JAP&T TPA-Timişoara

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Journal of Agroalimentary Processes and Technologies 2010, *16*(3), 333-340

Journal of Agroalimentary Processes and Technologies

The influence of potato varieties grown in Fagaras area on rheological characteristics of dough for bread with potatoes

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Received: 30 May 2010; Accepted: 17 August 2010

Abstract

The objective of this study is to examine the behaviour of white flour with additives dough (WF add) and brown flour with additives (BF add.) which was replaced hydrothermally treated and chopped potato, Laura, Impala, Lady Claire, Lady Christl and Orchestra varieties, at a rate of 5%, 10 %, 20 %,30 %. For the rheological characterization of the mixtures we used Flourgrapf E6 Haubelt. We obtained mixtures with different rheological properties. We compared the parameters characterizing the flourgrams for each potato variety used for each type of flour. The formation time and stability decreased, the degree of softening increased and the quality number was increasingly smaller. The hydration capacity of the mixture lowered on average with 27,9% for the mixture of white flour with additives and 31,2% for the mixture of brown flour with additives. From the results obtained it was concluded that the potato variety that less destabilizes the structure of the mixture is Laura variety if flour is replaced with potato in small proportions, 5% -10% and Lady Christl or Lady Claire, if flour is replaced with potato in large proportions 20% -30%. The quality of the obtained dough is different, although the amount of water was added up to a consistency of 500 HE (Haubelt units). We observed that differences arise due to a change in the composition of the mixture under analysis which implicitly leads to changes in friction, the ratio between hydrophilic and hydrophobic groups and redox reactions.

Keywords: rheology , Flourgraph E6 Haubelt, water absorbtion, quality number, flour, potatoes

1. Introduction

Dough rheology play an important role in the quality of baking products [3] and morevor posed many intriguing questions about mechanical behavior. The investigation of dough rheology goes back a long way; the early work (1932-1937) of Schofield and Scott Blair [16] estabilished the solid like behavior of dough, and science then there have been many investigations [3,11]. In 1930 the first special instruments to study dough were created, among which the farinograph and mixograph, that give the force moment generated during dough mixing [11].

The characteristics of dough with hydrocoloids adding was studied using the Brabender farinograph [15]. To determine the rheological characteristics of dough we can also use the E_6 Flourgraph, and dough consistency and softening degree is expressed in HE (Haubelt units). The correlation between the farinographic units and Haubelt units were made for white flour with additives and brown flour with additives. The correlation indices, R_{2WFadd} = 0,8441; $R_{2BFadd.}$= 0,9995 [9] demonstrates that the two devices can similarly characterize the colloidal mixture.

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Bread dough is a soft-solid, which may be regarded as a filled elastometric network. Starch particles of two kinds (lenticular particles of about 14 μmin size and smaller spherical particles of about 4 μm diameter)make up the filler, which comprises about 60% of the volume in natural doughs [3]. Electron microscopie pictures of dough show clearly the network and the starch particles, manipulation of the starch content to change dough properties has also been discussed [19]. In dough , the filler particles are not stongly attached to the rubbery gluten net work, and the starch can easily be washed out of the dough with water. Bread dough is considered to be a soft solid [17] which is subject to an overall degradation during the process of bread obtaining.

The potato (Solanum tuberosum) contains a small percentage of protein (2,1%) and a large amount of carbohydrates (17,1g/100 g) [6].Turgor or fresch plant tisues depends, among others, on ratios and distributions of chemical constituents in the cell wall and intracellular spaces. These constituent include: cellulose, hemicelluloses and pectins, generally referred to as non-starch polysaccharides (NSP) and lignin [7]. The cell structure of outer tissue is deteriorated when the potato is peeled, the pectic content is reduced, proteins are denatured, enzymes are inactivated and water soluble chemical constituents are partially removed by washing [12]. Besides starch, the components that influence texture are non-starch polysaccharides and lignin [1, 2], which represents half of non-starchy substance content of the dry mass of potato [14].

