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Research on the rheometric elements of the potato dough and the influence of measured variables upon bread quality

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Abstract

The aim of this study is to establish the relationships between values of measured variables that would characterize rheometric elements with characteristics bread with potato. The other added materials and operational parameters were constant in order to better emphasize the influence of the studied adding (potato pulp that replaces flour). To establish the hydration capacity of the mixture we used the Haubelt Flourgraph E6 and rheological behavior and the dough containing potato pulp performed by Haubelt Flourgraph E7.The studied quality parameters of the bread were specific volume, the hight/diameter ratio, elasticity, porosity and to appreciate the chemical composition we determined the humidity. They were used to analyse standard methods and their modified variants. Bread improves its quality index, the specific volume increases, the height/diameter increases, the porosity decreases and the elasticity increases. Humidity increases as well. In general bread quality has improved. This study shows that choice for potato variety is important because based on its structural and functional characteristics the technological results on the bread manufacturing flow diagram are more or less profitable. We consider that Orchestra variety would be a more appropriate choice than Impala variety.

Keywords: potato pasta, dough rheology, bread quality, white wheat flour

1. Introduction

Current food, which is base on food prepared in a comlicated manner, has in potato bread exactly the representative of the opposite, i.e. of simplicity and closeness to nature.

From the bakery products, the "Transylvanian potato bread" is on the groceries list submitted to the European Union containing geographical indications, origin appellations, protected and known in Romania. This list was issued under the order no.212/30 March [1]

Potato is a diet component in many cultures and is a source of many nutrients. They can be consumed boiled, baked or fried. The ones processed by heat develop several flavour components [2].

It is the raw material for other food industries such as: alcohol manufacturing industry, starch and vegetable canning. It is used in bakery as a natural and inexpensive method to enlarge the maintenance of bread freshness time [3] or gluten free-bread, [4, 5].

The remplacement of gluten present a major technological challenge, as is an essential structure building protein contributing to the appeareance and crumg structure of many baked products.Thus, the gluten matrix is a major determinant of the important rheological characteristics of dough, such as elasticity, extensibility, resistance to extension and gas holding ability [6,7].

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To ensure 86 g su of dry matter it is recommended to use the balance equation to correct the proportion of flour and potato pulp [8]. Will prove useful in bakery, in situations when wheat flour has to be replaced by another raw material, in high amounts. The study may be a starting point for selecting the appropriate recipes and foreseeing the behavior of the mixture during processing [9].

This calculation formula allows us to treat any gluten free material used to replace flour the same way as flower itself, from the point of view of its quality characteristics, although this material will form a mixture with different quality indicators [10].

The potato (Solanum tuberosum) containing a small percentage of protein (2.1%) and large amount of carbohydrates (17.1g/100g) [11]. Turgot or fresch plant tisues depends, among other, on rations and distribution of chemical constituents in the cell wall and intracellular spacec. These constituent include:cellulose, hemicellulose and pectins, generally referred to as non-starch polisaccharides(NPS) and lignin [12].

In this procedure we used white wheat flour type 550 and potato varieties with different dry matter content and different texture features. These varieties were, Impala 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 E7 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 (energy, resistance to extension, extensibility, maximum resistance) that characterize flour strength. In this study they have characterized the behaviour of the mixture.

In this research I will analyze the physical and chemical parameters of potato bread and I will correlate the obtained values.

2. Materials and Method

White wheat flour type 550(u=14.5%;Gl_u=29%; ID = 4 mm; I_{GL}=49;FN = 330 s; TTA =2.3 degree,ash 0.549 %) producer *Mill Cibin Sibiu, Romania*, Method of analysis: Gl wet, AACC METHOD 38-10 Hand Wasing Method; ID-STAS 89-90- STAS 6283; Ash ICC STANDARD 105/2; Acidity STAS 90-88; „Falling Number”ISO 3093-97, ICC STANDARD No.107/1-1995; Hydration degree ISO 5530/1/1999 ICC No115/1-Haubelt 2010. Umidity–termoanalyzer, Potato Impala variety, u = 83.5 % and Potato Orchestra variety, u = 81.3 %, Producer: *Potato Research and Development Station Târgu Secuiesc Romania,* Method of analysis: The determination of moisture with the gravimetrical method, using the thermobalance, Yeast Bakery (Power of growth=10 minute; u=68,9%, with STAS senzoriale characteristics),producer Pakmaya-SC Rompak S.R.L-Paşcani,Romania, Method of analysis: The organoleptic characteristics(STAS 985-79), humidity (%)(STAS 985-79), Power of growth, the rapid method [13].

