition, the dough must have the physical properties necessary to withstand dough manipulation and allow for gas retention, so that the optimal structure has been obtained for the final proof and baking. [6]

The principle of rheological apparatus, used for the evaluation of fermented dough properties during its maturation, is the measurement of gaseous volume or pressure produced. [7] Zymotachegraph or advanced type Rheofermentometer (Chopin, France) can describe this dough behaviour.

The objective of this study was to analyze dough behaviour when fermenting (using flour of weaker/average quality for bread making), by means of the Chopin rheofermentometer.

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2. Materials and Method

For experiments there were chosen flours with a weaker potential for bread-making as raw material. For the yeast, a compressed Saccharomyces cerevisiae type, made by S.C. Rompak S.A. Romania, was used. Control flour was analyzed by performing Romanian standard methods: SR ISO 712:1999, SR EN ISO 20483/2007, SR ISO 2171, SR 90/2007, SR 90/2007, SR EN ISO 21415-2/2008, SR90/2007, SR ISO 3093/2007, SR 90/2007 SR 90/2007. In experiments was used a flour with 14.96% moisture, 11.46% crude protein content, 1.5% lipid content and 75.27% carbohydrates content. The determined values for physical-chemical properties are mentioned as following: acidity 3.2 degrees, ash content 0.47%, wet gluten content 26.5%, gluten deformation 6mm, falling number 404 s and sedimentation index - Zeleny test 27 ml. Rheological behaviour of dough prepared from wheat flour was carried out on Brabender farinograph and Chopin alveograph according to SR ISO 5530-1/1999 and, respectively, SR ISO 5530-4/1999. The values for rheological properties are indicated as following: for farinograph - water absorption 56.9%, dough development time 2.3 min, dough stability time 5.8 min, weakening of dough 84 UB, flour strength 65 and for alveograph – tenacity (P) 91 mm H_2O, extensibility (L) 45 mm, index of swelling (G) 14.9, baking strength (W) 156, configuration ratio of the curve (P/L) 2.02. Data acknowledge that the control flour has a weaker-average potential for bread-making from that point of view.

The fermentation behaviour of the flours was analyzed using the Chopin rheofermentometer. The dough capacity to produce and retain carbon dioxide was monitored. The fermentation is conducted in a temperature controlled airtight tank, connected with the pressure sensor. A piston placed on the dough measures volume variations during the test. At the same time, a set of electrovalves allows the measurement of total production of gas, the exact moment when the dough becomes porous and the amount of this porosity. At the end of the test, the Chopin rheofermentometer automatically calculates all results from the curves obtained. [8]

3. Results and Discussion

Dough behaviour analyzed using the Chopin rheofermentometer is presented in figures 1 and 2, and the corresponding curve parameter values are emphasized in tables 1 and 2.

Based on the values of the parameters, it was estimated that the analyzed sample presents features which are characteristic for a average quality flour for bread making.

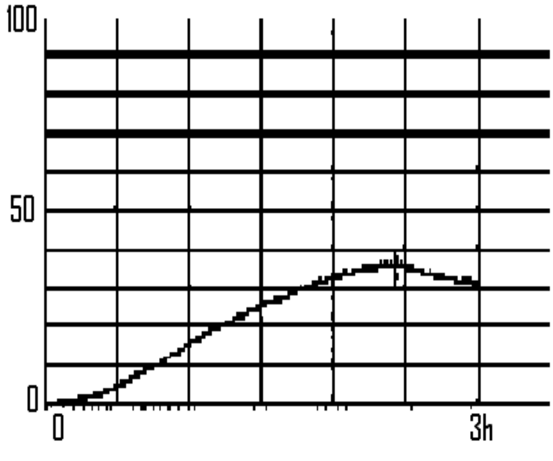

Figure 1. Development of the dough

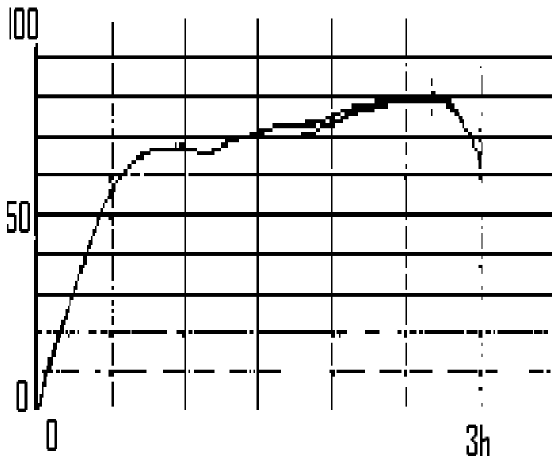

Figure 2. Gas release

Table 1. The parameters for the gas emissions graph

H'_m, mm	T_1, h	V_{tot}, ml	A_1, ml	A_2, ml	R
80.4	2:40:30	1830 ml	1810	20	98.9

Legend: H_m- maximum curve height; T_1- time until reaching H'_m ; V_{tot} – total volume of released gases; A_1- retention volume; A_2- lost gases volume; R – retention coefficient.

Table 2. The parameters for the dough development graph

H_m, mm	h	$(H_m$-h)/H_m %	T_1, h
47.5	43.9	7.6	2:25:30

Legend: H_m- maximum curve height; h- curve height at the end of the test; T_1- time until reaching h.

