RHEOLOGICAL BEHAVIOR OF DOUGH WITH ADDED POTATO (VARIETIES LAURA AND IMPALA) IN PRESENCE OF NaCl AND *Saccharomyces cerevisiae*

— research paper —

MARIA LIDIA IANCU[1] *, GÜNTER HAUBELT **

*Lucian Blaga University of Sibiu, Faculty of Agricultural Science, Food Industry and Environmental Protection , Sibiu, Romania
** Haubelt Laborgeräte GmbH Garten felder str.13599 Berlin,Germany

Abstract: Rheological behavior of dough obtained with white flour with potato variety Laura and Impala in presence of NaCl and *Saccharomyces cerevisie* is analysed during this study. Haubelt Flourgraph E6 was used to study the dough properties. The following parameters were measured: water absorption capacity, development time, the stability, the degree of softening and the quality number. Moreover, the behaviour of the dough obtained from flour blended with 5%, 10%, 20%, 30% minced hydrothermally treated potato Laura and Impala variety potato was studied. Mixtures with different rheological properties were obtained. At increasing the percentage of minced hydrothermally treated potato at 30% the formation time and stability decreased the degree of softening increased with 443.4% for Laura variety potato and the quality number was lower with 82.9-84%. Different values were obtained for each variety. NaCl and yeast enhanced the mentioned above characteristics.

Keywords: rheology, Flourgraph E6, wheat white flour, potato variety, NaCl, yeast

INTRODUCTION

Some ingredients in the bread formulation contribute to improving its quality or sensory and nutritional characteristics (Hoseney, at al., 1986) (Sing, at al., 2002). Bread contains important nutritional components that have a beneficial effect on human health (Gellynck, at al., 2009). These ingredients have an effect on the rheological properties of dough (Jansen, at al., 1996). The addition of materials such as NaCl and yeast species *Saccharomyces*

[1] Corresponding author. Mailing address: University "Lucian Blaga" of Sibiu, Faculty of Agricultural Sciences, Food Industry and Environmental Protection, Str. I. Raţiu 7-9, 550012 Sibiu, Romania. Phone: 0040/269/211338. Fax: 0040269212558. E-mail address: maria.iancu@ulbsibiu.ro

cerevisiae is usual. NaCl is used for a long time in food preservation as well as flavor enhancer (Bidlas, et al, 2008). It is an important source of Na^+ as essential mineral (Matters, at al, 1991) and an organic stabilizer better than substitutes, KCl, $CaCl_2$, $MgCl_2$ and Mg SO_4 (Samapundo, at al., 2010). NaCl produces an effect of strengthening the gluten network and increases dough stability and dehydration due to the action on gluten. It reduces osmotic water bound, so the proteins compaction giving conformation changes. Fewer connections are willing to interact with hydrophilic water (Codina et al., 2007).

Yeast *Saccharomyces cerevisiae* is a starter culture having a crucial role in bread quality. Basic rheological tests without yeast showed that it influences the viscoelastic properties (Esselink, at al., 2003).

Other materials added to the starch gel, protein concentrates can lead to changes in the rheological parameters (Hong at al., 2004). A good example would be the use of starch, with good rheological properties (Mironescu et al., 2011).

The use of equipment such as Brabender farinograph, Alveograph Chopin, mixograph, Brabender extensograph, flourgraph Haubelt E6, E7 for the rheological characterisation of doughs is usual. Earlier studies of the authors showed that the influence of replacing flour with potato pulp can be studied by using the Haubelt Flourgraph E6 and E7; such studies were useful for calculating the quantity of flour, potatoes and other materials using special formulas (Iancu, at al., 2010a). Humidity was reported as 86 g dry weight for the rheological studies. Also, it was concluded that hydration reduces time of dough development (TDD), dough stability decreases, quality number (QN) decreases, the dough softening increases (Iancu, at al., 2010b). The values of operational parameters studied seemed to be influenced by the type of flour (Iancu, at al., 2010 b) and the percentage of flour replacement by potato (Iancu, at al., 2010 c).