*Preparing the potatoes:*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 ϕ2 mm mesh sieve with mixer HV4.

*Rheological measurement:*For the first time determined flour and potato pasta umidity with termoanaliser(AND ML-50). Used analytical balance tipe WPS 210/C/1Partner for weigh. Dough samples for the rheological test were prepared without adding any yeast but adding salt 2% to the formulation to avoid interference of bubble formation.The effect different quantity of potato pasta on stretching dough properties was investigated by Haubelt Flourgraph E6 and E7 (Berlin, Germania) [14,15]. From the Haubelt Flourgraph E6, E7 curves, the water absorbtion (the percentage of water requirement to yield a dough consistency of 500 HE) at the and of mixing. From the Flourgraph E7 curves compared energy, resistance to extension, extensibility and maximum resistance.

*Bread making procedure:*Basic dough recipe on 1500g white wheat flour (with 14% humidity), 3% yeast, 1.5% salt and 5%, 10%, 20%, 30% is percentage potato pasta was replacement flour, was used in the experiments.

The amount of water(30^{0}C) added to the dough was folowing flourgraphic water absobtion with Haubelt Flourgraph E6 (Berlin, Germania).These water content have been determined in the preliminary experiments to procedure breads having the best quality(500 HE).

*Bread making process:*The baking test were carried aut in an electric oven with an incorporated proofing chamber(type ESM 3710 SADKIEWICZ). Firstly yeast was suspension in warm water(35^{0}C) and this was added the flour and potato pasta, then the mixture was blended with mixer (JZ SADKIEWICZ) for 12 min. The dough proofed at the 30^{0}C for 120min and subsequetly baked at 230^{0}C for 25 minute, following steaming for 15 s. Measurements of the loaves were carried aut after cooling to room temperature for 2.5 h.

*Bread quality evaluation:*Some physico-chemical parameters of fresh bread including volume, porosity and elasticity were determined following the national standard method of Romanian [16]. Bread volume was determined by a bread volumeter (Fornet, Chopin, France) using the rapessed displacement method. For determination of bread porosity(%) a cylindrical piece of crumb was cut from 60 mm slice obtained from the middle of the loaf by a cylindrical sharpened brass perforator. For determination of bread crumb elasticity(%) a piece of bread crumb was cut as previously described and pressed of the half of its height for 1 min. using a screw driven pressing device which consisted of a fixed and mobile plate and a ruler. Measurement of all the above quality parameters were performed at least in six replicates.

Analysis of variante and the statistical multiple range test were esed dubble serie to analise the data ($P< 0.05$) [17].For the organoleptic analysis of fresh breads Romanian scoring method is used [16].

3. Results and Discussion

*Dough properties:*Dough hydration capacity for the research Flourgraph E7 decreases as the percentage of flour replacement with potato increases. Compared with the control sample that contains no potato, the hydration capacity value is on average lower with 2% [3]. This verifies the rule confirmed by other specialized studies [18].

For the working version of 5%, the hydration capacity value decreases the most for the dough made with Impala potato variety, namely by 4.1%. For the working version of 20%, the hydration capacity decreases the most for the dough made with Orchestra potato variety, namely by 25.35% (Table 1). The consumed energy, the area (surface) below the registered curve (Table 1, figure 1, 2), consumed in order to stretch the dough after 45 minutes is higher than the value obtained after 90 minutes, respectively 135 minutes of resting. A higher value of the energy results in an improved dough quality. A higher value was obtained for the dough made with Orchestra potato variety.