The gas volume modification during the dough fermentation, determined by the Chopin rheofermentometer was a polynomial variation, with an ascending trend up to 150 minutes into the fermentation process, followed by a strong decrease between 150 and 180 minutes marks, as shown in figure 3.

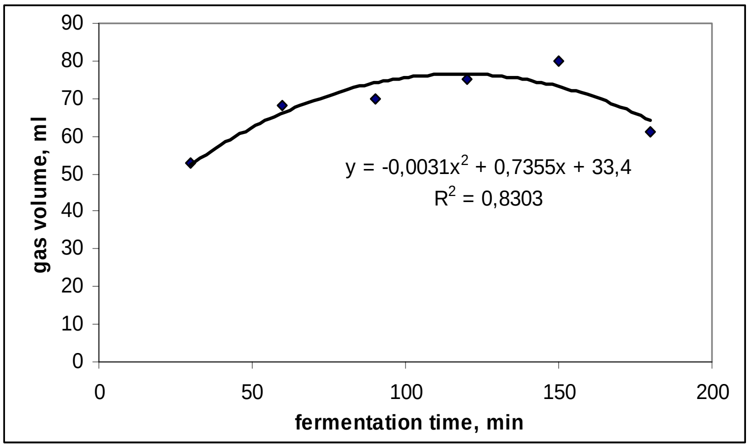

Figure 3. The gas volume variation during the dough fermentation, determined by the Chopin rheofermentometer

Between the 30 and 60 minutes marks, into the fermentation, the gas volume increases dramatically by 28.3% because in the first phase of the fermentation the glucoses in the flour are decomposed, accompanied by a release of carbon dioxide. After 60 minutes of fermentation, the gas release slows down by 17.6% until the 150 minutes mark into the fermentation because of the reduction in initial sugars in the flour. The fermentation intensity is dependant on the presence of sugars and their concentration. Thus in the final steps of the fermentation process, when the sugars initially found in the flour are depleted, the fermentation speed is directly correlated with the maltose producing speed in the dough. The flour used in the test has a low α-amylasic activity and that is why the maltose metabolization is a slow process, which makes it impossible for the maltose to reach high levels in the dough. As a consequence a strong decrease by 31.14% in gas volume can be observed between the 150 and 180 minutes marks.

A similar behaviour as the gas volume variation during fermentation was observed for the dough height between the 30 and 180 minutes marks, as shown in figure 4.

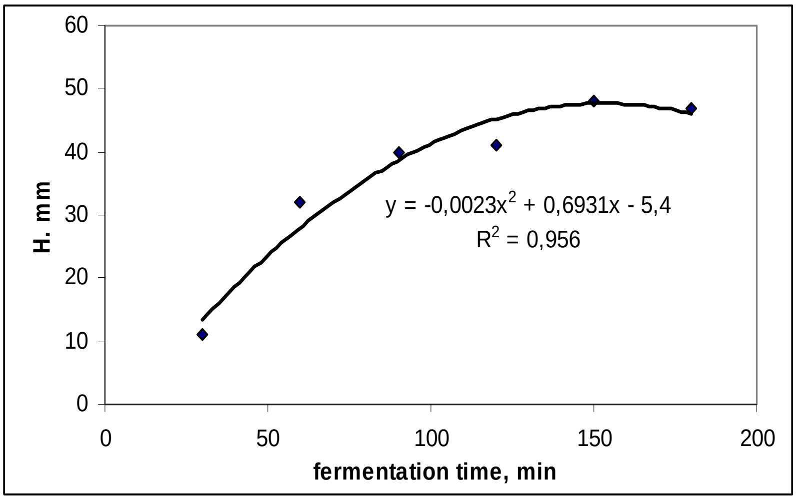

Figure 4. Dough height variation during fermentation determined by the rheofermentomete

The dough height has tripled between the 30 and 60 minutes marks, and further increased by 25% between the 60 and 90 minutes marks, keeping an almost constant value after that point until reaching 180 minutes of fermentation. The gases formed in the dough medium in the process of hetero lactic fermentation, and even more in that of alcoholic fermentation get trapped in the dough, thus forming pores which grow in size. The increase in pores volume determines shifting in the gluten network and affects it by subjecting it to forces that cause stress which is translated in mechanical work. As a consequence of the action of these forces, the gluten network is altered, resulting in a stretched three-dimensional structure with very good rheological properties.

4. Conclusion

To determine the changes occurring in the dough when fermenting, the gas volume and dough height were quantified and measured for a period of 180 minutes using a Chopin rheofermentometer and weaker/average quality flour for bread making regarding its physicochemical properties and rheological parameters. By analyzing the fermentation behaviour of the dough, important changes in gas volume release and dough height were observed in correlation with the fermentation phase, especially for the 30- 60 minutes interval of the fermentation process. For this interval, the gas volume increased by 28.3% and the dough height tripled. The decrease in gas release after 60 minutes and the almost constant value for the dough height after 90 minutes of fermentation are due to the depletion of mono glucoses and scarceness of maltose in the dough. The flour used for this test had a low α-amylasic activity and so a longer time is required to reboot the intense fermentation in the dough.

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