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REGULATION OF BAKING PROPERTIES OF WHEAT FLOUR BY USING OF POTATO PRODUCTS

Abstract

The most common in Ukraine today is the use of a synthetic group of technological additives used in flour mills, bakeries, confectioneries, etc. However, more promising and natural is the group of herbal supplements. The article analyzes the influence of different potato products in the amount of 4-10 % and extrudates of different cereals on the quality of flour products. The change of properties of trial baking in comparison with the control sample is investigated.

The materials of the article show the quality indicators of wheat flour TM "Bogumila" in comparison with the requirements of GSTU 46.004-99. The composition of model mixtures of wheat flour: potatoes in the ratios 96...90: 4...10, as well as mashed potatoes and mash 5-10% was developed. Physicochemical parameters of laboratory baking of bread were determined for the obtained samples.

Extrusion of model mixtures of grain with raw potatoes at a temperature of + 100-120 °C and a vapor pressure of 0.2 MPa. Extruded mixtures of wheat and potatoes were added to wheat flour TM "Bogumila" in the amount of 5; 7.5 and 10 % by weight of flour before kneading the dough and performed a test baking of bread. Organoleptic and physicochemical parameters were evaluated for the obtained bread samples. Changes in the baking properties of flour with the addition of similar crushed extrudates in different proportions have been studied. It was found that the starch content in extruded samples increases with increasing humidity and reaches a minimum value with a minimum content of potatoes and grains of 1.6 and 0.6 mm.

It was found that the addition of 7.5 % raw potato pulp and raw 5 % mashed potato in patent baking wheat flour is optimal due to the best quality indicators of products without significant deterioration of traditional organoleptic properties and somewhat delayed staling. Extruded wheat flour obtained from a mixture of wheat and potato, is recommended as an additive to baking flour in an amount of not more than 7.5 %.

Keywords: baking properties, wheat flour, potato, mashed potato, potato juice, potato pulp, extrudate.

Introduction. Formulation of the problem

To improve the quality of bread, bakery and flour confectionery products, regulation of technological processes use a variety of food additives, which by origin are conventionally divided into 3 groups: plant – fruit, herbal, algae and vegetable powders, flour of other cereals and legumes, ordinary and modified starch, extruded flour, fiber, dry wheat gluten, bran, malt, etc.; animal – milk powder and skim milk, whey powder, etc.; synthetic – microbiological (enzyme preparations) or chemical synthesis (oxidants, synthetic preparations of vitamins, amino acids, etc.) [1-8].

The most common today in Ukraine is the use of the latest group of technological additives used in flour mills, bakeries, confectioneries, etc. However, more promising and natural, from our point of view, is the first group of additives. Their use allows not only to change the properties of baking flour, improve the taste of bread, increase the porosity of bread, slow down staling, but also to enrich it with certain biologically active substances, give it a dietary, therapeutic and prophylactic effect, certain functional properties [1, 6, 9-11].

Analysis of recent research and publications

A great contribution to the development of theoretical and practical bases for the use of plant additives in the production of bakery and flour products, including potato products, was made by domestic scientists: L.Ya. Auerman, G.O. Magomedov, B.A. Baranov, R.Z. Grigorieva, L. I. Kazanska, V.I. Drobot, V.M. Kovbasa and others.

Potato is high-energy nutritious product. Existing technologies of its cultivation from 1 hectare of land allow to receive in 2.5-3 times more exchange energy, than at grain crops, productivity reaches 170 tones / hectare [12]. Potato is used as food, fodder crops, raw materials for starch, alcohol, chemical, textile, confectionery and other industries [13]. Potato protein (tuberin) has a high biological value, little inferior to egg white and meat. In comparison with chicken egg white, the biological value of tuberin reaches 85%, ideal protein – 70%. Potato also contains vitamins A (β-carotene), B1, B2, B6, C, PP, silicic acid, minerals such as potassium, sodium, calcium, magnesium, as well as iron, zinc, copper, manganese, cobalt [14].