Table 1. The flourgraphic (E6,E7) parameter of wheat white flour dough with potato

F1														
Parameter	**Water Absorbtion [%]**		**Energy [cm^2]**						**Resistance to extension [HE]**					
	Potato variety degree of cooking													
	I-PP	**O-PP**	**I-PP**			**O-PP**			**I-PP**			**O-PP**		
The working variant	-	-	45 min	90 min	135 min	45 min	90 min	135 min	45 min	90 min	135 min	45 min	90 min	135 min
Control	53.6	53.6	73	59	48	73	59	48	226	198	171	226	198	171
5%	51.4	51.8	80	67	64	77	72	69	255	322	306	263	349	352
10%	49	48	77	63	57	81	84	63	259	315	309	296	358	371
20%	41	40	72	78	65	77	74	59	267	434	430	309	493	363

Table 2. The flourgraphic (E7) parameter of wheat white flour dough with potato.

F1												
Parameter	**Extensibility [mm]**						**Maximum resistance [HE]**					
	Potato variety degree of cooking											
	I-PP			**O-PP**			**I-PP**			**O-PP**		
Variant of work	45 min	90 min	135 min	45 min	90 min	135 min	45 min	90 min	135 min	45 min	90 min	135 min
Control	165	163	170	165	163	159	295	239	200	295	239	200
5%	157	134	126	153	124	123	346	398	344	342	402	390
10%	153	121	117	144	123	110	343	373	347	377	419	386
20%	146	119	111	141	106	112	358	442	392	372	515	392

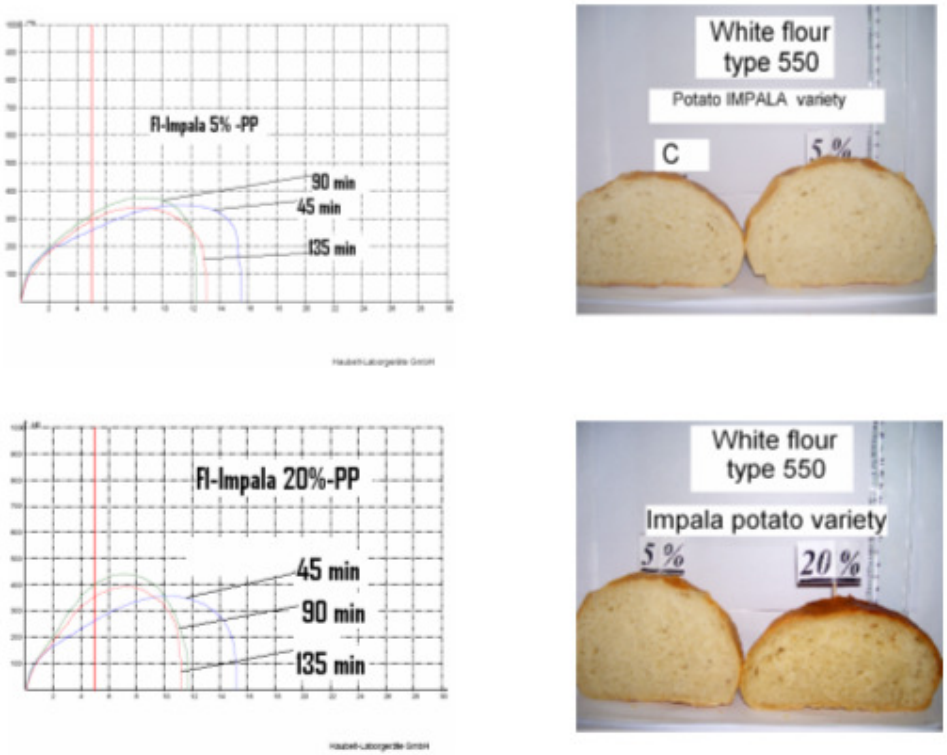

Figure 1. Effect of potato addition on internal structure of fresh bread with potato and evolution of flourgraphic E7 curbs profile of dough made of white flour and at a replacement percentage with potato paste Impala variety from 5% and 20%.

