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RESEARCH ON THE EFFECT OF NON-TRANSITIONAL RAW MATERIALS ON THE RHEOLOGICAL INDICATORS OF THE SEMI-FINISHED PRODUCTS OF FORMED POTATO CHIPS

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Abstract: *The paper considers the current state and prospects of enrichment of formed potato chips with bran, pulp and cryopowder containing from 14 to 40% of food fibres. The importance of the use of food fibres, which is connected with the prevention of alimentary-dependent diseases, has been substantiated. The optimum size of the degree of grinding of rye bran, barley bran, pumpkin seeds pulp, broccoli cryopowder and red beetroot cryopowder and their influence on rheological parameters of semi-finished products have been determined. The influence of temperature and time on the change of maximum viscosity of model solutions of potato semi-finished potato products has been investigated.*

Key words: *chips, food fibre, semi-finished products*

1. Introduction

Formed potato chips (FPC) are widely popular among the population of many countries of the world. At the same time, they have a number of disadvantages, including imbalance in chemical composition, high energy value, and low amount of biologically active substances. It is known that FPC contain a high content of fats, carbohydrates and low content of proteins, dietary fibres, unsaturated fatty acids, vitamins. In connection with this, in recent years the trend is aimed at the production of new types of FPC with increased nutritional value, by increasing the number of required functional ingredients [1].

The improvement of the nutritional value of final product can be achieved by using raw materials that contain a significant amount of useful nutrients for the human body. We propose to use raw materials of the secondary flour-mill production in the formulation of FPC such as: rye bran (RB), barley bran (BB), as well as pumpkin seeds pulp (PSP) and vegetable powders, namely broccoli cryopowder (BC) and red beet cryopowder (RBC) which today are relatively cheap and are available on the market in the necessary quantity by sources of food fibres (FF). They are isolated from plant material: cereals, fruit, nuts, root crops, berries and are divided into soluble and insoluble [2, 3, 4, 5].

Insoluble FF are not digested in the upper digestive tract and fall into the thick intestine almost unchanged, improving its motor skills. They carry out probiotic functions, providing Bifidobacteria with active growth, suppressing the negative

and pathogenic microflora in the intestine, strengthening immunity [6].
Functions of soluble fibres provide important mechanisms associated with the prevention of food-borne diseases. They improve lipid metabolism, contribute to the decrease of triglycerides and low density lipoproteins, slow the formation of fatty deposits in the liver, improve the action of liver enzymes, assimilation of calcium, and reduce the risk of tumours of the intestine.
Due to their functional properties, FF are recognized to be a necessary component of human food. In addition, FF contain in their composition a significant amount of minerals and vitamins of group B. Daily norm of intake of FF to the human body is of 25-40g. However, in the diet of modern humans, the content of food fibres is almost three times less than the required norm. This problem can be solved by enriching popular products by food fibres, which directly relate to FPC. Bran, pulp and cryopowders are promising raw materials for enriching FPC because they contain from 14 to 40% of the dietary fibres. It will allow using a small amount of their dosage to the mass of the product to provide 10-15% of the daily requirement of the human body of this nutrient [7, 8].

2. Materials and methods

In our study, potato cereals (Bikrampur Potato Flakes Ind.Ltd Dhanmondi 120 Dhala «Bangladesh», RB, BB, PSP ("Agrosilprom"), BC and RBC ("Gamma") were used [1, 9].
The purpose of this work was to investigate the rheological characteristics of semi-finished product of FPC (potato dough) with the addition of RB, BB, PSP, BC and RBC.
The fractional composition of the raw material was investigated using the Mastersizer Micro laser granulometer. The durability of the structure of the semi-finished samples and control ones were in the formulation RB, BB, PSP, BC and RBC was determined on penetrometer "Pioneer – 1". Rheological indicators of model solutions of experimental samples were determined on "Reotest-2". The maximum viscosity was determined on the "Brabender" amilograph [10].