In this research the evolution of values as: dough formation and properties of potato dough at the addition of salt and in the presence of yeast is investigated. White flour with additives, type 650 (WF add.) Potato varieties Laura (Lvp) and Impala (Ivp) as hydrothermally processed and shredded flesh are used. Potato flour is replaced by 5%, 10%, 20%, 30%. Salt is used in a ratio of 1.5% and yeast in a ratio of 3%. The values of variables measured under the conditions described above are compared, in order to evidence the influence of yeast and salt. The device used is the new market profile called Haubelt Flourgraph E6.

MATERIALS AND METHODS

White flour was provided by the Mill Cibin Sibiu, Romania; flour was supplemented with ascorbic acid 1.5 g/100 kg flour; L-cysteine 3 g/100 kg flour; α-amylase, xylanase, hemicellulase 8-9 g/100 kg. Flour had the following characteristics: moisture u=13.9%; wet gluten Gl_u= 32%; gluten deformation ID = 4 mm; gluten index I_{GL}= 55.68; Falling Number FN = 290-300s; titratable acidity TTA= 2.2 degree, ash 0.649 %; water absorption WA = 56.9 %.

The physico-chemical properties of the flour were evaluated as follows: the wet-gluten content using the 106 /2 ICC STANDARD method; gluten deformation index using STAS 89-90-6238; the ash content using 104/1 ICC method; the acid content using STAS 90-88 method; the "falling number", according to 107/1, ICC Hagberg-Perten STANDARD; the hydration potential through No115/1 ICC STANDARD flour.

Moisture determination was realised using the gravimetric method with thermobalance AND ML-50.

Hydration capacity, also called Water Absorbtion (WA), is the amount of water absorbed to achieve the standard consistency of 500 HE (Iancu, at al., 2010b). The equipment expresses the consistency as HE (Haubelt Einheit) - in the case of flourgraph

Two potato varieties were used: red potato LAURA variety and yelow potato Impala variety. They were kindly purchased by the Potato Research and Development Station Târgu Secuiesc, Covasna, Romania. LAURA variety was characterized by lower starch content, pasta moisture of 73.5 % whereas yelow potato Impala variety was characterized by lower starch content, pasta moisture of 83.5 %.

The potato paste (PP) was obtained by hydro thermal processing of the unpeeled raw potato for 30 minutes at water boiling temperature, then cooled, peeled and mashed by passing through a 2 mm mesh sieve.

Fresh yeast ”PAKMAYA” (S.C. Rompak Paşcani, România) with increase power 10 minute and moisture 68.9% and salt (Salina Ocna Mureş, Alba) with umidity 0.16% was used.

The flourgraphic measurements

The Haubelt Flourgraph with a small bowl (100g flour) measures and records the dough resistance to mixing. It is used to evaluate absorption of flours and to determine stability and other characteristics of doughs during mixing. Two methods are commonly used: Constant Flour Weight Procedure and Constant Dough Weight Procedure. Since the two procedures may not

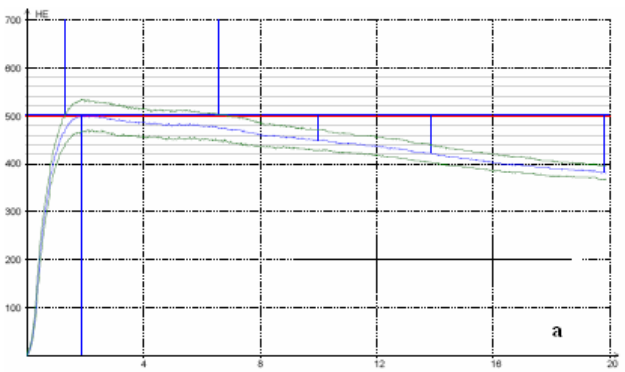
yield identical results, the method employed must be specified when absorbtion and other flourgram values are reported.
For the flourgraph-E both the methodology and result are identical to those of the mechanical flourgraph, 63 ± 2 rpm .
The E6 FLOURGRAPH that rely on the same principle makes programmable electronic measurements using Windows XP, and the titration curves are easy to follow on a touch-screen monitor located directly near the mixer device that has a capacity of 100 g of flour. The device was used in accordance with ICC Draft Standard no.179-2010.