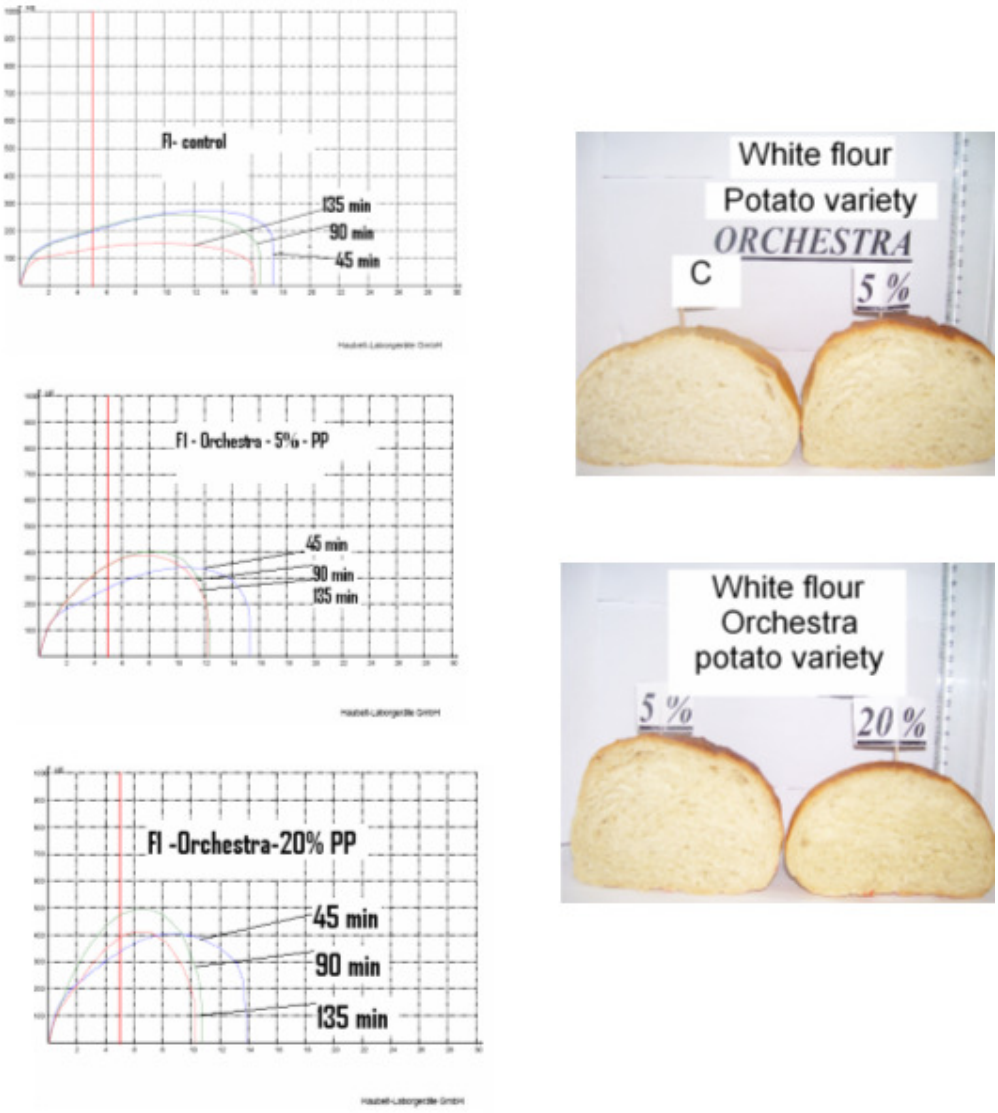

Figure 2. Effect of potato addition on internal structure of fresh bread with potato and evolution of flourgraphic E7 curbs profile of dough made of white flour an dat a replacement percentage with potato paste Orchestra variety from 5% and 20%

The resistance to extension increases compared with the control sample and the higher values were registered for the working versions of 20%, after 20 minutes of temperature control with a thermostat (493 HE), for the dough made with Orchestra potato variety (table 1). Extensibility decreases compared with the control sample. The lowest values (106 mm) were registered for the dough made with Orchestra potato variety (table 2).

The maximum resistance is increasing. The highest values were registered for the 20% working version, again for the dough made with Orchestra potato variety, after 90 minutes of temperature control with a thermostat, 515 HE(table 2).

*Bread quality:*It was examined the bread after 2h and 30 minutes of cooling at room temperature. The effect of replacing a part of the wheat flour with potato pulp was also noted in the end product quality. Crust color for the potato bread was examined organoleptically.

From Figure 3 I noted that with the increase of the replacement percentage of flour with potato, the crust color went from golden-yellow for the testing sample, to reddish-brown for the working version of 30%.