3. Results and discussion

Structural and mechanical properties of semi-finished products of FPC and organoleptic parameters of finished FPC are significantly influenced by the degree of milling of raw materials. According to the manufacturer, most particles of RB, BB and RSP used in our studies had an average size of 365, 385 and 351 microns [1]. Therefore, in order to ensure the homogeneity of the mixture of components of semi-finished products, we carried out an additional milling of RB, BB and RSP using a mechanical mill, followed by sifting on a laser granulometer to the proportion of potato cereals size (PC) and cryopowders. The obtained results are presented in the Table 1.
When analysing the obtained data, it can be concluded that the average size of particles of raw materials should be in the range of 30 to 100 microns in order to ensure the homogeneity of the mixture in the formulation of FPC. Large particles make structure of the dough semi-finished product worse, and also the organoleptic characteristics of the finished product.

Table 1

Disperse composition of crushed bran, pulp and cryopowders

Content, %	Faction, microns								
	0…10	10…20	20…30	30…40	40…60	60…80	80…100	100…140	140i≥
PC	0.3	10.4	37.8	49.2	2.3	-	-	-	-
RB	-	-	-	-	8.5	15.5	63.9	12.1	-
BB	-	-	-	-	7.9	20.7	58.7	12.7	-
RSP	-	-	5.1	22.4	51.3	17.4	3.8	–	-
RBC	-	1.2	5.4	44.7	31.2	9.8	2.9	–	-
BC	-	0.9	20.1	40.5	27.9	8.1	2.5	–	-

There were created recipes, in which the PC is mixed with RB, BB, RSP, BC, and RBC in a ratio (4:1), since ratios (0.5:1), (1:1), (2:1), and (3:1) deteriorate the organoleptic characteristics of the finished product. Experimental samples of semi-finished FPC were prepared with a mass fraction of moisture of 42%. A recipe of chips, which included potato cereals, salt and water, was chosen as a control sample. In order to study the structural and mechanical parameters of dough semi-products at a ratio (4:1), the definition of penetration rates was performed. The results of the research are presented in Fig. 1

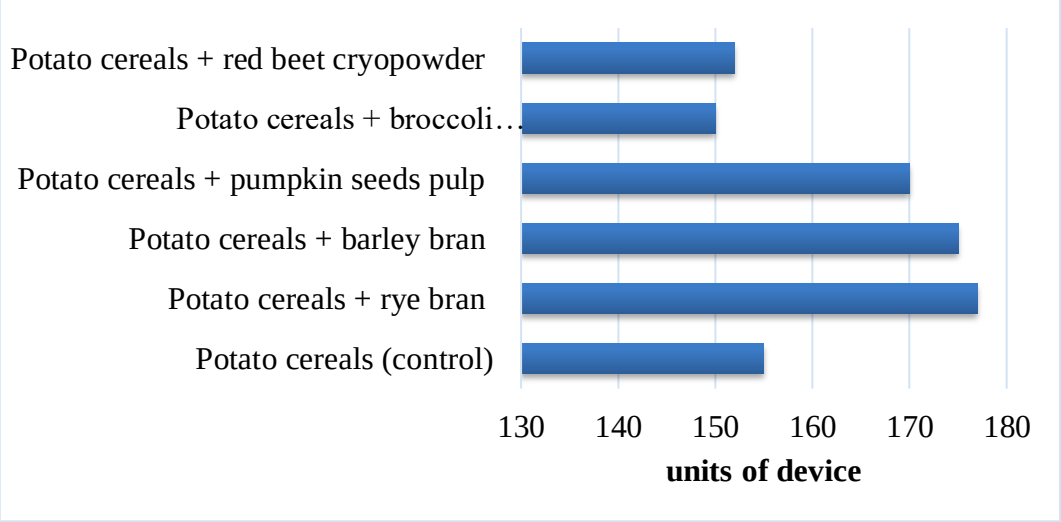

Fig. 1 Indicators of the penetrometer Pioneer-1 of semi-finished experimental samples in the ratio of potato cereals to additional raw materials as 4:1

From the obtained data we see that for the same amount and temperature of the added water, semi-finished products with RB, BB, and RSP have less stable structure as compared with the control and with samples where cryopowders were used. The obtained results can be explained by different water absorption capacity of raw materials. Previously, we have investigated that bran and pulp absorb 1.7-2 and 0.9-1.3 times more water than cryopowders. Obviously, this is due to their fractional

composition, and also because bran and pulp contain more FF, and cryopowders contain more pectin substances.