RESULT AND DISCUSSION

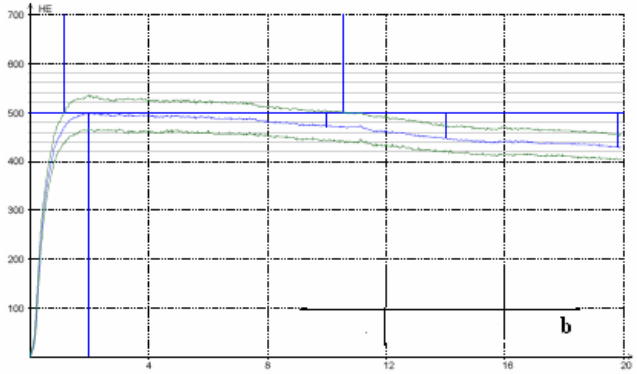
Figure 1 shows rheograms obtained with the E6 Haubelt Flourgraph at variable water and potato amount. As a consequence of the change of water absorption capacity by potato, wheat flour, salt and yeast mixture, the values of other indicators: dough development time, stability, degree of softening, change compared with the sample controls without potato (Figure 1).
Without salt and yeast hydration, WA of the mixture decreases with 20% for the mix with Lvp and 26.2% for the mixture with Ivp when the percentage of replacement of flour with potato is 30% (Table 1). TDD decreases, the stability decreases with 75.8% for both the variant with potato starch. This parameter is not influenced by the potato variety but by the rate of flour replacement; for a replacement rate higher as 10% a stable constant value of 1.4 minutes for TDD and stability are obtained.
QN decreased with 84.8% for the sample with Lvp and 80.3% for the sample with Ivp (Table 1). In drawing the diagram for a constant amount of water, uncorrelated with the absorption capacity of the mixture to obtain standard 500 HE, consistency of the mixture decreases with 17.96% for the mixture with Lvp and with 46.5% for the sample with Ivp, at the flour replacement in a percentage of 30% (Table 1).

Table 1. Reometrice values of characteristics of potato dough without salt and yeast.

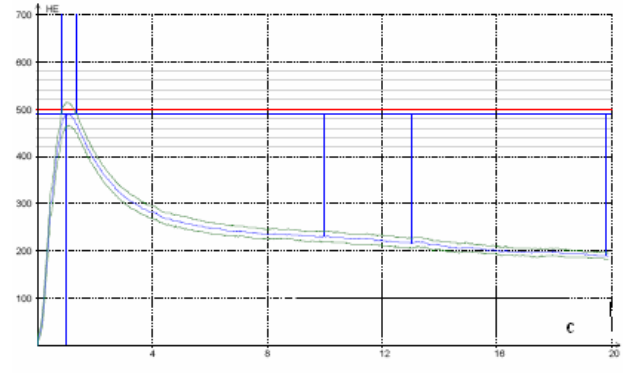
	Values at loss of consistency [HE]		*WA [%]*		*TDD [minute]*		*Stability [minute]*		*QN*	
	Lvp	Ivp	Lvp	Ivp	Lvp	Ivp	Lvp	Ivp	Lvp	Ivp
Control	501	501	56.9	56.9	2.7	2.7	5.8	5.8	66	66
5%	476	431	55.9	56	1.8	2	2.8	2.4	32	26
10%	475	376	54	53.1	1.3	1.3	1.4	1.4	14	18
20%	430	260	52	47.6	1.3	1	1.4	1.4	14	11
30%	411	268	45.5	42	1	1.1	1.4	1.4	10	13