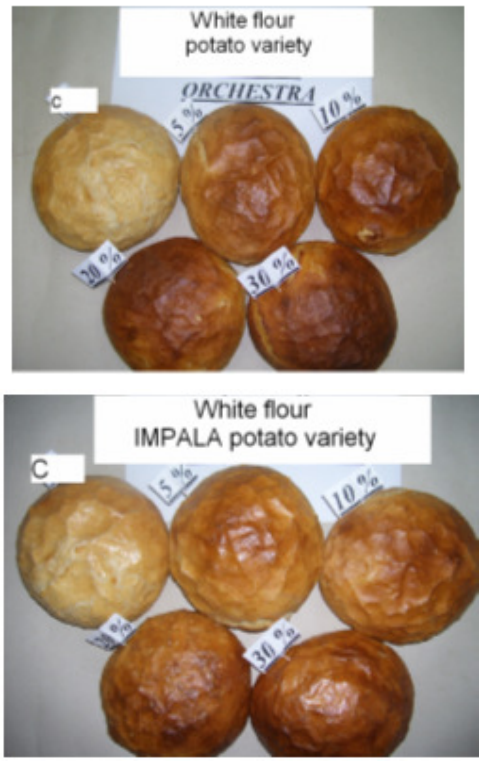

Figure 3. Effect of potato addition on external appeareance, crust of fresh bread with potato a replacement percentage with potato paste from 5%, 10% and 20%.

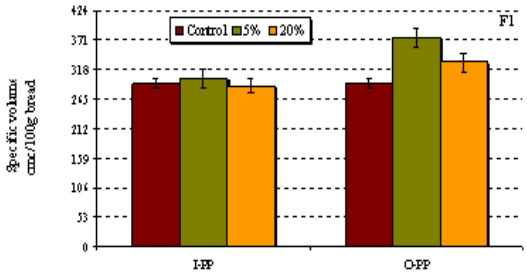

Figure 4. Bread specific volume variation in terms of replacement percentage of flour with potato and potato variey. Value are the average of six replicates and error bars represent standard deviation.

The specific volume increased with 5% for the working version (figure 1, 2) compared with the control sample.

If its used the Orchestra potato variety, the volume increase was higher than for the Impala potato variety (figure 4). The volume increased from 293 cm^3/100 g bread for the control sample to 376 cm^3/100g bread for the working version with Orchestra potato variety (figure 2). As a consequence of this fact the height/diameter ratio is higher. Its maximum value is of 0.52 and it was obtained for the bread made with Orchestra potato variety, the 5% working version (figure 4).

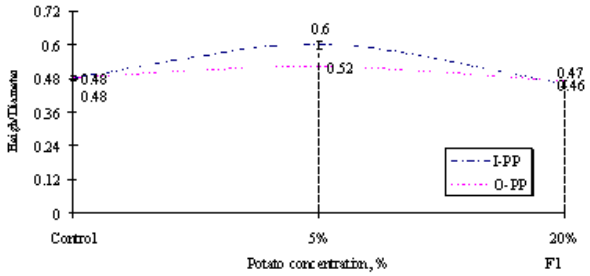

Figure 5. Ratio H/D variation of bread in terms of replacement percentage of flour with potato and potato variety

Due to the influence of potato pulp upon the dilution of the gluten network, upon the viscosity change and the wholes network caused by the fermentation gas release, the porosity and elasticity are changed. In consequence, the porosity decreases as the percentage of flour replacement with potato pulp increases, excepting the working version with 5% if we use the Orchestra variety potato (figure 2).

The porosity of the control sample is of 76% and the lowest value is of 67%. This is obtained for the bread core made with Impala potato variety, working version of 20% (Figure 6).

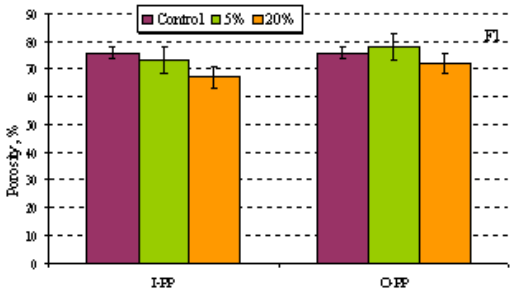

Figure 6. Bread porosity variation in terms of replacement percentage of flour with potato and potato variety. Value are the average of six replicates and error bars represent standard deviation.