Investigation on viscosity of model systems of experimental samples provides necessary information on the strength of interaction between raw material molecules and the structure they form.

The main structure former of semi-finished FPC is potato starch of potato cereals. We studied the curves of the flow and viscosity of the model samples according to which it is possible to assert the strength of the intermolecular bonds of potato starch of potato cereals in the model solutions of semi-finished FPC with RB, BB, RSP, BC and RBC with a concentration of dry substances of 16%. Their rheological curves have been constructed (Fig. 2.3).

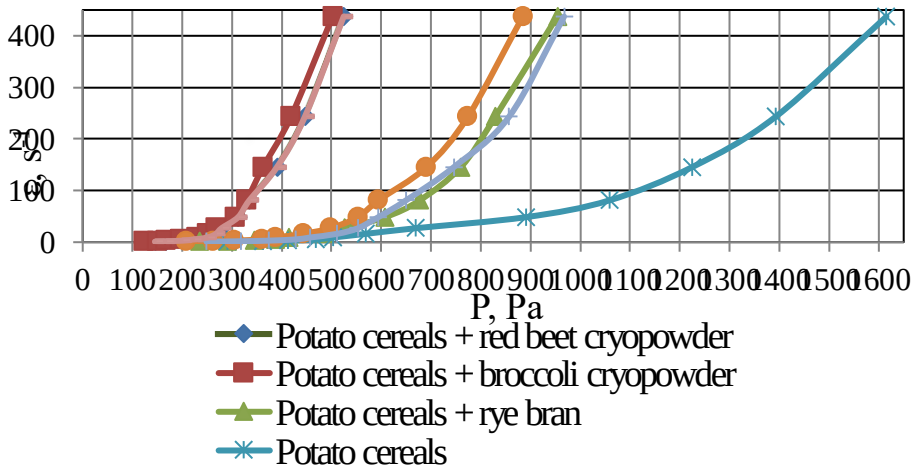

Fig. 2 Curves of flow of model solutions of samples of semi-finished products of FPC

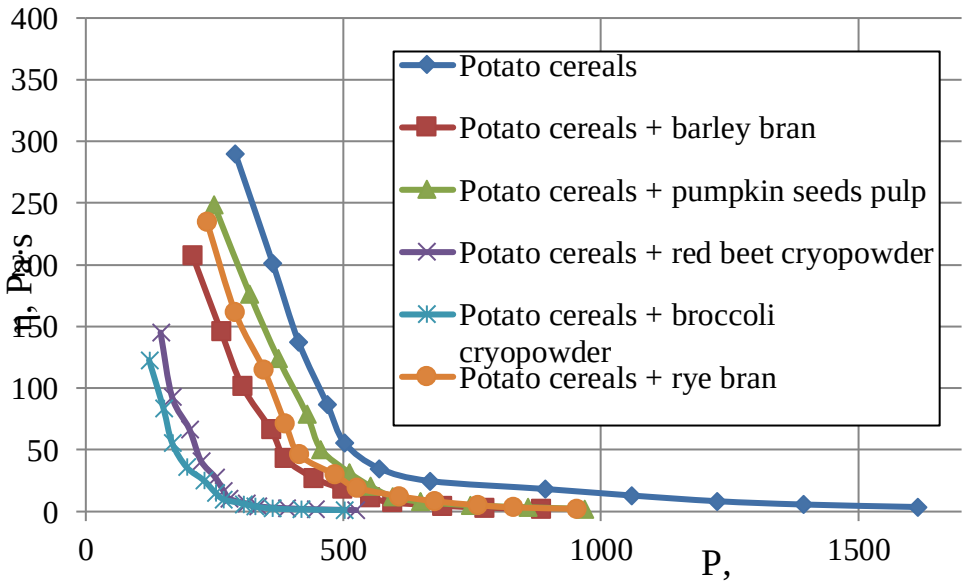

Fig. 3 Curves of viscosity of model solutions of samples of semi-finished products of FPC