The greatest contribution to the development of theoretical and practical bases of application of potato products in the production of bakery and flour products was made by L.Ya. Auerman. He substantiated the recommendations on the organization of the technological scheme of potato processing directly at bakeries, the use of boiled or raw potato in the production of bread from both rye and wheat flour. It was recommended to replace one part of flour with 3-4 parts of prepared potato [15].

Currently, potato products are added in the amount of 3-15% by weight of flour in various forms – mashed potato, flakes, starch, flour, etc. to supplement the insufficient amount of starch in the flour. This improves the quality of the crumb, especially in the case of excessively strong or short-grained gluten [16].

It is known from the literature that the introduction of up to 10% of potato products in the flour does not adversely affect the quality of bakery products, while in the case of 25% deterioration of their physico-chemical and organoleptic characteristics [17].

The results of other studies [18] show that the addition of 20% mashed potato in bakery products obtained the best quality indicators. This dosage maintains a pleasant appearance, improves the taste of the product, the structure of porosity, shape stability, increases the specific volume. The addition of mashed potato accelerates the ripening of the dough, significantly affects the nutritional value, increases the content of dietary fiber, vitamin PP, adds β -carotene, absent in flour, reduces the energy value of products.

It has been scientifically proven that fresh potato juice has a high nutritional value: it contains at least 12 free amino acids, in particular, valine, leucine, methionine, lysine, arginine, tyrosine. It is noted that fresh potato juice also contains B vitamins, ascorbic acid, carotene, pantothenic acid. The value of the minerals of potato juice: a large amount of phosphorus, calcium and magnesium compounds [19]. In [20], the authors note that the use of potato juice, which contains active lipooxygenase, is one of the effective ways to improve the quality of bakery products: increases the volume of bread, improves the structural and mechanical properties of the crumb.

Known ready-made flour mixtures for functional varieties of bakery products that contain potato flakes [21]. Increasingly, these flakes are used as an alternative to chemical leavening agents and preserving ways used in baking. NUFT conducted studies using potato flakes in the amount of 5-15% by weight of flour to extend the

shelf life of bakery products. It was found that the introduction of more potato flakes significantly delays staling, but slightly worsens their physical and chemical quality. [22]. Increasing the dosage of potato flakes gives the bread a sweet taste, it increases the content of sugar and dextrins, freshness lasts longer, but the optimal dose of potato flakes is not more than 5% by weight of flour [23].

Dry potato fiber is a promising source of dietary fiber in the production of bread, it is hypoallergenic, finely dispersed; has advantages over dietary fiber in wheat bran, fruits and vegetables because it does not contain phytin, which prevents the absorption of calcium. This allows it to enrich bakery products [24,25]. Given the dispersion of potato fiber, bread with its content can be recommended for people with diseases of the gastrointestinal tract. Potato fiber should be added to the recipe of bread from wheat flour in an amount not exceeding 5% by weight of flour [26].

The aim of the work is to study the influence of processed and unprocessed potato products on the quality of wheat flour bread. Objectives of the study:

- to determine the quality indicators of patent wheat baking flour;
- to enter into the composition various potato products into the flour and to investigate the change in the properties of test baking in comparison with the control sample;
- to extrude model mixes with raw potato and to investigate the change of baking properties of flour with the addition of similar ground extrudates in different proportions.

Research materials and methods

The subject of research – patent baking wheat flour TM "Bogumyla", raw mashed potato and juice, mashed potato, wheat, extrudates. All studies were performed according to standardized methods (Table 1) in the laboratory at the Department of Grain Processing Technology and at the Department of Feed and Biofuel Technology at ONAFT.

At the first stage of research, the quality indicators of patent wheat baking flour TM "Bogumyla" were determined (Table 1) and their full compliance with the requirements of GSTU 46.004-99 was established.

In the studied potato tubers the dry matter content was determined according to [27] and the initial moisture of $75 \pm 1\%$ was calculated.