In during heating the starch granules within the cell absorb the cellular water and swell in the form of a gel. The other major changes are the loss of cellular membrane integrity by turgescence appearance and free diffusion of the cellular content from the destroyed tissue. The warming effect on the structure of cellular walls and protein degeneration results in reducing the cohesion between cells [18].

For rheological determinations we use a quantity of "soft" solid matter with 86% dry matter content. If we replace flour with potato pulp, mixture humidity changes.

To ensure 86% of dry matter it is recommended to use the balance equations to correct the proportions of flour and potato pulp [8].

In this procedure we used white wheat flour with additives, black wheat flour with additives, and potato varieties with different dry matter content and different texture features. These varieties were Laura, Impala, Lady Claire, Lady Christl and Orchestra. Flour was replaced with potato pulp at a rate of 5%, 10%, 20%, 30%. The potato pulp was subjected to hydrothermal treatment and it was minced before using it. The E_6 Flourgraph was used to characterize the rheological behaviour of the dough with potato.

The rheological characteristics of the dough made out of wheat flour mixed with potato pulp were compared and the relations between them were discussed. The results were used to predict the bakery performance of the colloidal mixture. We studied the evolution of the mixture hydration capacity and the rheological characteristics (stability, softening, and consistency) that characterize flour strength. In this study they have characterized the behaviour of the mixture.

2. Materials and methods

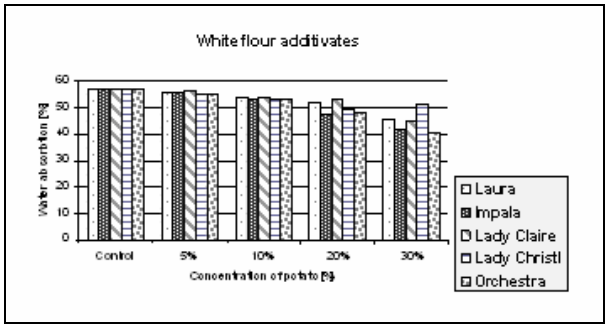
Materials. White flour additivates (ascorbic acid 1,5 g/100 kg flour; L-cisteina 3g/100 kg flour; α-amilaza, xilanaza, hemicelulaza 8-9g/100 kg flour), u =13,9%; Glwet = 32%; ID = 4 mm; IGL = 55,68; FN = 290-300s; TTA = 2,2 degree, ash- 0,649 %; WA = 56,9 %: brown flour additivates (ascorbic acid 4g/100 kg flour; L cisteina; α-amilaza hemicelulaza 8-9 g/100 kg flour) u = 12,9%; Glwet = 30%; ID = 8 mm; IGL = 44,4; FN = 280 s; TTA = 3,3 degree, ash 0,1250 %,WA = 61,5% - Mill Cibin Sibiu, Romania; potato Laura u = 73,5%, Impala u = 83,5%, Orchestra u = 81,3%, Lady Claire u = 70,9%, Lady Christl u = 79,3% variety, supplay Potato Research and Development Station Targu Secuiesc, Covasna, Romania.

Method: Wet gluten-ICC No.106/2-1984; AACC METHOD 38-10 Hand Wasing Method; ID-STAS 89-90- STAS 6283; Ash Content ICC STANDARD 105/2; Acidity STAS 90-88; Determination of „Falling Number" ISO 3093-97, ICC STANDARD No.107 / 1-1995, Hydration degree ISO 5530 / 1 / 1999 ICC No115 / 1 - Haubelt 2006; Umidity – termoanalizer - moistur analyzer AND ML-50 [10]. The E_6 Flourgraph that functions on the same principle like farinograph [8] 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 is has a 100 g flour capacity.

Kneading arms rotation is of 63 r.min-1. Preparing the potatoes for analysis: the potato paste (PP) is obtained by hydro thermally processing theunpeeled raw potato for 30 minutes at water boiling temperature, then cooling it, peeling, and mashing it by passing it through the 2 mm mesh sieve.

3. Results and Discussion

Twe managed to determine the moisture capacity which is a fundamental parameter that defines the ratio between water and potato pulp mixture, necessary to obtain an optimum dough with vasco elastic properties. Another important parameter was temperature, maintained constant at 300C.



