JAP&T
TPA-Timişoara

Available online at http://journal-of-agroalimentary.ro

Journal of Agroalimentary Processes and Technologies 2010, *16* (1), 41-48

Journal of Agroalimentary Processes and Technologies

Experimental model for the application of the flour-graphic technique to the study of the mixture of flour and raw potato, or hydro thermally processed potato

Maria Lidia Iancu[a], Luiza Mike[b], Günter Haubelt[c]

[a*] *"Lucian Blaga" University of Sibiu,Faculty of Agricultural Science ,Food Industry and Environmental Protection , Food Biotechnology Department,5-7, Dr.Ion Ratiu st.,Sibiu, Romania*
[b] *Potato Research and Development Station Targu Secuiesc 55,Ady Endre str.,Targu Secuiesc, Romania*
[c] *Haubelt Laborgeräte GmbH Garten felder str.13599 Berlin,Germany*

Received: 03 Octomber 2009; Accepted: 20 February 2010

Abstract

It is thought the mixture of wheat flour and crushed potato pulp, hydro thermally processed or not ,can be studied rheologically. Plotting the curves of rheological test allows the choice of the model that best fits the properties of the material tested. The first step of the present study was to establish the moisture content of the mixture, the amount of mixture required and the amount of flour and potato pulp corresponding to the selected proportions. Three types flour were used, displaying five different characteristics: white flour, additivated white flour, brown flour, additivated brown flour and durum wheat flour, as well as five types of potatoes: Laura, Impala, Lady Claire, Lady Christl and Orchestra. All the results were related to a control sample and four readings were proposed 5%, 10%, 20%, 30%.Viscosity of the mixture is affected by its moisture content.The flour-graphic technique is used to study the behavior of flour in the presence of the various additives. The first step is to study the factors that influence the moisture content of the mixture. These factors are the moisture content of the raw materials that combine and the chosen readings. The higher the moisture content of the component elements, or at least of one of the components, namely the potato, the higher the moisture content of the whole mixture. The higher the percentage by which the flour is replaced (specific reading) the higher the moisture content of the mixture. The higher the moisture content of the mixture, the higher its mass; the amount of flour, regardless of type and characteristics, is lower, while the amount of potato is higher, regardless of variety and degree of hydrothermal processing.

Keywords: moisture, flour-graph E6, white flour, brown flour, durum wheat flour, raw potato, potato pasta

1. Introduction

There are a variety of fundamental and empirical instruments typically used in the rheological testing of dough [6]. Rheometry describes physical properties. Rheological analyses and measurements performed before and after the processing influence the processors' behavior and assists them in making the best decisions [3, 7].

Knowledge of the rheological properties of wheat flour is important in the baking industry, as it helps in the selection of the best quality grains [5].

Wheat flour dough is a viscous elastic material and its characteristics depend on the make-up of the flour, on the amount of water added and on the mixing conditions [12].

The potato is used widely in bread manufacturing because of its specific properties of maintaining the bread fresh for a longer period of time and enriching the flavour and taste of the product [11]. In this study calculations were made on how to combine the two basic raw materials, wheat flour and potato pulp of

Corresponding author: *e-mail:* maria.iancu@ulbsibiu.ro

different varieties and having undergone various processing techniques [8, 9]. Given that the study was based on the replacement of part of the flour by potato pulp and the percentage was quite high, up to 30%, it can no longer be said that the flour is improved but that there is a mixture. The present analysis starts from a practical application of rheology in the baking industry by plotting and interpreting farinographic curves [1, 4, 10], and aims to reconsider and reformat the starting point. For this purpose, a new device is used, FLOURGRAPH E6, device that is still being tested.