Table 1 – Methods for determining the quality of grain, flour and laboratory baking of bread

Quality indicators	Method of determination
Moisture	DSTU GOST 29144:2009 (ISO 711-85). Grain and grain products. Determination of moisture
Quantity and quality of gluten	GOST 13586.1-68. Grain. Methods for determining the amount and quality of gluten in wheat
Starch	Evers method
Acidity by beaten-up flour and water	GOST 27493-87. Flour and bran. Method for determination of acidity by beaten-up flour and water
The content of crude ash	GOST 10847-74. Grain. Methods for determining the ash content
Whiteness of flour	GOST 26361-84. Flour. Whiteness determination method
Flour size (particle size distribution)	GOST 27560-87. Flour. Size determination method
Laboratory baking of bread	GOST 27669-88. Baking wheat flour. Method of trial laboratory baking

Table 2 – Quality indicators of patent wheat flour (n=3, p=0.95)

№	Quality indicators	Flour TM "Bogumyla"	Requirements of GSTU 46.004-99
1	Color	White with a yellow tinge	White or white with a yellow tinge
2	Odor	Inherent in wheat flour, odorless, not musty, not moldy	Inherent in wheat flour, odorless, not musty, not moldy
3	Taste	Inherent in wheat flour, without foreign flavors, not sour, not bitter	Inherent in wheat flour, without foreign flavors, not sour, not bitter
4	Moisture, %	14.2	Not more 15.0
5	Whiteness, un.	58	54 and more
6	The amount of crude gluten, %	27.0	No less 24.0
7	Gluten quality group	2	Not lower than the 2nd group
8	Size	3.9	5
9	Overtails on the sieve № 43, %	2	Not limited

To enter the potato into the dough, its tubers were cleaned of soil contaminants, washed, peeled, ground to a pulp and included in the dough in the following combinations:

- potato juice instead of water, which is usually used for mixing;
- mashed potato left after squeezing the juice (pulp), in the amount of 5.0; 7.5 and 10.0% by weight of flour;
- raw mashed potato in the amount of 5.0; 7.5 and 10.0% by weight of flour.

The quality indicators of wheat that was subjected to extrusion are as follows: moisture 11.3-11.5%, bulk density 780-790 g/l. To achieve the weighted average grain size: 1.6 mm; 0.8 mm and 0.6 mm – it was ground on a Nagema roller machine. Tubers of the same potato were prepared for extrusion similarly to the previous series of experiments. The moisture of the samples varied due to the different content of raw potato in the range of 4-10% of the total weight of the mixture, which provided its initial moisture of 14.2-18.3%. The mixture was mixed thoroughly, then kept under sealed conditions for 60-90 min to evenly redistribute moisture throughout the volume and extruded at a temperature of +100-120 °C and a vapor pressure of 0.2 MPa.

Table 3 – The composition of the model mixtures, %

Components	Sample mixture №			
	1	2	3	4
Wheat	96	94	92	90
Potato	4	6	8	10
Total	100	100	100	100

Table 4 – Physico-chemical parameters of the laboratory baking of bread

Indicators	Control	Sample with the addition of potato						
		juice	mashed			pulp		
			5	7,5	10	5	7,5	10
Specific volume, cm ³ /g	2.7	1.34	2.4	2.9	2.3	2.4	2.6	2.4
Moisture, %	40.7	50.0	41.0	41.8	43	40.8	41.6	42.0
Porosity, %	79	45	79	78	50	75	70	70
Acidity, degree	1.2	1.4	1.2	1.3	1.4	1.3	1.5	1.6

Extrusion of the samples was carried out on a production single-screw press extruder brand EZ-150 (manufacturer Cherkasyelevatormash).

Results of the research and their discussion

A control sample of bread was baked without the addition of potato products. Trial baking of bread was carried out according to GOST 27669-88. Evaluation of bread quality was performed the day after baking according to the main physical and chemical parameters (Table 4).

It is believed that potato juice is valuable in terms of baking, as it contains active lipoxygenase. This enzyme has an important role associated with improving the baking properties of flour. The oxidation products of fatty acids formed under the influence of the enzyme can cause oxidation of a number of other components of flour (pigments, SH-groups of gluten proteins, enzymes, etc.). At the same time there is a clarification of flour, strengthening of gluten, decrease in activity of proteolytic enzymes [19].

