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The effect of flour storage time on moisture change and impact on rheological properties. Case study

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Abstract

During the storage of the flour after grinding, the maturation process begins, with physico-chemical and biochemical changes. The final effect is to improve the characteristics of the flour.

Modern methods for flour analysis include techniques for rheological research, the results obtained being of real practical use for both mills and end users of flour. Flour has a long shelf life, supported by a low water content. This water content changes throughout storage, with changes in rheological parameters with a direct influence on the machinability of the dough. For this reason, most end users have to adjust their recipes or technological flow when using the same flour stored for a longer time.
The case study demonstrates by using modern rheological analysis equipment the influence of storage on the evolution of flour moisture, during the shelf life.

Keywords: bread, water, rheology, dough

1. Introduction

The concern to find links between the water added in the dough and the rheological properties and characteristics of bread have been the subject of many scientific studies, studies that demonstrate on certain segments the effects of kneading, storage, additives used on the finished product. Thus, a study investigates a higher dough water content (i.e., 60%) than predicted by the Farinograph test significantly improved the bread quality in terms of bread and crumb specific volumes, and bread texture. Combining the gradual water addition with high water content could be a strategy to enhance the quality of WWF doughs and breads, promoting the consumption of fibre-enriched foods [1]. The influences of bran components and glucose oxidase on the gluten development and water distribution in bread dough were investigated. Inclusion of free FA induced a weaker gluten network probably because of its accelerating effect of dough breakdown. Moreover, GOX improved dough porosity and increased dough development time and stability. GOX stabilized protein secondary structure by increasing α-helix and β-sheet conformation and enhanced water availability to gluten by promoting the proportion of less-tightly bound water [2]. Another studies have concentrated on the influences of either gluten or starch alone on the rheological properties of wheat dough and found the components of gluten and starch responsible for the dough behavior, including use of parameters, such as the content of protein, wet gluten and amylose, for the evaluation of wheat quality. Earlier, in our study of six wheat materials, significant differences were observed in size distribution of starch granules affecting the dough mixing behavior [3]. The kneading process is influenced by several parameters, notably kneading time, dough temperature, kneading speed, dough aeration, water temperature, and total water content. The correct management of the kneading process, and the application of improvement strategies, can significantly enhance dough rheology and resulting bread [4]. Another studies show that the water holding capacity of each hydrocolloid was determined and the water amount in the formulation was adjusted accordingly to it.

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The hydrocolloids were analysed in five concentrations (0.25%, 0.5%, 1%, 1.5%, 2.0 %).

Analysis of water adjusted doughs included rheological properties, pasting properties and the baking performance. With the aid of the prediction tool, it was possible to obtain bread-like products for each hydrocolloid [5]. The impact of pentosans on dough and bread properties of wheat flour considering its type (based on water extractability) and the wheat genotypic variation has been explored in this study. Both the fractions imparted positive influence on dough properties by increasing the water absorption capacities of flours [6]. Regarding the levels of maltitol were smaller than the control, which was proven through kinetics of retrogradation analysis, revealing an overall retarding effect of maltitol in prevention of bread staling [7]. A new water-soluble resistant dextrin (WSRD), fabricated by thermal-acid treatment following amylase hydrolysis from corn starch, was expected to strengthen the dietary fibers intake of flour products. A study was to investigate the effects of WSRD on flour processing quality, and further dissect its improvement mechanisms by farinographic and rheological analysis [8]. Low Field Nuclear Magnetic Resonance (LF-NMR) analysis demonstrated that the less tightly bound water of the dough was transferred to tightly bound water with the increase of konjac glucomannan, in frozen dough [9]. Starch retrogradation and water loss have effects of the same intensity on the increase in firmness in the phenomenon of bread staling. Concerning the physical phenomena, one study shows that a part of the water lost by the crumb escapes into the atmosphere while another part is absorbed by the crust [10].

2. Materials and Method

2.1. Materials

For the experiments, white wheat flour 650 was used, supplier Baneasa - Moara - Romania, in which the humidity was analyzed according to the method SR ISO 712/1999. In addition to the bread, salt, yeast purchased from local supermarkets and flour improver provided by SC Rompack - Romania were used to prepare the bread.