2.Materials and Methods

For determiners used next apparatus: Flour Graf E6 Hubert, supplay de Laborgerate HAUBELT in Berlin, Germania,moistur analyzer AND ML-50, analitycal balance tipWPS 210/C/1 Partner, mixer HV4 with sieve ϕ2 mm.White flour type 550 with u=14,5% (u - moisture), white flour additivates cu u = 13,9 %, brown flour tip 1250 with u = 13,9 %, brown flour additivated with u = 12,9% durum wheat flour with u=13,6%, supply Mill Cibin, Sibiu, Romania, red potato

variety Laura with small amount starch , and give pasta with u=73,5 %, with variante raw have u = 69,8 %, white potato with higer amount starch variety Impala, u = 83,5%, Lady Christl with u =79,3% with variante raw have u=80,4 %, Orchestra u= 81,3%, variety of potato early dormancy with small amount starch like Lady Claire with u = 70,9% with variante raw have u =79,4%, supplay *Potato Research and Development Station Targu Secuiesc in Judetul Covasna, România.*

Preparing the potatoes for analysis: the raw potato (RP) is washed, peeled, finely minced and passed through a 2 mm mesh sieve. 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.

Methods: Determinations of moisture content for Moisture Analyer.Moisture analyzer,base don the principle of thermogravimetric analysis,dries a sample using a halogen lamp and obtains the moisture content in % and other result by the difference between the wet weight.This functions apparatus functions confform stas BS EN 61326, BS EN 61010.

3. Results and Discussion

Development of formulas for calculating the mass of the mixture and the required amounts of flour and potato pulp

The principle that powers the Flourgraph E6 device is that of measuring the resistance of the material under analysis, the dough in this particular case, to the kneading arms of the rotating kneading shaft in which it is mixed. Torque is proportional to the resistance, providing the measure for the viscosity and consistency of the material. When a computerized system is used, a digital signal is transmitted by an electronic signal and a communication port. The method is consistent with international standards [4] and the results are presented in the form of a diagram / chart.

In order to determine the necessary amount of mixture corresponding to 86% dry material, it is necessary and compulsory to determine the dry material content of its component elements, that is flour and potato pulp prepared according to the Materials and Methods section.

Calculating the amount of flour and potato pulp, u_{mix}

$$\%\ F \cdot u_F + \%\ PP \cdot u_{PP} = u_{mix},\ \% \qquad (1)$$

in wich:
% F – ratio flour wich contribute at mixture forming,
% PP–ratio of potato pulp wich contribute at mixture forming,
u_F – the moisture of flour,%
u_{PP}- the moisture of potato pulp, %
u_{mix}-the moisture mixture,%

Calculating the amount of mixture (mass of mixture), M_{mix}

In order to determine the amount of mixture that provides 86% of the dry material of the mixture, a specific formula is used which takes into account the fact that the dry content of the mixture is different from the standard values for which the method was developed:

$$M_{mix} = \frac{86}{dw_{mix}} \cdot 100, g \qquad (2)$$

Given that the proportions under study range from 5 % to 30%, that is: 5%, 10%, 20%, 30%, therefore the moisture content of the mixture varies, a specific method of calculating the amount of flour and PP is required so as to always maintain the standard moisture content of the mixture, that is 14%.

Calculating the amount (mass) of flour and potato pulp

$$M_F = M_{mix} \cdot \%[F], \text{ g}, \quad \textbf{(3)}$$

$$M_{PP} = M_{mix} \cdot \%[PP], \text{ g} \quad \textbf{(4)}$$

in wich:

M_F, amount flour wich contribute at mixture forming,

M_{PP}, amount potato pulp wich contribute at mixture forming,

% F,procent flour wich recovered with PP, ex: 0,7; 0,8; 0,9; 0,95

% PP, procent PP wich recovered with flour ex.: 0,05; 0,10; 0,2; 0,3

The calculations made according to the formulas above were based on changes in the moisture content of the variables.

Influence of the degree of hydrothermal processing of the potato pulp on the moisture content of the mixture.

The study analyzes the influence on the moisture content of the mixture of raw and hydro-thermally processed potato pulp mixed with white flour, brown flour, and durum wheat flour (see Materials and Methods). These varieties of flour are different from one another in as far as their chemical make-up, color, and texture are concerned. These were the qualitative indices taken into account in this study. The moisture content played a significant part from this point of view.If u F > 14% (u-moisture, F-flour), for non-additivated white flour,with u= 14.5%, then, in order to ensure a dw = 86% of the mixture, the amount of flour, calculated according to formula no. 2, needs to be increased by 0.58 g. If u F <14%, that is 13,9 % for non-additivated brown flour and 13,6% for durum grain flour, the amount of flour needs to be reduced by 0,47 g for the durum wheat flour and by 0,12 g for the non-additivated brown flour.