The addition of potato juice in the selected amount led to a darkening of the color of the crumb. Perhaps this is due to the presence among the nitrogenous substances of the potato juice of the amino acid tyrosine, which oxidizes to form dark melanins, which give a gray tint to the bread crumbs. The crust of bread has numerous tears, the porosity is underdeveloped, the crumb is inelastic, poorly baked. There is a significant decrease in the quality of bread not only in organoleptic but also physicochemical parameters when baking using potato juice in the selected amount: reduction of specific volume by 50%, porosity – by 45%, and moisture increases by 43% compared with a



control sample.

Thus, for this sample of flour (with sufficiently strong gluten), the addition of potato juice led to a decrease in its baking quality.

However, the addition of 5% raw mashed potato on the contrary has a positive effect on the quality of laboratory baking. In terms of porosity and acidity, the test samples are not inferior to the control sample, and the specific volume and moisture are even higher than the control. However, with an increase in the content of mashed potato to 10%, the porosity of the product decreases sharply by 37%, the specific volume – by 17%, and moisture increases to 43%, which is associated with a decrease in the mass content of gluten, lower viscosity of the dough. According to organoleptic evaluation, this sample differs little from the sample with the addition of potato juice.

The addition of raw potato pulp has a less negative effect on the quality of laboratory baking, compared to the control and samples for the addition of raw mashed potato and potato juice. In terms of porosity and acidity, the test samples are slightly inferior to the control sample by an average of 11%, the moisture level is close to the control. However, as the content of mashed potato increases to 10%, the porosity of the product remains constant and the moisture increases to 42%, the specific volume of the product corresponds to the sample with 5% pulp. The 7.5% pulp sample has similar quality indicators to the control sample: close specific volume and slightly higher moisture and acidity.

The obtained results show that the sample with the addition of 7.5% potato pulp and 5% mashed potato has the best quality indicators and a slightly delayed staling period. The only organoleptic disadvantage of the prototypes is a slightly darker shade of bread. This is consistent with other scientific studies: in [17] it is noted that due to the dark color of the pulp of bakery products are often used not raw potato, and potato products: starch, protein concentrate, puree, grits, flakes, etc. That is, the addition of potato products should be carried out after their heat treatment, such as extrusion.

Extrusion is a technological process of forming product harnesses everywhere forming a hole of the matrix in order to obtain products of a given shape and improved physical and mechanical properties. Its essence is to convert the mechanical energy that occurs when moving wet material through the press, into heat by overcoming internal friction and plastic deformation, and thus increase the pressure in the machine; and in "decompression shock", which occurs at the outlet of the raw material from the extruder at a sharp drop in pressure and temperature due to evaporation of moisture [28,29]. A significant contribution to the development of extrusion technology is made by prominent scientists: Kovbasa V.M., Drobot V.I., Pivovarov P.P., Egorov B.V., Vinnikova L.G., etc., who substantiate the technology of production and use of extruded product (EP) in food concentrate, confectionery, meat processing, confectionery, feed industries [28-36].

In recent years, research has emerged on the use of EP, including cereals, in baking. The use of EP (extrudates of rice, corn, rye, barley, oats) is considered one of the promising areas of functional enrichment of bakery

products [37] and at the same time - one of the ways to change the baking properties of flour [38,39].

Thus, according to prof. Kovbasa V.M. extruded wheat flour of the highest grade improves the organoleptic properties (color, aroma, porosity of the crumb), as well as intensification of the fermentation process, mainly due to increased gas-forming ability, has high solubility and water absorption, increased dextrin content compared to conventional. Its introduction in the amount of 10% in the recipe of wheat bread from second grade flour promotes the formation of dough close in consistency to the traditional, improves the organoleptic characteristics of the finished product), prolongs the shelf life of bread [40].