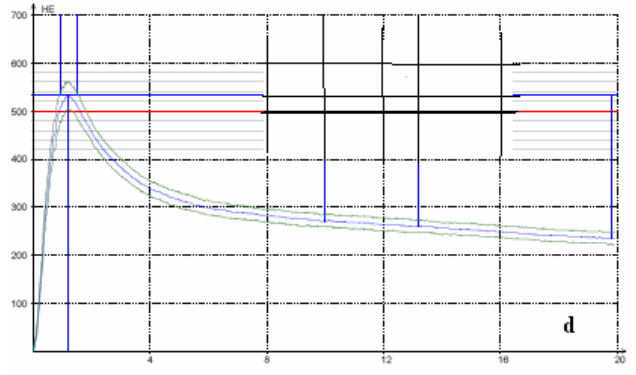
Haubelt-Laborgeräte GmbH



Haubelt-Laborgeräte GmbH



Haubelt-Laborgeräte GmbH



Haubelt-Laborgeräte GmbH

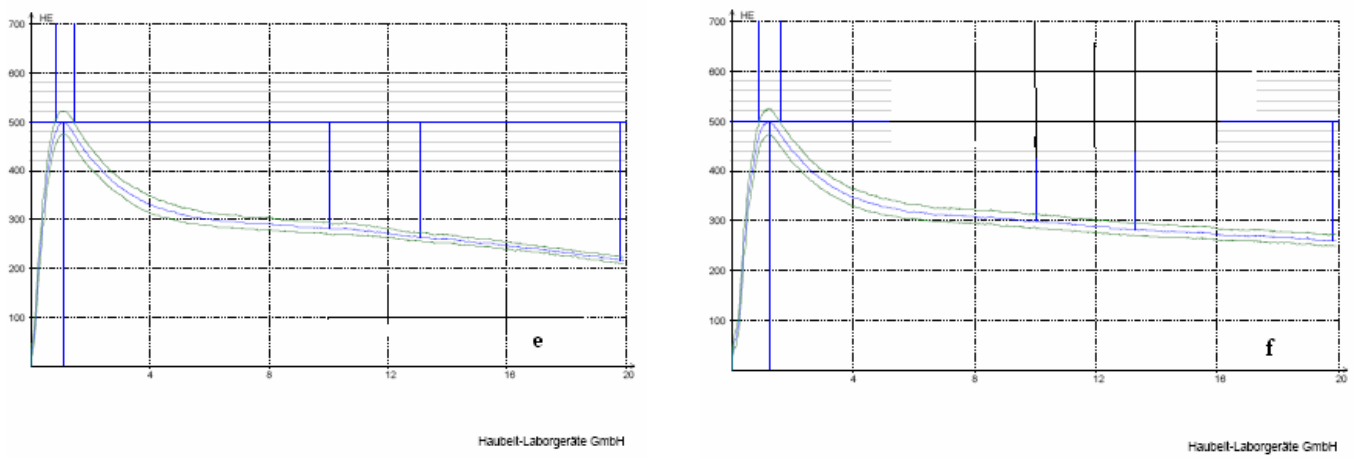


Figure 1. Influence of potato pulp processing degree and of added materials on the profile of the flourgraphic curves of the WF add and PP (a-control sample without salt and yeast, b-control sample with salt and yeast, c- sample with 30% Lvp without salt and yeast, d- sample with salt and yeast with 30% Lvp, e- sample without salt and yeast with 30 % Ivp, f- sample with salt and yeast, with 30% Ivp.

Some authors like (Peressini and Sensidoni, 2000) consider that some materials as salt added to the dough have a small influence on freshly kneaded dough rheology. Others say that the changes that occur due to salt addition increase the hydrophobic inter-protein interactions (Preston, at al., 2001). Figure 2 present the results obtained at the addition of salt and yeast; dough consistency decreased with 4.9% compared to the control. In the presence of PP with a replacement rate of 30%, an increase of consistency up to 493 HE for LVP and 473 HE for sample with Ivp compared with the sample without salt and yeast (presented in Table 1) is observed. It seems that a potato percentage higher as 20% gives a prevalence of potato components in the mixture. The resulting values are atypical for the mixture with flour and parameters should be reviewed.