The same tendency was found in the samples with potato pulp added, and is so much more relevant as the amount of potato replacing part of the flour is higher. The degree of potato processing did not influence this aspect, except in terms of moisture content. It was found that shredded raw potato pulp has a higher moisture content than hydro-thermally processed pulp; for example, the Lady Claire variety has a uRP = 79.4%, (RP-raw potato) compared to uPP = 70.9% (PP-potato pasta), while the Lady Christl variety has a uRP = 80,4% > uPP = 79,3%. This led to an increase in the mass of the mixture for which the rheological characteristics were determined; the mass was so much higher as the percentage of flour replaced by potato was higher. This rule was valid irrespective of the degree of processing of the potato.

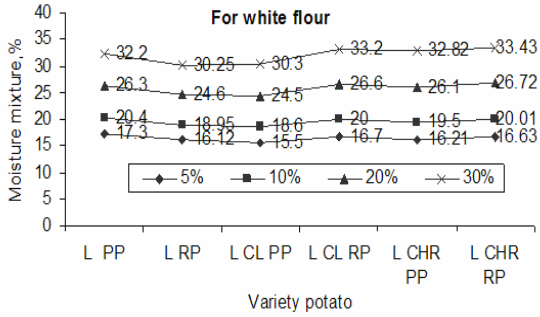

Figure 1.Changes in the moisture content of the mixture of non-additivated white flour (WF n-add) and potato according to the reading: 5%, 10%, 20%, 30%, to the variety of potato used(hydro-thermally processed L PP-Laura, raw L RP-Laura, hydro-thermally processed L CL PP-Lady Claire, raw L CL RP Lady Claire, raw L CHR RP Lady Christl, hydro-thermally processed L CHR PP Lady Christl), and to the degree of hydro-thermal processing.

If white flour is used in the mixture, for a replacement rate of 5%, the minimum moisture content of 15.5% is obtained for the hydro-thermally processed Lady Claire variety (L CL PP) and the maximum rate of 17,3% for the hydro-thermally processed Laura variety (L PP); for a replacement rate of 10%: an 18.6% minimum is obtained for the hydro-thermally processed Lady Claire variety (L CL PP) and a 20.4% maximum for the hydro-thermally processed Laura variety; for a replacement rate of 20%: a minimum of 24.5% is obtained for the hydro-thermally processed Lady Claire variety and a maximum of 26.72% for the raw Lady Christl variety (L CHR RP); for a replacement rate of 30%, a minimum of 30.25% is obtained for the raw Laura variety and maximum of 33,43% for the raw Lady Christl variety (Fig No .1)

If brown flour is used in the mixture, for a replacement rate of 5%, a minimum of 15.3% is obtained for the hydro-thermally processed Lady Claire variety (L CL PP) and a maximum of 17,41% for the raw Lady Christl variety (L CHR RP); for a replacement rate of 10%, a 18,08% minimum is obtained for the raw Lady Christl variety and maximum of 20% for the raw Lady Claire variety; for a replacement rate of 20%, a minimum of 22,6% is obtained for the raw Lady Claire variety and a maximum of 26.24% for the raw Lady Christl variety; for a replacement rate of 30%, a minimum of 29.83% is obtained for the raw Laura variety (L RP) and a maximum of 31.7 % for the hydro-thermally processed Laura variety (L PP) (Fig. no. 2)

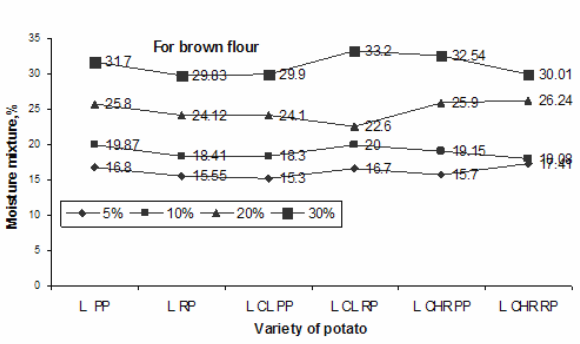

Figure 2. Changes in the moisture content of the mixture of non-additivated brown flour (BF n-add) and potato according to the reading: 5%, 10%, 20%, 30%, to the variety of potato used (hydro-thermally processed L PP-Laura, raw L RP-Laura, hydro-thermally processed L CL PP-Lady Claire, raw L CL RP Lady Claire, raw L CHR RP Lady Christl, hydro-thermally processed L CHR PP Lady Christl), and to the degree of hydro-thermal processing.