R^2=0,8832 - Laura
R^2=0,9283 - Impala
R^2=0,8011 -Lady Claire
R^2=0,8109 - Lady Christl
R^2=0,9088-Orchestra

Figure 1. The evolution of the hydration capacity of a mixture white flour with additives and potato pulp, in correlation with potato variety (Laura, Impala, Lady Claire, Lady Christl, Orchestra) and the replacement rate of white flour with additives with potato pulp (5% , 10%, 20%, 30%).

CH, hydration capacity is the amount of water absorbed to achieve standard consistency 500 BU [13]. We studied the hydration capacity of a colloidal mixture of flour and potato pulp having a consistency of 500 HE-constant.

Flours used have qualitative indicators that recommend them for baking, but white flour with additives is qualitatively better than brown flour with additives.

The potato variety for which we obtained smallest hydration capacity decrease was Lady Chistl with 9,5% in the WF add mixture and with 16,5% in the BF add. The values obtained at a replacement rate of 30% were again of 51,4%.

Thus for 100 g of mixture with 86% dry matter with a flour replacement rate of 30% we obtained the same flourgraphic hydration capacity regardless of the used flour.

The largest decrease was obtained for the Orchestra variety both for the white and brown flour. This is of 27,9% for the WF add. mixture and 28,3% for the BF add.

The hydration capacity of brown flour mixed with potato pulp of different varieties decreases. Although considering the value of hydration capacity value for brown flour and potato pulp mixture (Figure No 2) is superior to that of white flour with additives (Figure No 1), however reported to the CH (hydration capacity) of the control sample is more proeminent in brown add. flour compared with white add flour regardless of the potato variety.

At a concentration of 5-10% flour replacement ratio with potato pulp, hydration capacity values for a mixture consistence of 500 HE are very close irrespective of potato varieties. Work versions of 5-10% are influenced than flour characteristics and CH values are more uniform. Work versions of 20-30% are more influenced by the characteristics of potato pulp and differences due to variety are more obvious (figure No 1, figure No 2).

The percentage of flour replacement with potato pulp is an independent variable that has a great influence on the dependent variable, the hydration capacity. The correlation indices obtained are very close to 1, $R^2 \in [0,8011;0,9938]$ (figure No 1 and figure No 2).

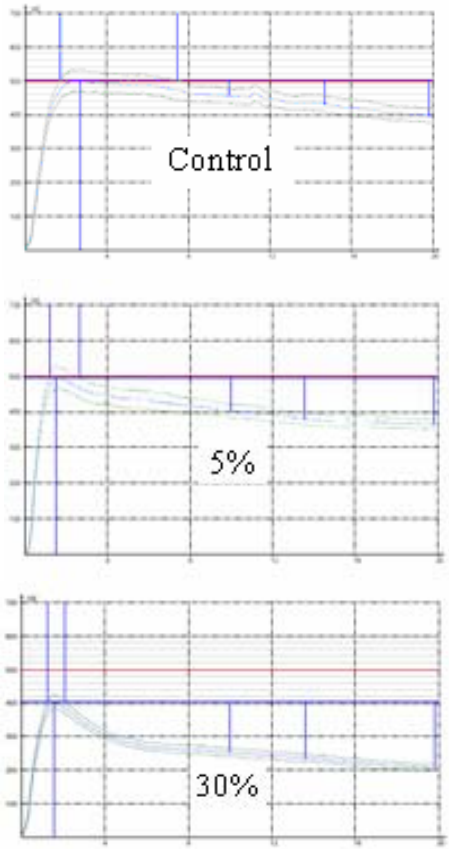
If we do not respect the hydration capacity correcting according to the proportion of potato pulp a loss of consistency takes place. This is even higher as the percentage of potato pulp is higher. Mix consistency decreases to values of approximately 400 HE in the mixture of white flour with additives and approximately 300 EU if in the mixture of black flour with additives (figure No 3).

The development time (minutes) is the necessary time so as the mixture reaches a maximum consistency [5].