2.2. Flour mixing proprieties

Mixograph (AACCI Method 54-40.02) and alveograph SR EN ISO 27971/2015 were used to determine the rheological characteristics of the flours used immediately after production, after 3 months of storage and after 5 months of storage. The doughs for analysis were obtained using only water and flour. The coding of the samples was done as follows: P1 - freshly ground flour, P2 - flour the same ground, but after 3 months from the manufacture and P3 flour after 5 months from the date of manufacture. Rheological parameters were collected for each sample.

2.3. Preparation and characterization of bread

The formula for making bread is: flour (250 g), water (150 ml), salt (3.5 g), yeast (6.7 g) and 0.2% flour enhancer. For each baking sample P1, P2, P3 flour was used and the obtained products were also coded P1, P2, P3. The baking test was performed in accordance with SR 90: 2007. The breads obtained were measured and the volume was determined, based on the SR 91: 2007 standard.

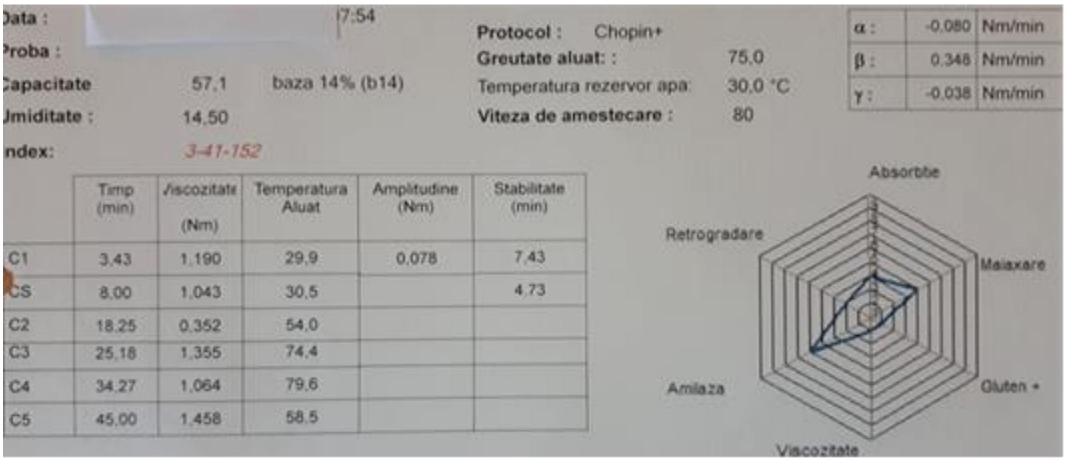
3. Results and Discussion

3.1. The impact of the flour humidity variation on the rheological parameters

The rheological characteristics of the flour used, for the same gluten, 28.4%, from the point of view of alveographic analysis, are given centrally in Table 1. It can be seen that during storage there is a change in flour moisture, with impact on rheological characteristics. This demonstrates that as the flour matures, the strength of the flour increases, even if not significantly compared to freshly ground flour, by only $1\text{-}18 \cdot 10^{-4}$ J. The P / L ratio is also affected in terms of growth during storage, by about 0.30 units. The elasticity index Ie is an indicator of the elasticity of the dough, for this reason a very good relationship was obtained for this parameter as well. Following the graphic representation, it was observed that as the flour matures, it increases. From the point of view of the mixographic analysis, the modification of the humidity affects the hydration capacity with implications on the other rheological parameters. As shown in Figures 1, 2 and 3.

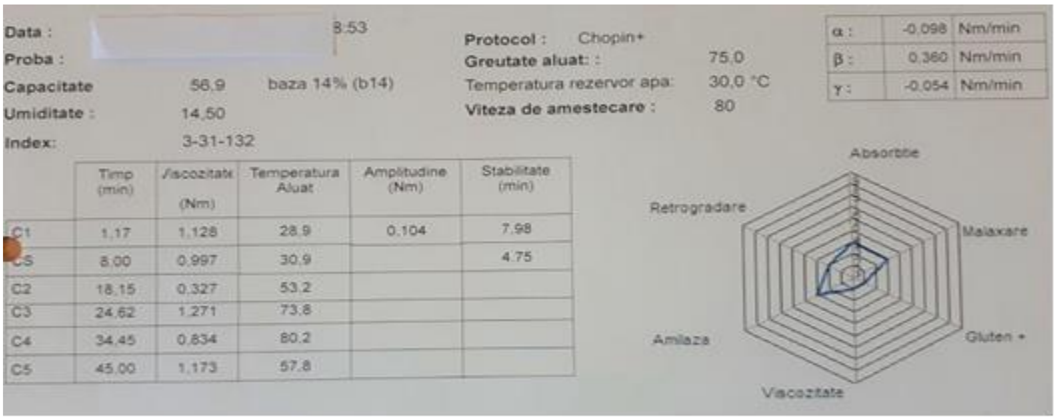
Table 1. Alveographic analysis of flours based on the evolution of moisture