If durum wheat flour is used in the mixture, for a replacement rate of 5%: a minimum of 16.03% is obtained for the raw Laura variety and a maximum of 16.84% for the raw Lady Christl variety hydrothermal(L CHR RP); for a replacement rate of 10%: a minimum of 18,86% is obtained for the raw Laura variety (L RP) and a maximum of 20,05% for the raw Lady Christl variety (L CHR RP); for a replacement rate of 20%, a minimum of 22.44% is obtained for the hydro-thermally processed Lady Claire variety (L CL PP) and a maximum of 26,64% for the raw Lady Christl variety; for a replacement rate of 30%, a minimum of 30.07% is obtained for the hydro-thermally processed Laura variety and a maximum of 33.36% for the raw Lady Christl variety (Fig no.3)

The mass of the mixture was calculated on the basis of the moisture content of the mixture established by formulas (1) and (2). The higher the moisture content of the mixture, the higher its mass. This holds true irrespective of the type of flour used and the degree of processing of the potato pulp.

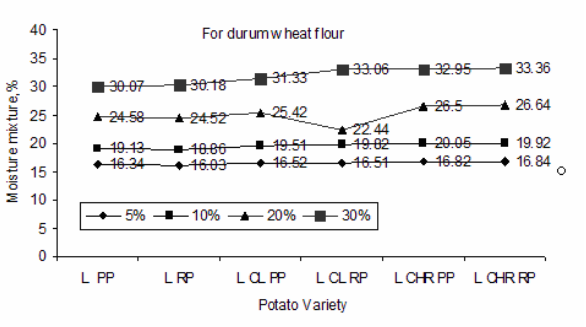

Figure 3 Changes in the moisture content of the mixture of non-additivated dorum wheat flour (DWF n-add) and potato according to the reading: 5%, 10%, 20%, 30%, to the variety of potato used(hydro-thermally processed L PP-Laura, raw L RP-Laura, hydro-thermally processed L CL PP-Lady Claire, raw L CL RP Lady Claire, raw L CHR RP Lady Christl, hydro-thermally processed L CHR PP Lady Christl), and to the degree of hydro-thermal processing.

Influence of potato varieties mixed with the types of flour studied, on the moisture content umix and the mass Mmix of the mixture

Moisure mixture Mmix

The main quality indicators that influenced the selection of potato varieties were their cooking characteristics, as well as the content of dry matter and of starch. However, the characteristic that had the most significant impact on the selection was the moisture content of the potato.

Regardless of the variety of potato used for the same reading, the mass of the mixture underwent very slight changes, mainly due to the type of flour used. The minimum value of moisture content for a 5% potato concentration was found to be 14.9 % for the sample of non-additivated brown flour mixed with potato pulp of the Lady Claire variety, while the maximum value was 17,3% for the sample of white flour mixed with Laura potato. For the 10% potato concentration sample, the maximum value of 20.41% was obtained for the mixture of durum wheat flour and Impala potato, while the minimum value of 17,89% for the mixture of non-additivated brown flour and Lady Claire potato. It was found that the Lady Claire variety of potato, mixed with additivated

brown flour provides the lowest values of moisture content of the mixture both for the 20 % potato concentration sample (23,78%) and for the 30% potato concentration sample (29,7%). For a 20% concentration, the maximum value is provided by durum wheat flour mixed with Impala potato (27,14%), while for a 30% potato concentration, the maximum value is provided by additivated white flour mixed with Impala potato (34,85%) (Fig No .4). For the same variety of potato, an increase in the amount of flour added to the mixture led to a proportional increase in the moisture content of the mixture, and this applies to all potato varieties.