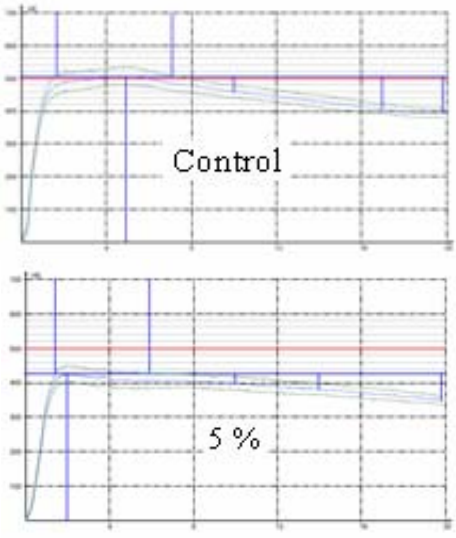
The rheology of dough is sensitive [19] to change in water content, starch content, wheat genetics and mixing procedure, as well temperature. The formation time is influenced by all the interaction forces between proteins. Their number was increasingly lower in the studied samples.

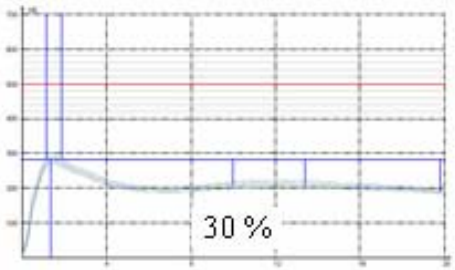
Kneading tolerance was increasingly weaker due to the dilution of gluten network.

The development time is correlated with flour quality and is influenced by the amount of water.



Flourgram for white flour add. replace *Laura variety*





Flourgram for brown flour add. repleace *Lady Claire variety*

Figure 3. Loss of mixture consistency, without correcting the hydration capacity of brown flour with additives, white flour with additives and hydrothermal treated potato pulp, varieties Laura and Lady Claire that replace flour in a ratio of, 5% no 30%

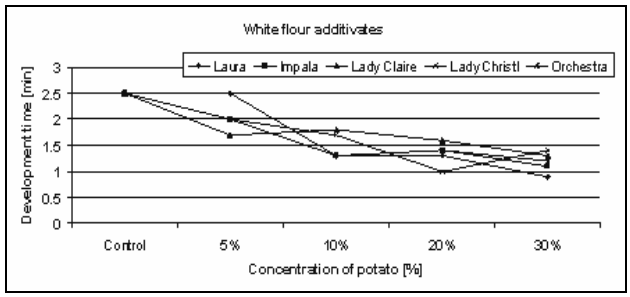


Figure 4. The evolution of development time [min] of a mixture of with white flour additives and potato pulp, depending on potato variety (Laura, Impala, Lady Claire, Lady Christl, Orchestra) and the replacement rate of white flour with additives (5%, 10%, 20%, 30%)

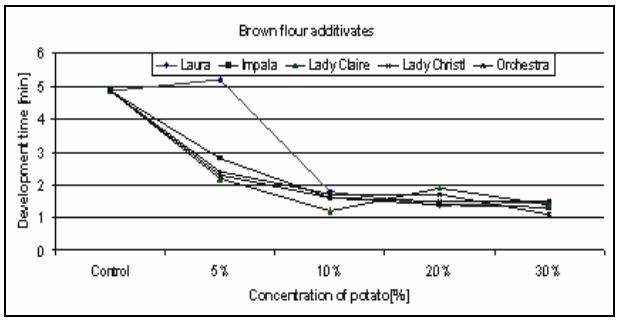


Figure 5.The evolution of development time [min] of a mixture of with brown flour additives and potato pulp, depending on potato variety (Laura, Impala, Lady Claire, Lady Christl, Orchestra) and the replacement rate of white flour with additives (5%, 10%, 20%, 30%)

For the samples with adding the development time is under 2 minutes (figure No 4, figure No 5) and this is characteristic for weak flours. For the working version of 5% the highest developing time was reached when using Laura variety mixed with WF add or BF add. For the working version of 10% Lady Claire variety mixed with BF add and Laura variety gave the best values.