Sample	Moisture, %	W, 10^{-4} J	P/L	Gluten, %	Ie, %
P1	14.7	237	1.07	28.4	46.2
P2	14.5	238	1.35	28.4	51.7
P3	13.9	255	1.35	28.4	51.1



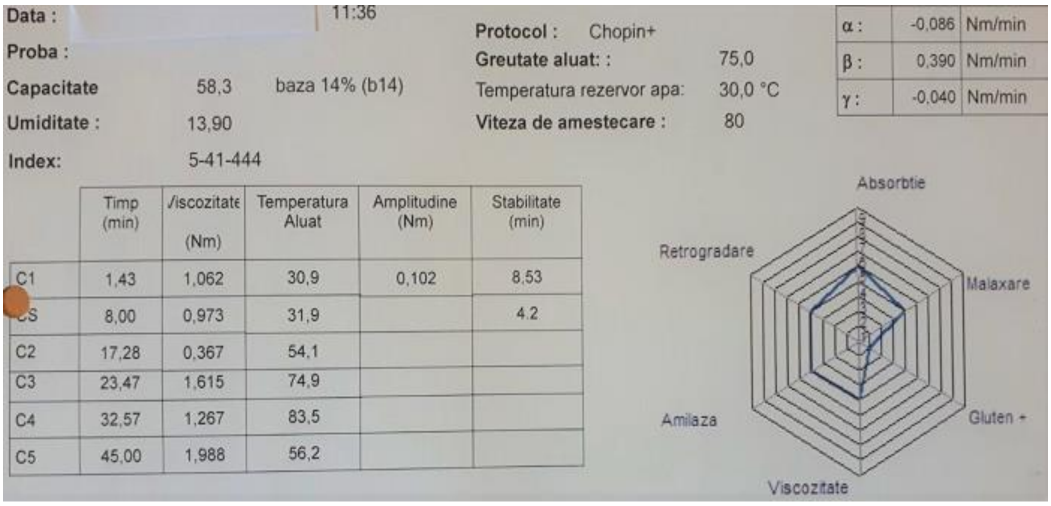
	Timp (min)	Viscozitate (Nm)	Temperatura Aluat	Amplitudine (Nm)	Stabilitate (min)
C1	3,43	1,190	29,9	0,078	7,43
CS	8,00	1,043	30,5		4,73
C2	18,25	0,352	54,0		
C3	25,18	1,355	74,4		
C4	34,27	1,064	79,6		
C5	45,00	1,458	58,5		

Figure 1. Mixolab for P1 flour



	Timp (min)	Viscozitate (Nm)	Temperatura Aluat	Amplitudine (Nm)	Stabilitate (min)
C1	1,17	1,128	28,9	0,104	7,98
CS	8,00	0,997	30,9		4,75
C2	18,15	0,327	53,2		
C3	24,62	1,271	73,8		
C4	34,45	0,834	80,2		
C5	45,00	1,173	57,8		

Figure 2. Mixolab for P2 flour



	Timp (min)	Viscozitate (Nm)	Temperatura Aluat	Amplitudine (Nm)	Stabilitate (min)
C1	1,43	1,062	30,9	0,102	8,53
CS	8,00	0,973	31,9		4,2
C2	17,28	0,367	54,1		
C3	23,47	1,615	74,9		
C4	32,57	1,267	83,5		
C5	45,00	1,988	56,2		

Figure 3. Mixolab for P3 flour

According to the results obtained with the help of Mixolab Profile, for the 3 flour samples P1, P2, P3, it is observed that the absorption index is influenced by humidity, the lower the humidity, the higher absorption index. P3 has the highest index 5. For the kneading index and the gluten index there are no significant differences, which indicates that long-term flour storage does not improve these indices. Instead, the viscosity increases from 1 to 4. The variation of humidity over time does not significantly influence the stability of the system, it being around 4 seconds.