Mass of the mixture, Mmix

The amount of mixture was calculated using formula no.2, and taking into account the moisture content of the mixture. For 5%: minimum - additivated brown flour mixed with Lady Claire potato-101.77 g, maximum - white flour mixed with Laura potato – 103,9 g. For 10%: minimum - brown flour mixed with Lady Claire potato-105.2 g, maximum – durum wheat flour mixed with Impala potato-108.05 g. For 20%: minimum - additivated brown flour mixed with Lady Claire potato-112,83 g, maximum–durum wheat flour mixed with Impala potato – 118,03 g. For 30%: minimum – additivated brown flour mixed with Lady Claire potato –122,4g, maximum – additivated white flour mixed with Impala potat-132 g (fig No 5)

The amount of mixture was calculated according to formula No. 2. Its value is higher than 100 g because the moisture content of the mixture isis higer than 14%.

Influence of moisture content on the flour - potato pulp ratio that make up the final mass of the mixture

The ratio of flour and potato pulp was calculated according to formulas no. 3 and no. 4.The amount of flour used in the control sample is influenced by the moisture content measured with a device called thermoscales, and it is higher than 100 g for white flour (100,58 g), and lower for the other types of flour. The lower the moisture content of the flour, the lower the amount of flour used in the mixture: eg. 99,53 g for durum wheat flour (Fig No 6).

For the various types of flour, the higher the percentage of substitution of the flour, the lower the amount of flour used in the mixture, reaching a minimum figure of 85.68 g for additivated brown flour, which is replaced at a rate of 30 % with Lady Claire potato, and a maximum of 92.4 g for additivated white flour replaced with Impala potato at the same 30% rate (fig No 6).

For the different varieties of potato, the higher the percentage of substitution of the flour, the higher the amount of potato pulp, reaching a minimum figure of 36,72 g for additivated black flour replaced with Lady Claire potato at a rate of 30%, and a maximum of 39,6 g for additivated white flour replaced with Impala potato, at the same 30% rate (Fig No7).

There are only slight differences between the various types of flour and the different varieties of potato within the same reading; differences in the mass of potato are even lower than those in the mass of flower and sometimes there are no differences between types of flour with different characteristics (Fig. No 6 and No 7).

The small differences occur because of the initial moisture content of the components, the types of flour and the potato varieties, while the more significant differences occur because of the various readings and of differences in the moisture content of the various types of flour (eg. 14.5% for white flour and 13.6% for durum wheat flour) and of the different varieties of hydro-thermally processed mashed potato (Laura variety-73.5% Orchestra variety-80.3%). In calculating the amount of potato pulp at low percentages, 5% or 10%, the differences produced by the type of flour and the potato variety are close to invisible (5.01 to 5.18) g, (10.24 to 10.8)g. The differences are more noticeable at higher percentages: 20% (22.56 to 23.58)g and 30% (Fig No. 7).

The most significant drop in the amount of flour depending on the reading: 5%, 10%, 20%, 30%, on the potato variety and flour type and characteristics, everything related to the control sample is shown in Table No.1. The drier the flour, the lower the losses in quantity. The most significant losses were recorded for white flour, which initially had a 14,5% moisture content and a 100,58 g mass and, regardless of potato variety, losses ranged between 9,79% (Orchestra variety) and 14,28% (Lady Claire variety). Therefore, the figures were significantly influenced by the potato variety. The most significant losses were recorded for the Laura variety (between 11,8% and 11,4%), with very slight variations depending on the type of flour, while the smallest losses were recorded for the Orchestra variety (Table No.1)

Table 1. Losses of flour necesary for mixture, for readind 30 %

Laura Variety					ImpalaVariety					Lady ClaireVariety					Lady ChristlVariety					OrchestraVariety				
WF	WF ADD	BF	BF ADD	DWF	WF	WF ADD	BF	BF ADD	DWF	WF	WF ADD	BF	BF ADD	DWF	WF	WF ADD	BF	GF ADD	DWF	WF	WF ADD	BF	BF ADD	DWF
11,8 %	11,63	11,64	11,64%	11,43%	13,45%	9,23%	7,49%	8,83%	8,23%	14,28%	13,7%	9,77%	13,05%	11,87%	10,98%	10,49%	10,66%	9,33%	9,75%	9,79%	9,1%	9,23%	8,52%	9,55%