Rheological curves of viscosity of model samples are characteristic to structured systems. The systems we are investigating have anomalous viscosity, which varies depending on the speed of the cylinder rotation and the tension of displacement. In the analysis of rheological curves, the values of the anomaly of viscosity η_0-η_m were determined, which characterizes the strength of the coagulation structures that are formed in the system. With insignificant rates of displacement rate, the anomaly of viscosity of the PC is quite pronounced, with an increase in the rate of displacement, the anomaly of viscosity practically does not change (Fig. 4).

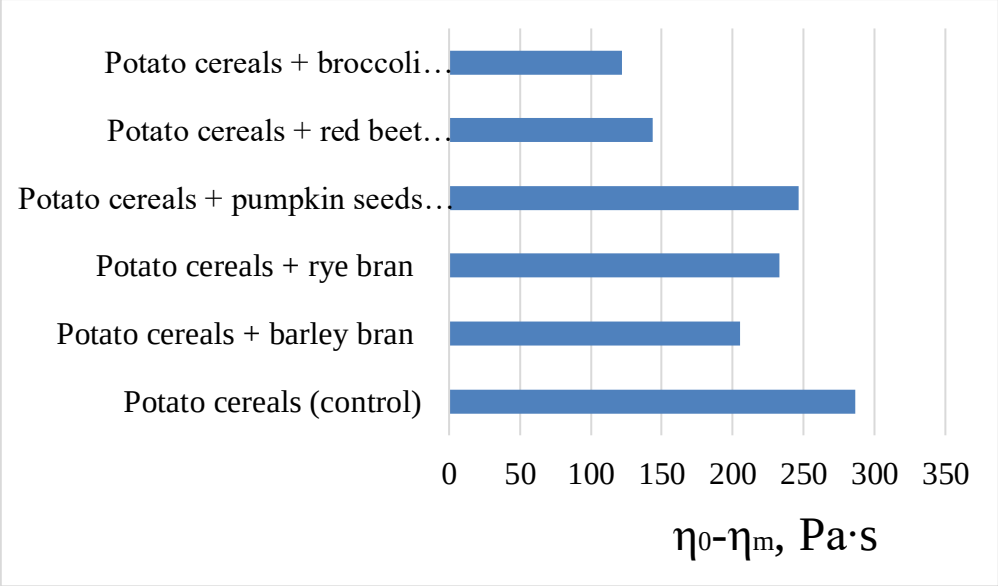

Fig. 4 Diagram of values of anomalies of viscosity η_0-η_m of model solutions of semi-finished products of FPC

When comparing the values of the "viscosity anomaly" (η_0-η_m) for the studied samples, it was found that a control sample has the strongest coagulation structure, which can be explained by a greater number of intermolecular bonds produced by potato starch as compared to model samples whose structure was made by RB, BB and RSP. Even smaller values of η_0-η_m were shown with vegetable powders. The obtained results are likely to indicate that the molecules of the added raw material do not form strong intermolecular bonds with each other and reduce the viscosity of the system accordingly, by reducing the number of contacts between starch molecules. The difference in data between samples with bran and vegetable powders can be explained by different chemical composition and the degree of dispersion of raw materials, which is higher in vegetable powders (Table 1), respectively, the area of contact with starch molecules, will also increase. The strength of the formed structural framework decreases in experimental samples, which can be confirmed by the tension diagram of the practically destroyed structure P_m (Fig. 5) obtained during the analysis of rheological curves.