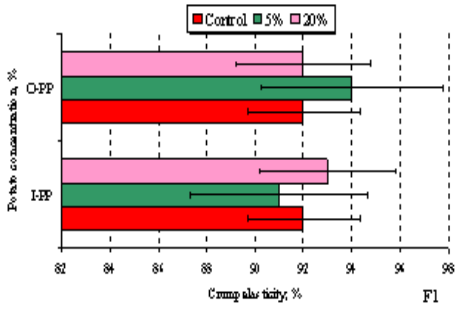

Figure 7. Bread crump elasticity variation in terms of replacement percentage of flour with potato and potato variety. Value are the average of six replicates and error bars represent standard deviation.

Elasticity generally decreases except for the 5% working version if we use the Orchestra potato variety and. The elasticity increases from 92% to 94% (Figure 7).

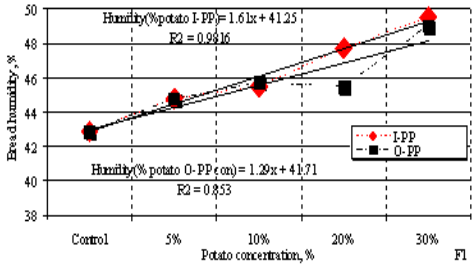

Figure 8. Bread humidity variation in terms of replacement percentage of flour with potato and potato variety.

Humidity increases with the percentage of flour replacement with potato. It increases from 42.9 % for the control sample to 49.5% for the working sample of 30% if we use the Impala potato variety.The dependency of bread humidity on the flour replacement with potato is calculated with linear equations. The correlations were very good: R^2 = 0.9616 if we used the Impala potato variety and R^2 = 0.853 if we used the Orchestra potato variety (Figure 8).

Dough extensibility is an important characteristic on which depends the dough ability to expand under the fermentation gas pressure, with implications upon the bread volume. The best correlation, namely a conditioning of the end product quality depending on the replacement of flour with potato pulp were obtained for the working version of 5% at 45 minutes of temperature control with a thermostat (figure 9).

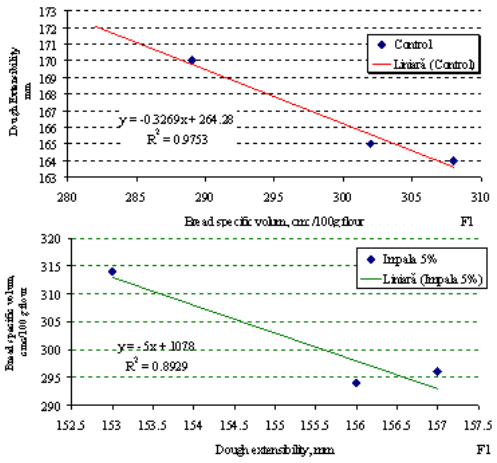

Figure 9 . Correlation between bread specific volume made of white flour type 550 and dough extensibility determined with Haubelt Flourgraph E7, for control and variant with potato pasta.

4. Conclusion

Predictive analysis of the quality of the finite product may be used, based on primary result obtained with Haubelt Flourgtaph E7

Destabilization of the mixture structure is greater if wateris not added according to the hydrating capacity. The hydrating capacity of the studied mixtures lowers and the influence factors are descending order compared to the percentage of flour replacement with potato, the potato variety.

Energy consumed for potato dough stretching grows after 45, 90 and 135 minuten of thermostating. Extensibility in general decreases while time elapses and the growth of the potato pulp percentage as compared to the witness.

Extension resistance generally grows at the same time with the growth of the replacement percentage and in time.

From evaluating the technological potential of potato varieties obtained:

- specific volume is growing;
- bread crump elasticity is growing with exception,
- porosity is improved and humidity is generally growing without exception

Another aspect that until setting these correlation has not been so obvious is the fact that the processing degree of the potato pulp shadows variety's specificities and at the same time

hydrothermal non processing shows peculiarities connected with the potato variety.

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