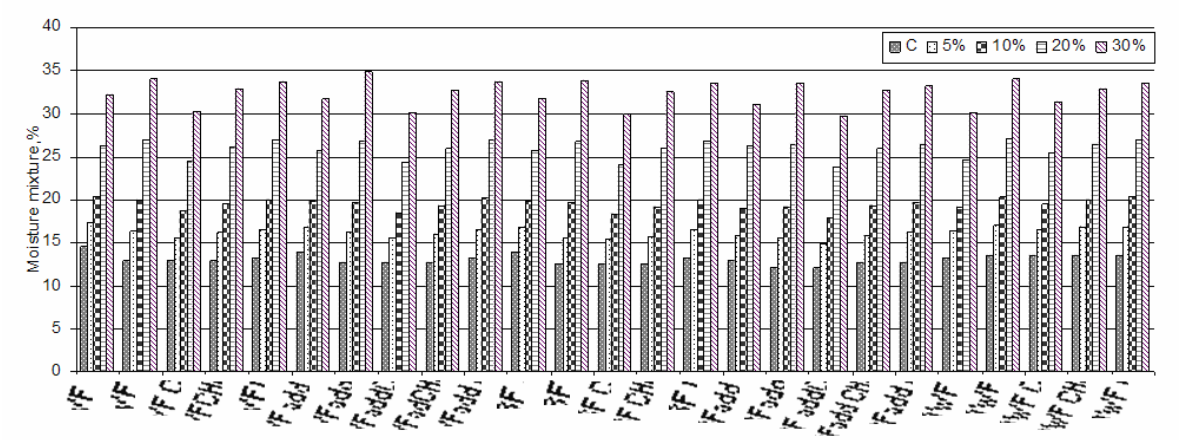

Figure 4. Changes in the moisture mixture in according to the reading: Control, 5%,10%,20%,30%,to the variety of potato used L(Laura), I(Impala), CL(Lady Claire), CHR(Lady Christl), O(Orchestra), type and characteristic of flour WF(white flour), WF-add(white flour additivated), BF(brown), BF-add(brown flour additivates), DWF(durum wheat flour)

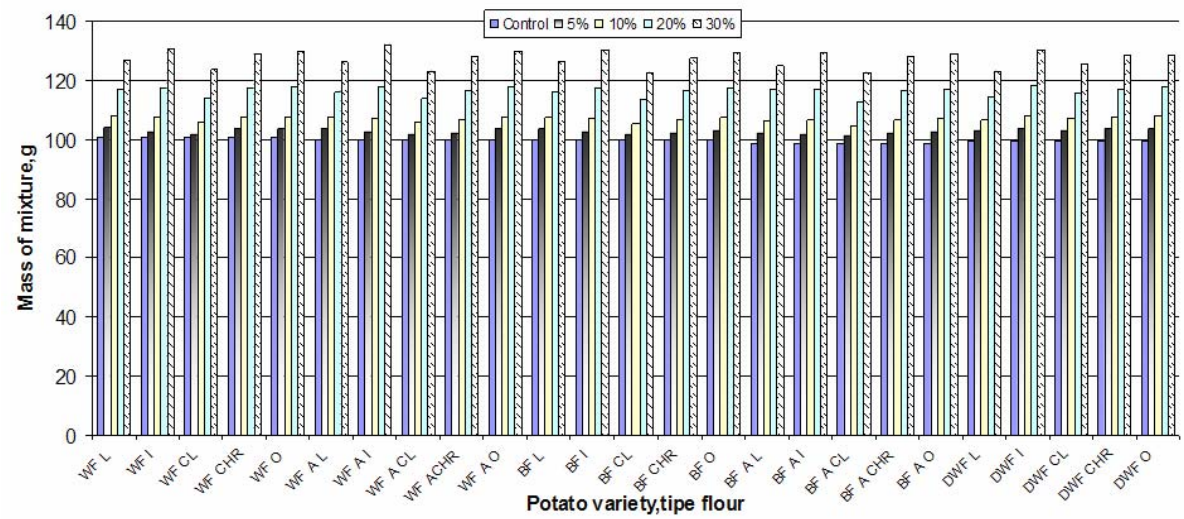

Figure 5. Change of the amount of mixture M_{mix} in acording to the reading: Control, 5%,10%,20%,30%,to the variety of potato used L(Laura),I(Impala),CL(Lady Claire),CHR(Lady Christl),O(Orchestra), type and characteristic of flour WF(white flour),WF-add(whitw flour additivated), BF(brown), BF-add(brown flour additivates), DWF(durum wheat flour)