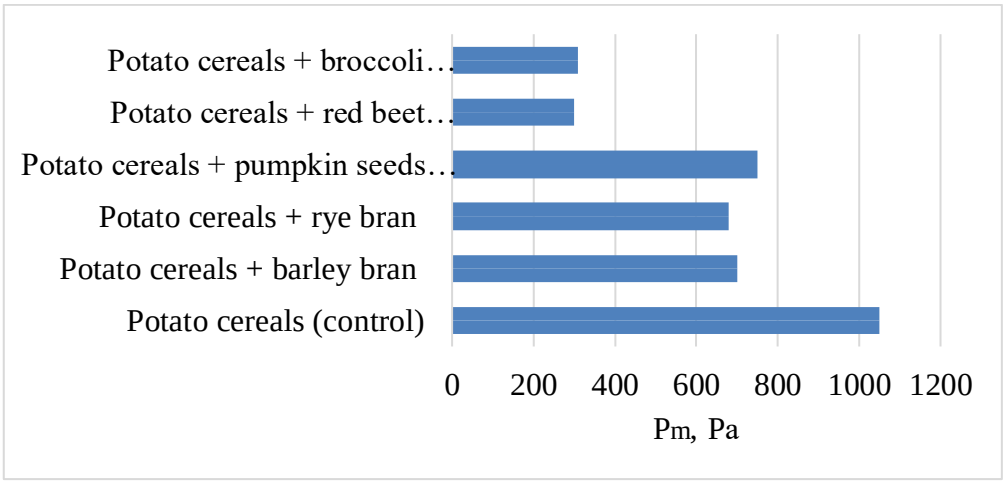

Fig. 5. Tension of practically destroyed structure P_m of model solutions of samples of semi-finished products of FPC

The obtained data partly explain the penetration data - the reduction of the strength of the structure of semi-finished formed potato chips when incorporated in their formulation of raw materials rich in food fibres.

The change in the condition and properties of the raw material under investigation when heated, which contains starch in its composition, is critical during the heat treatment of semi-finished products.

Taking into account the specifics of the chemical composition and properties of the investigated raw materials, it was necessary to investigate the process of starch gelatinization, which is contained in the investigated semi-finished products of FPC. To characterize the change in the consistency of the mixture of PC with bran, pulp and cryopowders, an amylogram of model solutions during heating was analysed (Fig. 6).

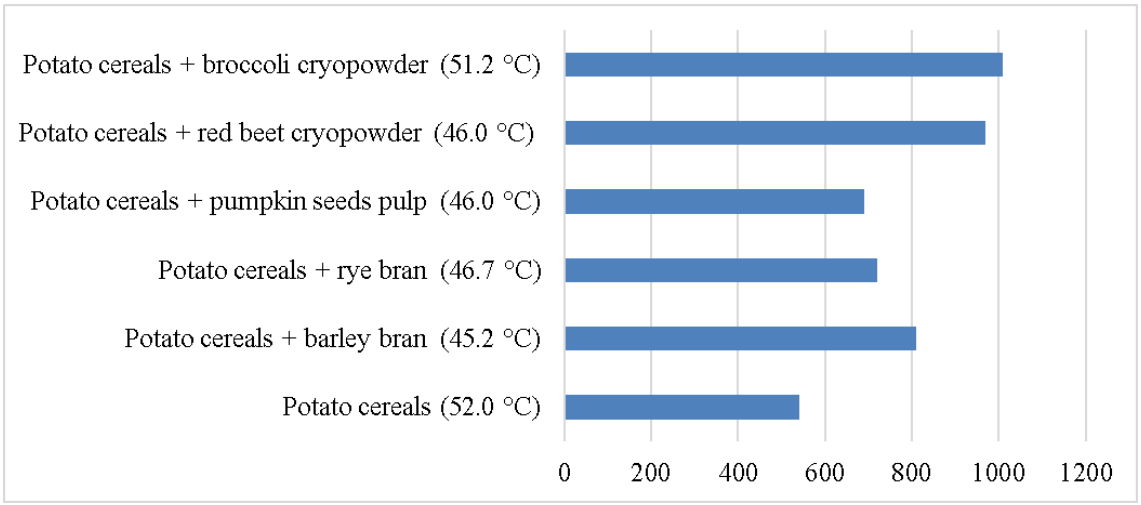

Fig. 6. Maximum values of viscosity of model solutions of semi-finished products of FPC