For amylase activity, the index is an average of 4, and related to downgrading, low values of the index indicate that we can ensure long shelf life.

Analyzing the parameter α, slope, which represents the speed of softening of proteins due to heat, we will observe that the highest speed of destruction of proteins at heat is P1, i.e. freshly ground flour.

$$\alpha\ P2 < \alpha\ P3 < \alpha\ P1$$

$$-0.098 < -0.086 < -0.080 \text{ Nm/min}$$

Analyzing the parameter β, the slope, which represents the gelatinization rate of starch, we will observe that the highest speed o P3, the flour sample at the end of the shelf life

$$\beta\ P3 > \beta\ P2 > \beta\ P1$$

$$0.390 > 0.360 > 0.348 \text{ Nm/ min}$$

A final parameter that completes the rheological analysis of the samples is $_{\gamma}$, the slope, which represents the rate of enzymatic degradation. As expected, P1 has the highest rate of enzymatic degradation in freshly ground flour.

$$\gamma\ P1 > \gamma\ P3 > \gamma\ P2$$

$$-0.038 > -0.040 > -0.054 \text{ Nm/ min}$$

3.2. The impact of moisture on the viscosity of the dough

In point 2.3, the dough preparation formula for the baking sample was presented. 3 baking samples were made, for which the dough was analyzed to confirm the influence of the humidity variation on the consistency. As it appears from the rheological analysis of the flours, with the decrease of the humidity during the storage, the hydration capacity increases, which practically means that in order to obtain a dough of constant consistency, a baker will complete the dough with water when kneading. Economically, this is a benefit.

The same amount of water was used for the prepared doughs and the technological parameters were not changed.

The way the dough obtained from the 3 flour samples looks is illustrated in Figures 4, 5 and 6.

The doughs were kneaded for 10 minutes, and it is observed that the most consistent dough is the one obtained from P3 flour. Technologically this problem can be solved by adding a percentage of max 1% water relative to flour.

Figure 4. Dough from P1 flour

Figure 5. Dough from P2 flour

Figure 6. Dough from P3 flour

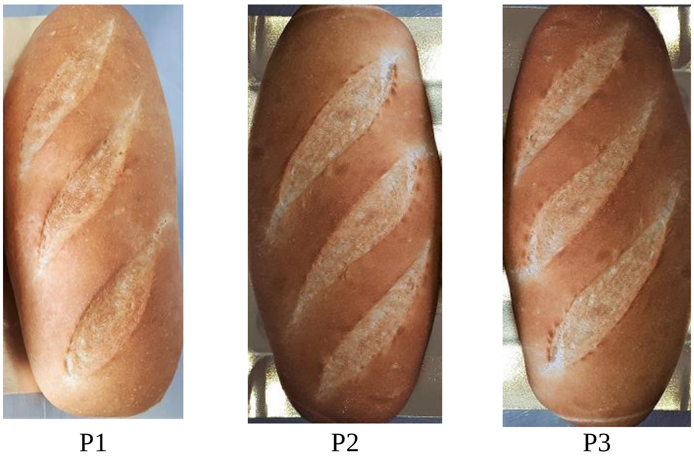


Figure 7. Images with the breads obtained at the baking test

3.3. Macroscopic influence of moisture variation on bread volume

The bread obtained from the 3 flours was analyzed organoleptic, the volume of bread expressed in cm^3/ 100 g was analyzed. The values were obtained: VP1 520 cm^3 / 100g, VP2 535 cm^3 / 100 g and VP3 510 cm^3 / 100g. As can be seen from Figure 7, there are no significant differences in volume, but sample P3 is closer. This defect can be corrected either by adding a larger amount of water, which would transform the dough into an easier-to-process viscoelastic system, or by adding a larger amount of improvers. A similar effect can be obtained by prolonging the kneading time.

4. Conclusion

In the present study, the influence of the flour storage period on its humidity was analyzed, with direct implications on its rheological properties.