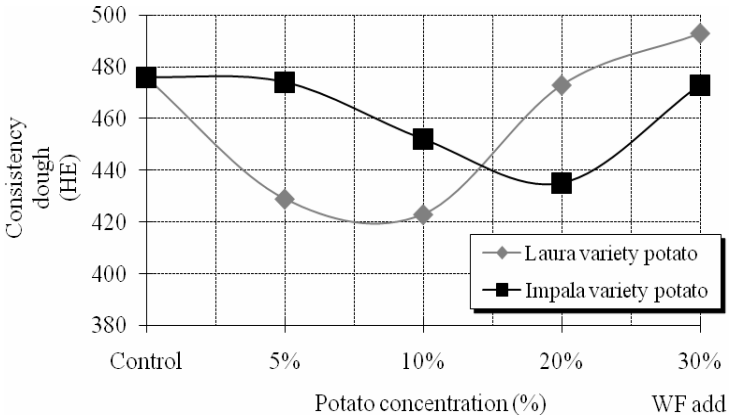


Figure 2. Influence of potato varieties, salt and yeast on consistency loss of WF added with potato mixed with a constant water quantity.

Water absorption of the mixture with potato decreases with 20.2% compared to the control sample with salt and yeast and with 20.9% compared to the sample without salt and yeast. Absorption capacity decreases with 26.9% compared to the blind sample with salt and yeast and with 27.6% compared to the sample without salt and yeast (Figure 3). At the use of potato varieties Impala and Laura WA values vary as follows: at 5% flour replacement with potato, WA decreases with 4.6% - 6%; at 10% replacement, WA is reduced with 6.7% - 9.2%; at 20% potato WA is reduced with 8.8% - 20%; at 30% potato, WA decreases with 20.2% - 26.9%.
Regression equations are:

$$Y_{Lvp} = -2.52x + 59.4 \text{ , } R^2 = 0.8797 \quad (1)$$

$$Y_{Ivp} = -3.83x + 60.87 \, , \, R^2 = 0.9719 \quad (2)$$

The hydration capacity of the blends with additivated white flour is correlated with the proportion of potato Lvp according to equation (1). The hydration capacity of the blends with additivated white flour is correlated with the proportion of potato Ivp according to equation (2). The independent variable coefficients have negative values in equations (1) and (2), meaning that, if flour is replaced, the hydration capacity decreases.

This parameter is directly influenced by the replacement of flour with potato. The correlation index indicates this.

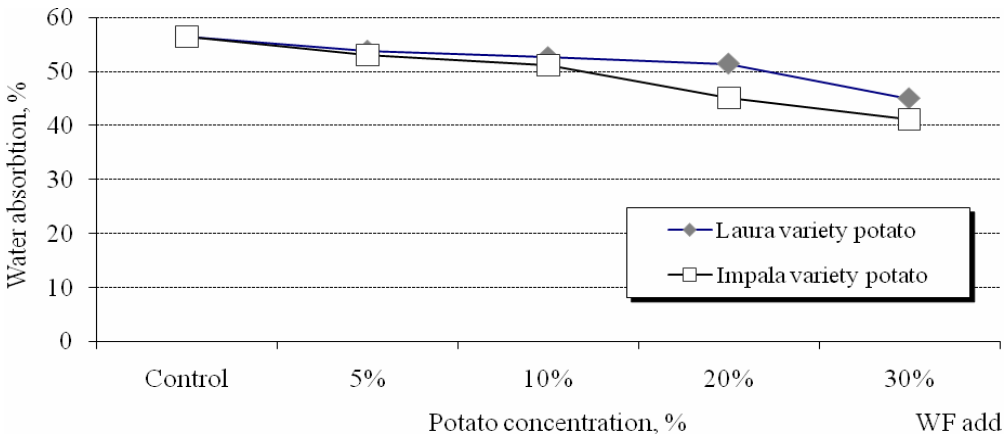


Figure 3. Evolution of hydrating capacity of the mixture with salt and yeast, prepared of WF added with potato in variable proportion

TDD, in minutes, is the time necessary to reach the maximal consistency (Bordei, 2007). It is dependent on the time of gluten structure formation in dough and is measured as the time between the first addition of water and the time when maximum consistency of dough or minimal mobility is attired. TDD in the presence of salt and yeast decreased from 2.7 minutes to 2 minutes. As the protein content decreases, this parameter drops to 1.3 minutes. However when potato is 30% of the total content, TDD is higher compared with the sample without salt and yeast. The solution with 30% potato could be considered a sensitivity threshold which would reconsider theories about the influence of proteins on the duration of mix formation (Figure 4.)