The obtained figures show that the combination of PC with RB, BB, RSP does not affect the time when the maximum viscosity of the gelatinized mixture is reached, but lower the temperature of the gelatinization for RB, BB, RSP by 10, 13, 11.5%, respectively, in comparison with the control sample. Bran and pulp are practically insoluble in hydro colloidal mixtures, but do not form viscous solutions. Due to the large size of the molecules and the increased amount of carboxyl groups in their composition, they are capable to retain a significant amount of moisture by thickening the semi-finished product of FPC.

BC and RBC are a complex mixture of colloidal structured polysaccharides consisting of galacturonic acid polymers having pentose and hexose branching. The combination of PC with cryopowders does not significantly reduce time to reach the peak and the temperature of the gelatinization, but significantly increases the viscosity of the suspension due to the presence of a large number of polysaccharides and pectin substances that are capable to increase the viscosity of solutions when dissolved in water with increasing temperature.

4. Conclusion

In the manufacture of semi-finished formed potato chips using RB, BB, RSP, BC, RBC, the chemical composition of the investigated raw material, its fractional composition and homogeneity of the particles, and also the ability to absorb water during the formation of semi-finished potato dough influence on its the structural and mechanical properties.

In our opinion, the strength of the formed coagulation structures of molecules of potato starch is likely to be influenced by the degree of milling, and therefore in samples with cryopowders, the degree of milling of which is greater, the viscosity of the system will decrease. The heating process indicates an increase in the viscosity of the system in cryopowder samples compared to samples with bran and pulp, which obviously can be explained by the difference in the chemical composition of the prescription components, namely, an increase in the amount of pectin substances in vegetable cryopowders, in comparison with bran and pulp in which the greater predominates amount of FF. The degree of water absorption of the formulation components will determine the strength of the structure of the semi-finished formed potato chips, confirming the penetration data.

5. References

[1]. TS 15.8-24239651-007: 2007 «Vegetable fiber».
[2]. MARINA M.V., NOVOSELOVA G.N., SHAVNIN S.A. Products of increased biological value from non-traditional vegetable raw materials, *News of Samara Scientific Center of the Russian Academy of Sciences*, ed. 12.1 (8): 2079-2082, (2010).
[3]. TS U 02070938-004-98 «Cryopowders of vegetable food».
[4]. SIPOS P., HORVÁTH M., ADÁCSI C., HORVÁTH B., BABKA B., GYŐRI Z. Enrichment of pasta products using beetroot, *Food and Environment Safety*, 16(4): 209-215, (2017).
[5]. CODINĂ G.G., ATUDOREI D., CIMPOI A., MIRONEASA S., TODOSI-SĂNDULEAC E. Quality evaluation of wheat-pumpkin-golden flaxseed composite bread, *Food and Environment Safety*, 16(2): 61-70, (2017).
[5]. KRICMAN E.S. New Generation of Food Fibers, *Nutritional Ingredients*, 1: 28, (2008).

[6]. LYSIY O.V., ZAPOTOTSKA O.V., PICHKUR V.Ya., GRABOVSKAYA O.V. Investigation of rheological properties of various types of modified starch, *Ukrainian Food Journal*, 3: 35-38, (2012).
[7]. SIROKHMAN I.V., ZAVGORODNYA V.M. Commodity study of functional food products: a training manual. K.: CSL, 544, (2008).
[8]. SPIRICHEV V.B. Theoretical and practical aspects of modern vitaminology, *Questions of nutrition*, 5: 12-19, (2005).
[9]. DROBOT V.I., ARSENYEVA L.Yu., BILYK O.A. Laboratory workshop on the technology of bakery and macaroni production. Kyiv: Center for Educational Literature, 341, (2008).