At 20% replacement rate, Lady Claire variety proved to be the most appropriate mixed with both with white flour add., and the brown flour add For the working version of 30% Lady Christl proved to be the best variety. In conclusion, to get the highest levels of development time, if we use a small percentage of replacement 5-10% it is better to use the Laura variety, and for higher concentrations Lady Christl or Lady Claire variety.

For the working versions with a high replacement ratio 20%, 30% we cannot say that there is a strong gluten network starch granules are caught but a structure of potato pulp stabilized with a gluten network. Dough quality is different although the amount of water was added to a consistency of 500 HE.

Regardless of the adding and for the same flour, in the same work conditions different curves were obtained. We noted that differences arise due to changes in the environment composition which implicitly lead to changes of friction, of the ratio between hydrophilic and hydrophobic groups and redox reactions.

The power of flour is influenced by the protein content, photolytic enzymes activity and proteolysis activators [4].

In the studied mixture we observed the influence of the other component existent in a large amount, namely starch. The gluten network is diluted and the behaviour of the mixture is similar to that of poor quality flour.

The stability [minutes] is the time interval between the moment when the top edge of the curve intersects the line corresponding the maximum consistency of the dough and the moment when it exceeds it [5]. In the studied mixture we observed the influence of the other component existent in a large amount, namely starch.

The gluten network is diluted and the behaviour of the mixture is similar to that of poor quality flour. In this study we observed is a decrease in stability along with the increase of flour replacement percentage regardless of the flour type.

Comparatively, for white flour with additives it was of 5,6 min and for brown flour with additives 5,2 minutes, very close values. For the working versions of 20-30% the stability value was nearly constant and equal and 1,4 minutes regardless of the potato variety (figure No 6 c, d).