According to [41, 42], the use of extruded corn flour obtained by hot extrusion in a mixture with patent wheat flour for the manufacture of biscuits increases the elasticity of gluten in a dosage of up to 15% with its constant quality.

Adding the extrudate to the formulation of bakery products increases the water absorption capacity of the dough; the proportion of increase in bound water depends on the amount of extruded material added, not on the type of source cereals. From a rheological point of view, the most suitable improver is extruded corn middlings. Rye extrudate, which was added to wheat-rye dough, improved the organoleptic properties of the finished products, as well as slowed down the staling process. Wheat middlings extrudate did not significantly affect the quality of the product. Extruded patent wheat flour provided improved organoleptic properties (color, odor, porosity of the crumb), as well as intensified the fermentation process, mainly by increasing the gas-forming ability. In the case of using flour with deteriorating baking properties, there was an improvement in the shape-retaining ability of bread [30, 36, 38, 40].

The possibility of production of bakery products with the addition of extrudates from whole grain barley in the amount of up to 25% of flour according to the recipe was studied [43]. According to other studies, the rational amount of barley extrudate is 5-15% by weight of patent wheat flour, which contributes to the intensification of alcohol fermentation and increase the nutritional value of bread: it has an attractive appearance, pleasant taste and odor. Porosity structure: medium, uniform, developed; bread crumb is well baked, not moist, not sticky, with barely noticeable inclusions of barley extrudate particles. The color of the crumb of the finished bread is light and light with a grayish-yellow tinge [44].

The addition of crushed extruded wheat bran to wheat flour in the production of bread also leads to an increase in the autolytic activity and gas-forming ability of the flour mixture, as well as to an increase in the quality of gluten. The recommended optimal amount of additive introduced into the formulation of products is 5-15% by weight of flour [45, 46].

The authors [47, 48] consider dry mashed potato as a raw material for extrusion products. However, recent scientific studies have shown the possibility of using energy-efficient technologies, avoiding the drying process, to include in the extruded grain product (EGP) raw materials with high moisture (fruits, vegetables), including potato [48]. Theoretically, it is possible to use extru-

Table 5 – Properties of samples of model mixtures

№ sample	The weighted average particle size, mm	Indicators of extrudate quality				
		Moisture, %	Starch content, %	The content of destroyed starch, %	Volumetric mass, g/cm ³	Expansion index
1	1,0	9.5	39.0	57	0.14	2.4
2		9.6	39.6	51	0.20	2.3
3		11.3	40.0	40	0.20	2.2
4		12.6	41.1	34	0.25	2.0
1	0.8	10.3	60.3	29	0.18	1.6
2		11.2	61.5	26	0.17	1.4
3		11.6	64.3	23	0.26	1.25
4		12.9	68.5	20	0.24	1.15
1	0.6	10.3	39.0	55	0.18	2.2
2		10.8	47.6	36	0.17	1.9
3		11.0	65.4	21	0.21	1.3
4		11.2	70.7	10	0.20	1

Table 6 – Physico-chemical parameters of the laboratory baking of bread

Indicators	Control	Sample with EP content in amount, %		
		5	7,5	10
Specific volume, cm ³ /g	2.7	2.8	2.9	2.2
Moisture, %	40.7	40.4	40.4	40
Porosity, %	79	76	76	50
Acidity, deg	1.2	1.6	1.6	1.7

sion of a mixture of cereals with shredded raw potato, rather than dry mashed potato, for efficient heat treatment of the latter and at the same time directed change in the structure of grain biopolymers to obtain further "swellable" flour. It is proposed to extrude shredded potato in combination with other dry components (adsorbents) in a ratio that provides its weighted average moisture at the level of optimal for this process [50, 51].

At the next stage of research on model samples of mixtures (Table 4) studied the effect of the size of the grinding of wheat and the initial moisture of the raw material on the efficiency of the extrusion process. In the obtained samples of extrudates quality indicators were determined (table 6): moisture, expansion index, bulk density, starch content and content of destroyed starch [52]. The expansion index was defined as the ratio of the diameter of the cross section of the extrudate to the hole diameter of the die of the extruder.