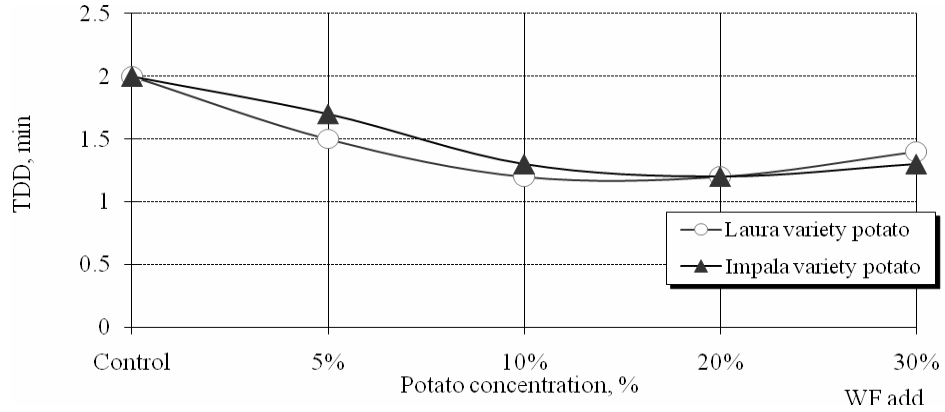


Figure 4. Formation time evolution, of salt and yeast, prepared out of WF add mixed with potato varieties that has replace flour in different proportion.

Stability, in minutes, is the interval time between the moment when the upper edge of the curve intersects the line corresponding to the maximum consistency dough and the moment when it exceeds (Bordei, 2007). This indicator gives a measure of tolerance to mixing. Without salt and yeast, stability is 5.8 minutes; stability increases at the addition of salt and yeast (figure 1 a, b) to 9.4 minutes, compared with the control sample. When potato is added in percentage of 30%, stability decreases with 85%, with or without yeast (Figure 5).

The degree of softening is the difference in consistency measured between the center of the curve at the end of the dough development and the center after this point at 12 minutes (AACC, 54-21), 10 minutes, 20 minutes (ICC 115/1). Tolerance Index is the difference between the maximum value of dough consistency and dough consistency after 5 minutes or after 10, 20 minutes from the start tracing the curve; it shows how quickly the dough leaves at over-molding (Bordei, 2007). Since TDD and stability undergone transformation, it was considered more appropriate to take into account for comparison the degree of softening at 12 minutes, which increases with 443.4% in the sample with Lvp and with 309.43% for sample with Ivp, both compared with control.

Growth is influenced by the potato type and the percentage of flour replacement with pulp. As Figure 6 shows, this parameter is closely correlated with the percentage of replacement of flour with potato. The correlation index is higher as 0.9 with or without salt and yeast.

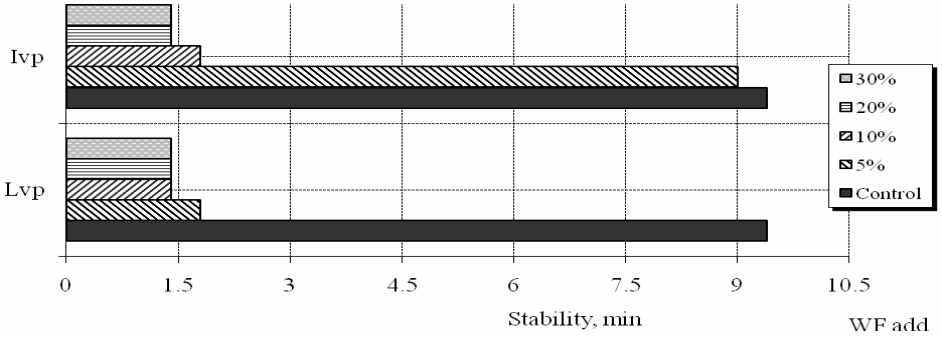


Figure 5. Stability evolution, of salt and yeast, prepared out of WF add mixed with potato varieties that has replace flour in different proportion.