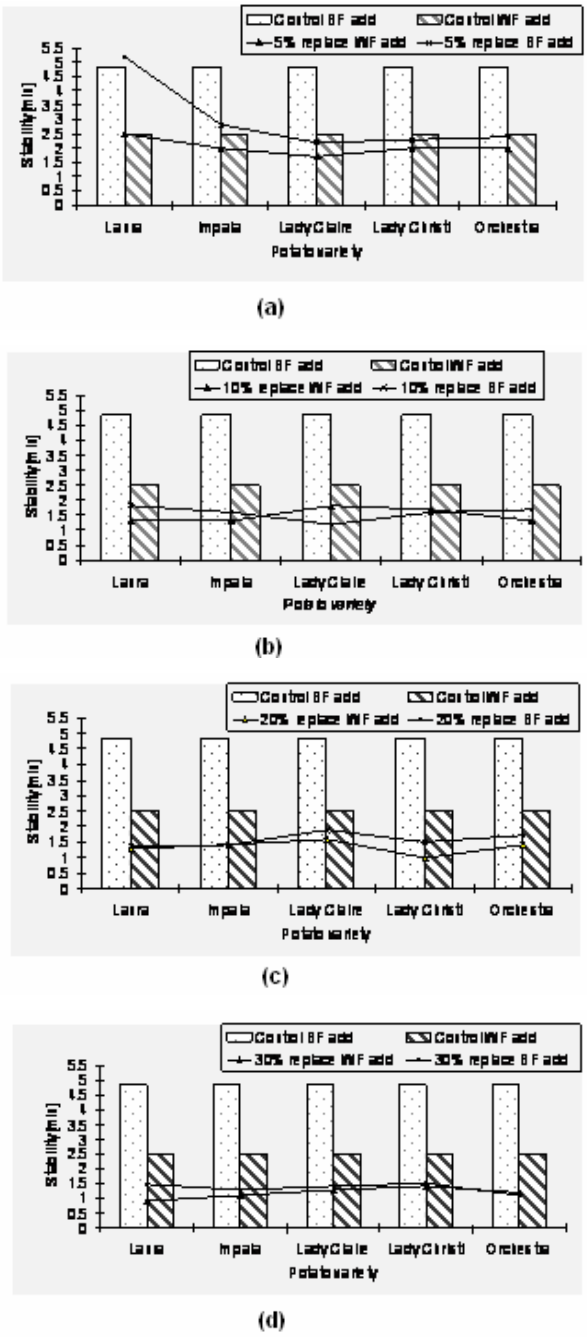


Figure 6. The evolution of stability [min] of a mixture of brown flour or white flour with additives and potato pulp, depending on potato variety (Laura, Impala, Lady Claire, Lady Christl, Orchestra) and the replacement rate of flour with potato :5%(a), 10%(10), 20%(c), 30%(d)

For the addition of 5% the mixture with brown flour with additives has improved considerably its stability that rose up to 8,2 minutes for Laura variety, up to 7,7 minutes for Orchestra variety and decreased to 3,7 min for Lady Claire variety (figure No 6., a).

In general, dough stability decreased with maximum 75%. The numerical value is higher than 1 thus around the value that characterizes poor quality flour. The degree of softening, [HE], is the consistency difference measured between the curve centre at the end of dough development and the curve centre at 12 minutes after this point (AAC-54-21), at 10 minutes, 20 minutes (ICC 115/1). The tolerance index [HE] is the difference between maximum dough consistency and consistency value after 5 minutes of kneading or after 10 ; 20 minutes from the beginning of tracing the curve. It shows how fast the dough falls when it is over kneaded [5]. Brown and white flour with additives used in this study are recommended in terms of the degree of softening as being part of the category of medium quality flours. Regardless of the replacement ratio and potato variety, the softening degree increased more as the replacement percentage increased.

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Table 1. The evolution of degree of softening [HE] of a mixture of brown flour or white flour with additives and potato pulp, depending on potato variety (Laura, Impala, Lady Claire, Lady Christl, Orchestra) and the replacement rate of flour with potato :5%, 10%, 20%, 30%

Flour	Variant of work	Degree of softening [HE]	Potato variety				
			Laura	***Impala***	***Lady Claire***	***Lady Christl***	***Orchestra***
White flour additivates (ascorbic acid 1,5 g/100 kg flour;L-cisteina 3g/100 kg flour;α-amilaza, xilanaza, hemicelulaza 8-9g/100 kg flour)	**Control**	**12**	**73**	**73**	**73**	**73**	**73**
		10	**44**	**44**	**44**	**44**	**44**
		20	**109**	**109**	**109**	**109**	**109**
	5%	*12*	*116*	*92*	*116*	*93*	*99*
		10	83	68	95	73	80
		20	150	146	167	137	148
	10%	*12*	*174*	*125*	*151*	*134*	*142*
		10	155	108	126	113	121
		20	210	171	213	187	196
	20%	*12*	*236*	*198*	*245*	*192*	*189*
		10	213	178	213	173	173
		20	266	254	297	256	238
	30%	*12*	*279*	*234*	*271*	*220*	*273*
		10	264	217	278	195	217
		20	311	281	327	283	280
Brown flour additivates ascorbic acid 4g/100 kg flour; L cisteina; α-amilaza hemicelulaza 8-9 g/100 kg flour	**Control**	**12**	**97**	**97**	**97**	**97**	**97**
		10	**46**	**46**	**46**	**46**	**46**
		20	**115**	**115**	**115**	**115**	**115**
	5%	*12*	*75*	*84*	*76*	*71*	*58*
		10	30	37	52	38	30
		20	86	98	118	112	91
	10%	*12*	*134*	*94*	*109*	*87*	*104*
		10	97	73	93	65	81
		20	178	132	153	127	144
	20%	*12*	*194*	*157*	*125*	*137*	*135*
		10	173	133	90	113	108
		20	224	194	192	187	185
	30%	*12*	*254*	*224*	*266*	*248*	*233*
		10	224	198	244	126	213
		20	280	253	305	275	270

Orchestra variety potato mixed with white flour with additives gave the lowest value of the hydration capacity, so in this mixture we added the smallest amount of water.

As a consequence the degree of softening at 10 minutes after the start, 12 minutes after reaching the maximum and at 20 minutes after the start was lower.