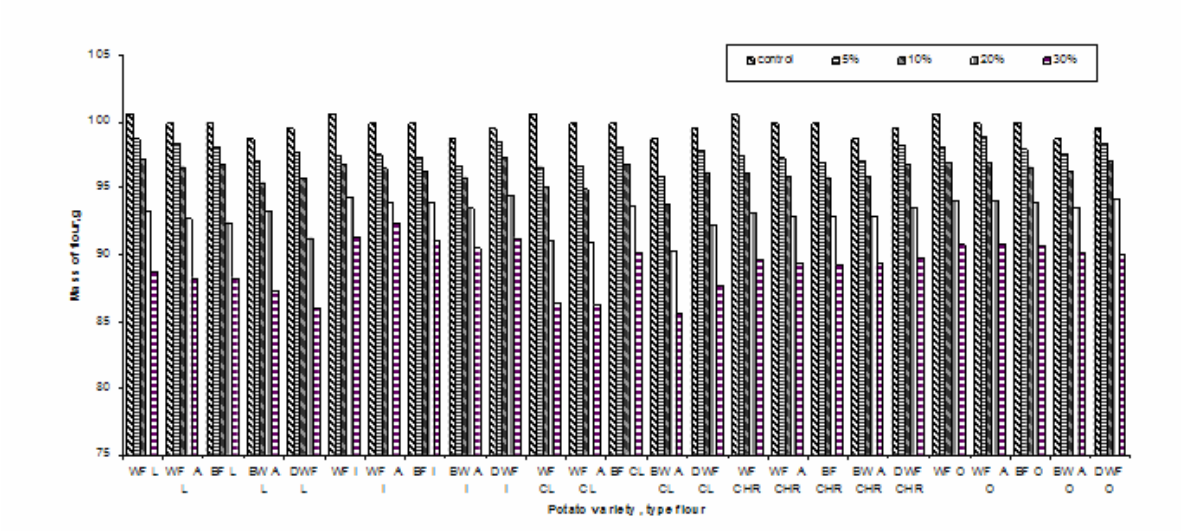

Figure 6 .Change of the amount of flour WF(white flour), WF-add(whitw flour additivated), BF(brown), BF-add (brown flour additivates), DWF(durumWheat flour) necessary for mixture in accordind to the reading Control, 5%, 10%, 20%, 30%, to the characteristic of flour and if used variety of potato hydro thermally processed L (Laura), I (Impala), CL (Lady Claire), CHR (Lady Christl), O(Orchestra**)**