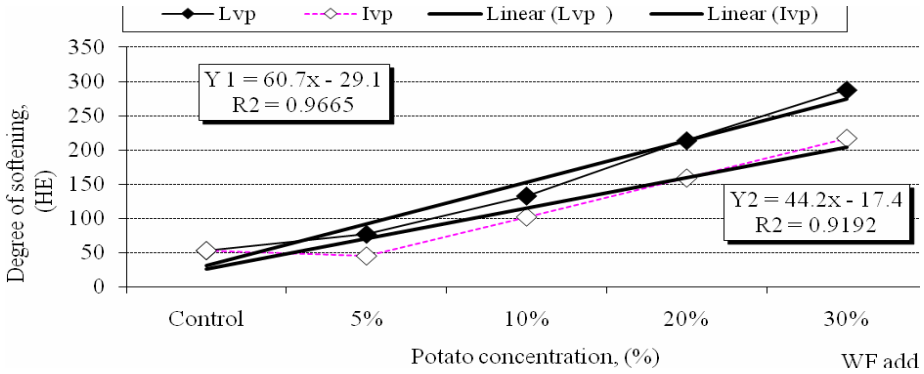


Figure 6. Degree of softening evolution, of salt and yeast, prepared out of WF add mixed with potato varieties that has replace flour in different proportion.

Quality number is the length in mm along the time axis between the point of adding water and the point where height of the center of the curve decreased with 30 units from the center height curve during development (Bordei, 2007). The addition of salt and yeast improved value of QN (Table 1, Figure 7). Value of this parameter decreases with 84% for the sample with Lvp and 82.9% for the sample with Ivp. These values are comparable with the variant without salt and yeast. This decrease in QN (Figure 1, a, d, f) is due to reductions in the chart length between the point of adding water and the point where height of the curve center decreased by 30 units (Figure 7).

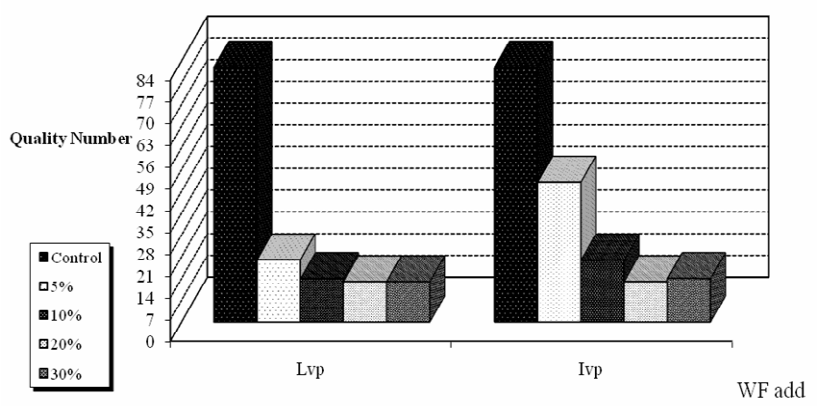


Figure 7. Quality Number evolution, of salt and yeast, prepared out of WF add mixed with potato varieties that has replace flour in different proportion

CONCLUSION

In this research a quantitative description of the mechanical properties of dough was obtained. Studies concluded that all indices measured (dough development, dough stability, quality number, dough softening) are influenced by the percentage of replacement of flour with potato and by the potato variety. Because of the QN reduction, the reduction of mixing and fermentation time is recommended at the replacement of flour with increasing percentage of potato.
NaCl and yeast bread enhances the decreasing of the hydration capacity, time of dough formation, stability, quality number and the increasing of the degree of softening.
This study allowed the characterisation of the performance of dough during baking.