The mixture of brown flour with additives and potato pulp Impala variety had the lowest value of hydration capacity but it did not lead to lower values of the softening degree. They were highly diverse and influenced by the characteristics of potato varieties. The best values, thus the lowest were obtained for mixtures with Impala and Lady Christl potato varieties (table No 1).

The highest values for the addition of 30% and the most stable was Lady Christl variety (for values higher than 20% -30%) and for small additions we recommend to use brown flour mixed with potato pulp of any variety. The over-kneading tolerance decreases (table No 1). Another indicator that is compared for various registered diagrams is the quality number (Figure No 7).

The quality number is the length in mm along the time axis between the point of water adding and the point where the height of the curve centre has decreased with 30 HE compared with the height of the curve centre during development [5].

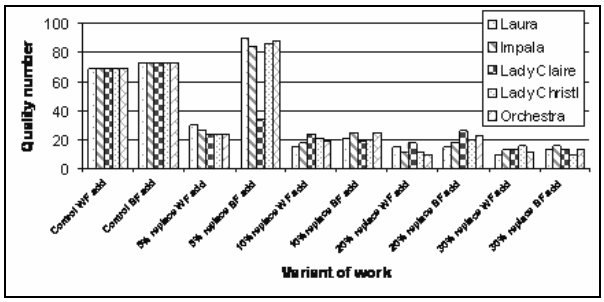

Figure 7. The quality number for mixture white and brown flour (WF add. , BF add.) and potato pasta variety Laura, Impala, Lady Claire, Lady Christl si Orchestra and the replacement rate of flour with potato: 5%, 10%, 20%, 30%

This parameter that characterizes the system as a whole decreases with the percentage increase of flour replacement with potato pulp. For the work variant of 5% the mixture of potato pulp and brown flour with additives, we obtained the best results and a note increase with 23% Impala Laura variety 13%, for Impala variety, 53%-Lady Claire variety, Lady Christl variety 17% Orchestra variety.

For 10% 20% 30% the QN (quality number) value decreases regardless of the flour type and has different values depending on the potato variety used. We recommend the use of Laura variety for small levels of the replacement rate, and Lady Claire variety for high levels of the replacement rate.

4. Conclusion

Flour absorption determined with E_6 flourgraph decreases with the percentage of potato pulp that replaces flour. The correlation indices of the hydration capacity, depending on the potato percentage that replaces flour are in the range R_2 [0,8011;0,9938].

This is due to the dilution of gluten generating protein content, modification of the hydrophilic and hydrophobic bonds ratio. At a concentration of 5-10% replacement percentage of flour with potato pulp, hydration capacity values for a consistent mixture of 500 HE are very close irrespective of the potato variety. The work variants of 5-10% are influenced by flour characteristics and CH values are more uniform. The work variants of 20-30% are more influenced by the characteristics of the potato pulp and the variety differences are more obvious.

The results were used to predict the bakery performance of the studied colloidal mixture. As a result the characteristics of the titration curve change. These changes are influenced by the characteristics of potato variety and the flour type. The development time is reduced, dough stability in general decreased with maximum 75%. The numerical value for stability is higher than 1minute so it is around the value that characterizes poor quality flour. The degree of softening increases the tolerance to over-kneading decreases because of the dilution of the gluten network. The flourgram note as a parameter that completely characterizes the mixture decreases. For the work variant of 5% the mixture of potato pulp and black flour with additives we obtained the best results and a note increase with 23% for Laura variety, 13% for Impala variety, 53%-Lady Claire variety, 15%-Lady Christl variety, 17% - Orchestra variety. For 10%; 20%; 30% the quality number value decreases regardless of the flour type and has different values depending on the potato variety used.

Dough quality is different although the water amount was added up to a consistency of 500 HE. Regardless of the addition, and for the same flour, under the same working conditions we obtained various titration curves.

We noted that differences arise due to changes in the environment composition which implicitly lead to changes of friction, of the ratio between hydrophilic and hydrophobic groups and redox reactions.

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