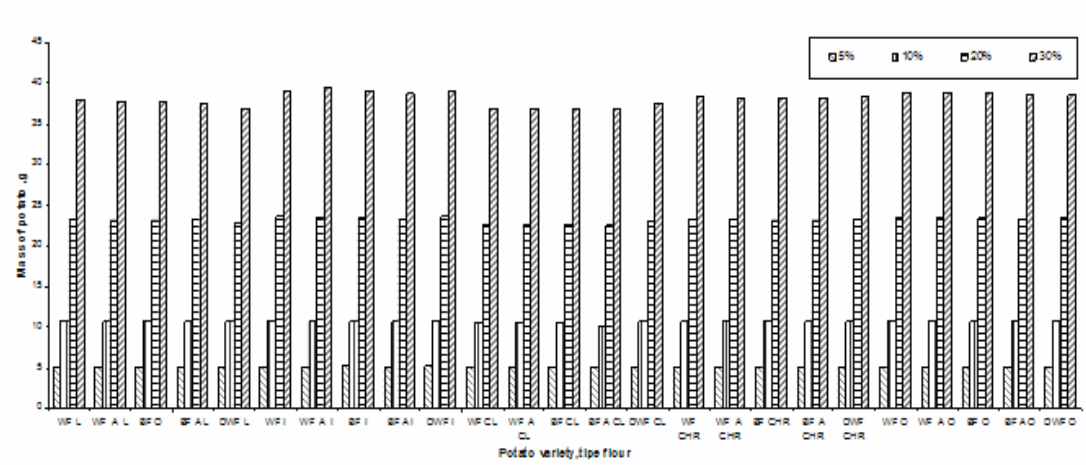

Figure 7. Change of the amount of potato hydro thermally processed L (Laura), I (Impala), CL (Lady Claire), CHR (Lady Christl),O (Orchestra**)** in acording with characteristic flour WF (white flour), WF-add (white flour additivated), BF (brown),BF-add (brown flour additivates), DWF (durum wheat flour) necessary for mixture in accordind to the reading: Control, 5%, 10%, 20%, 30%.

4. Conclusions

This study has demonstrated the need to reconsider the method of analysis already in use. The present study 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.

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.

The higher the amount of flour replaced by another material, the higher the moisture content of the mixture. The higher the replacement percentage, the lower the amount of flour and the higher the amount of potato pulp hydro-thermally processed or not.

The only rule that applies both to the control sample and to the different samples selected for analysis is taking into account the moisture content of the flour, that of the potatoes and the mass of the mixture.

Slight differences may occur for the same reading because of the use of different potato varieties, various types of flour and various flour characteristic.

5. References

1. AACC Approve d Methods , 9th edition. ,American Association of Cereal Chemists, St.Paul,Minnesota 1995, No 54-21 Farinograph Method for Flour
2. Asghar, A., Anjun, F.M., Allen, C.J., Daubert, C.R., Rasool, G., Effect of modified whey protein concentrates on empirical and fundamental dynamic mechanical properties of frozen dough, *Food Hydrocolloids,* 2009, *23*, 1687 – 1692;
3. Huang, V.T., Kaletunc, G., Utilizations of rheological properties in product and process development. InG, Kaletunc, and K.J. Breslauer (Eds.), C*haracterization of cereals and flours: Properties, analysis and applications*, Marcel Dekker, New York, 2003, 351-368;
4. ICC STANDARD No 115/1 , Method for using the Brabender Farinograpf,1992,
5. Letang, C., Piau, M., Verdier, C., Characterization of wheat flour-wheat doughs. Part I. Rheomerty and microstructure, *Journal of Food Engineering*, **1999**, *41*, 121-132;
6. Steffe, J.F., *Rheological methods in food process engineering*, Freeman Press, USA, 1996 (2nd ed.);
7. Inglett, George E; Xu, Jingyuan; Stevenson, David G; Chen, Diejun, Rheological and Pasting Properties of Buckwheat (*Fagopyrum esculentum Möench*) Flours With and Without Jet-Cooking, *Cereal Chemistry*, **2009**, (1);
8. A. Baublis, E. A. Decker, and F. M. Clydesdale, Antioxidant effect of aqueous extracts from wheat based ready-to-eat breakfast cereals, *Food Chemistry*, **2000**, *68* (1), 1-6;
9. Lovedeep Kaur, Navdeep Singh Sodhi and Balmeet Singh Gill, Morphological, thermal and rheological properties of starches from different botanical sources, *Food Chemistry*, **2003**, *82* (2), 219-231;
10. K. M. Clegg, The application of the anthrone reagent to the estimation of starch in cereals, *Journal of the Science of Food and Agriculture*, **2006**, 7(1), 40-44;
11. Mehmet Musa Özcan, Effect of some essential oils on rheological properties of wheat flour dough, *International Journal of Food Sciences and Nutrition*, **2009**, *60*(2), 176-181, DOI 10.1080/ 09637480701635555;
12. Linlaud, N. E., Puppo, M. C., Ferrero, C., Effect of Hydrocolloids on Water Absorption of Wheat Flour and Farinograph and Textural Characteristics of Dough, *Cereal Chemistry*, **2009**, *86*(4), 376-382;