The case study followed the way in which a technological process of bread preparation can be conducted, through baking tests and what impact the moisture of the flour has on the production of quality products.

With the storage of flour during the shelf life, it is found that moisture is lost, a loss that leads to changes in rheological parameters. It has the greatest impact on the absorption and viscosity coefficient.

The modification of the rheological parameters contributes to the modification of the vascoelastic properties of the dough and of the bread quality.

The high viscosity of the dough leads to a small, tight bread.

Based on these sensory observations, supplementing the water when kneading the P3 dough can lead to an improvement in the volume of the bread with economic benefits.

Several in-depth studies on the mechanisms of action of water on the quality of flour and bread can be performed.

Compliance with Ethics Requirements. Authors declare that they respect the journal’s ethics requirements. Authors declare that they have no conflict of interest.

References

1. Parenti, O.; Carini, E.; Marchini, M.; Tuccio, M.G.; Guerrini, L.; Zanoni, B., Wholewheat bread: Effect of gradual water addition during kneading on dough and bread properties, *LWT* **2021**, *142*, 111017, https://doi.org/10.1016/j.lwt.2021.111017.
2. Xiao, F.; Zhang, X.; Niu, M.; Xiang, X.; Chang, Y.; Zhao, Z.; Xiong, L.; Zhao, S.; Rong, J.; Cuie,T.; Wu, Y., Gluten development and water distribution in bread dough influenced by bran components and glucose oxidase, *LWT* **2021**, *137*, 110427, https://doi.org/10.1016/j.lwt.2020.110427.
3. Gao, X.; Tong, J.; Guo, L.; Yu, L.; Li, S.; Yang, B.; Wang, L.; Liu, Y.; Li, F.; Guo, J.; Zhai, S.; Liu, C.; Rehman, A.; Farahnaky, A.; Wang, P.; Wang, Z.; Cao, X., Influence of gluten and starch granules interactions on dough mixing properties in wheat (*Triticum aestivum* L.), *Food Hydrocolloids* **2020**, *106*, 105885, https://doi.org/10.1016/j.foodhyd.2020.105885.
4. Cappelli, A.; Bettaccini, L.; Cini, E., The kneading process: A systematic review of the effects on dough rheology and resulting bread characteristics, including improvement strategies, *Trends in Food Science & Technology* **2020**, *104*, 91-101, https://doi.org/10.1016/j.tifs.2020.08.008.

5. Horstmann, S.W.; Axel, C.; Arendt, E.K., Water absorption as a prediction tool for the application of hydrocolloids in potato starch-based bread, *Food Hydrocolloids* **2018**, *81*, 129-138, https://doi.org/10.1016/j.foodhyd.2018.02.045.
6. Arif, S.; Ahmed, M.; Chaudhry, Q.; Hasnain, A., Effects of water extractable and unextractable pentosans on dough and bread properties of hard wheat cultivars, *LWT* **2018**, *97*, 736-742, https://doi.org/10.1016/j.lwt.2018.07.066.
7. Ding, S.; Peng, B.; Li, Y.; Yang, J., Evaluation of specific volume, texture, thermal features, water mobility, and inhibitory effect of staling in wheat bread affected by maltitol, *Food Chemistry* **2019**, *283*, 123-130, https://doi.org/10.1016/j.foodchem.2019.01.045.
8. Huang, Z.; Wang, J.J.; Chen, Y.; Wei, N.; Hou, Y.; Bai, W.; Hu, S.Q., Effect of water-soluble dietary fiber resistant dextrin on flour and bread qualities, *Food Chemistry* **2020**, *317*, 126452, https://doi.org/10.1016/j.foodchem.2020.126452.
9. He, Y.; Guo, J.; Ren, G.; Cui, G.; Han, S.; Liu, J., Effects of konjac glucomannan on the water distribution of frozen dough and corresponding steamed bread quality, *Food Chemistry* **2020**, *330*, 127243, https://doi.org/10.1016/j.foodchem.2020.127243.
10. Monteau, J-Y.; Purlis, E.; Besbes, E.; Jury, V.; Le-Bail, A., Water transfer in bread during staling: Physical phenomena and modelling, *Journal of Food Engineering* **2017**, *211*, 95-103, https://doi.org/10.1016/j.jfoodeng.2017.04.016.