REFERENCES

1. [***]ICC Standard Methods, International Associations for Cereal Science and Technology,1998
2. [**]Colecţie de Standarde pentru Industria de Morarit si Panificatie,vol .I, 1988
3. [*]AACC. Approved Methods American Association of Cereal Chemists: St.Paul,MN, 2000

4. Bidlas, E., Lambert, R.J.W.,Comparing the antimicrobial effectiveness of NaCl and KCl with a view to salt:sodium replacement. Int.J. Food Microbial,2008, 124, 98-102,
5. Bordei, D., coordonator, Controlul calitatii in industria panificatiei. Metode de analiza, Editura Academica Galaţi, 2007
6. Codina G,G., Cretu I., Pslaru,V., Salt influence on dough's behaviour, Journal of Agroalimentary Processes and Technologies, 2007, XIII(2), p.p.291-294,
7. Esselink, E., van Aalst, H., Maliepaard, M., Henderson, T. M. H., Hoekstra, N.L. L. & van Duynhoven, J., Impact of industrial dough processing on structure: A rheology, nuclear magnetic resonance and electron microscopy study. Cereal Chemistry, 2003, 80, 419-423,
8. Gellynck, X., Kuhne, B., Bockstaele van F., Davy Van de Walle, Dewettinck, K., Consumer perception of bread quality, Appetite, 2009, 53, 16 – 23, doi.10.1016/j.appet.2009.04.002
9. Hong,Y., Irudayaraj,J., Otgonchimeg,S., Walsh,M., Rheological study of starch and dairy ingredient-based food systems, Food Chemistry, 2004, 86, 571-578,
10. Hoseney, R. C., Principals of cereal science and technology(pp.205-206). St Paul, MN: American Association of Cereal Chemists, 1986,
11. Iancu M.L., Luiza, M.,Haubelt,G., Experimental model for the application of the flourgraphic technique to the study of the mixture of flour and raw potato, or hydro thermally processed potato, Journal of Agroalimentary Processes and Technologies**,** 2010 a, 16(1),41-48,
12. Iancu, M.L., Ognean. M., Danciu, I., Haubelt,G., Evaluation of rheological properties of flour and potato pulp blends using Brabender Farinograph and E6 Haubelt Flourgraph, The Annals of the University "Dunarea de Jos of Galaţi", Fascicle VI- Food technology, 2010b, 34 (2), ISSN 1843-5157,
13. Iancu, M.L.,Mike L., Jâşcanu, V.**,** The influence of potato varieties grown in Făgăraş area on rheological characteristics of dough for bread with potatoes, Journal of Agroalimentary Processes and Technologies, 2010 c, 16(3), 336-340.
14. Janssen, A.,M.,van Vliet, T.,Vereijken, JM., Fundamental and empirical rheological behavoir of wheat flour dough and comparison with bread making performance, Journal of Cereal Science,1996b, 23,43-54,
15. Matters, R.D., Donnelley, D., Relative contribution of dietary sodium sources. J. Am. Coll. Nutr. 10, 383- 393, 1991
16. Mironescu M., Mironescu I.D., Oprean L., Steady and oscillatory shear behaviour of semi-concentrated starch suspensions, ICEF11 Congress Proceedings Food process Engineering in a Changing World, 2011, 1105-1106
17. Peressini, D.,Sensidoni,A., Rheology of wheat doughs for fresh pasta production: Influence of semolina – flour blends and salt content, Journal of Texture Studies, 2000, 31, 163 -168,

18. Preston, K.,R., Effect of neutral salts of the lyotropic series on the physical dough properties of Canadian Red spring wheat flour. Cereal Chemistry, 2001, 66, 144- 148,
19. Samapundo, S., Deschuyffeleer, N.,Van Laere, D., De Leyn, I., Devlieghere, F., 2010, Effect of NaCl reduction and replacement on the growth of fungi important to the spoilage of bread, Food Microbiology, 2010, xxx 1-8, doi:10.1016/j.fm.2010.03.009
20. Singh, N., Bajaj, K.I., Singh, R.P., Gujral, S.,H., Effect of different additives on mixograph and bread making propperties of Indian wheat flour, Journal of Food Engineering, 2002, 56, 89- 95