Starch as the main component of potato and mixtures, in the process of extrusion plays the role of structurant, which is manifested in its swelling and the formation of macroporous structure. With increasing moisture level, which corresponds to fluctuations from 4 to 10% of the potato content, changes in chemical composition are observed. This is confirmed by experimental

studies. As can be seen from Table 5, the starch content in the extruded samples increases with increasing moisture level in it and reaches a minimum value with a minimum content of potato and grain particle size of 1,6 and 0,6 mm.

As can be seen from Table 5, the expansion index acquires the greatest value at a mass fraction of potato of 4-6%, regardless of the size of the grinding of grain raw materials. It reaches the maximum value of 2.2-2.4 at a content of 4% of potato and the size of grinding of grain raw materials 1,6 and 0,6 mm, i.e. the dominant influence on the expansion index has moisture (i.e. potato content). As the mass fraction of moisture in the raw material increases, the mass becomes less porous, because the optimal conditions for efficient evaporation of moisture at the outlet of the extruder are not created: the pressure and temperature drop.

Another indicator of the quality of the extrudate that correlates with the index of expansion is the bulk density. It varied in direct proportion to the mass fraction of raw material moisture (Table 5). This dependence is explained by the influence of moisture on the rheological properties of the mass and the nature of stress relaxation, which lead to the formation of extrudates with a small number of air pores [47]. As the moisture in the raw material decreases, the bulk density

decreases as the porosity of the extrudate increases. The minimum value of the bulk density is reached by a sample with a content of 4% of potato and a grinding size of 1.6 mm of grain, which corresponds to the maximum value of the expansion index.

The degree of destruction of starch also correlates with previous indicators and has a linear relationship: decreases with increasing moisture of raw materials (Table 5); the maximum value has a sample № 1 with a grinding particle size of 1.6 mm. Its total amount increases due to the cleavage of amylose and amylopectin molecules as a result of pressure, temperature and moisture.

The extruded mixture of wheat with potato (EP) sample № 1 (with a minimum content of potato with satisfactory quality of the extrudate) was ground on a laboratory process mill to a powder state (full pass of the sieve № 43) and added to the patent wheat flour TM "Bogumyla" (Table 1) in the amount of 5; 7.5 and 10% by weight of flour before kneading the dough. A control sample of bread was baked without the addition of powder. Trial baking of bread was carried out according to GOST 27669-88, the next day after baking – assessment by organoleptic and physicochemical parameters (Table 6).



When adding 5% of crushed extruded flour to the weight of high-grade wheat flour, the specific volume and porosity of bread is slightly greater than the control (4%), moisture – within the limits set by DSTU 7517:2014 [53], the acidity increased by 0.4 degrees. The use of this amount of crushed extrudate does not significantly change the structure of porosity and nutritional value of bread.

When adding 7.5% of crushed extruded flour to the mass of patent wheat flour, the specific volume of bread increases by 7%, porosity decreases by 3.7%, acidity is 0.4 degrees above the control level, moisture – within the limits set by the standard [53]. The bread has a satisfactory appearance, pleasant taste and odor.

When using 10% crushed extruded flour to patent wheat flour, the specific volume of bread decreases sharply by 19% and porosity – by 37%, acidity 0.5 degrees above the control level, but within the limits set by the standard [53], moisture – within the limits established

by the standard. Bread has an unattractive appearance, the color of the crumb – grayish, the crust has numerous bursts.

Conclusion

As a result of this work, the influence of processed and unprocessed potato products on the quality of wheat flour bread was studied.

It has been found that the addition of 7.5% raw potato pulp and raw 5% mashed potato to patent baking wheat flour is optimal due to the best product quality indicators without significant deterioration of traditional organoleptic properties and somewhat delayed staling time. Extruded wheat flour obtained from a mixture of wheat and potato is recommended to be used as an additive to baking wheat flour in the amount of up to 7.5%, as exceeding its amount leads to a deterioration in the quality of bakery products.

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РЕГУЛЮВАННЯ ХЛІБОПЕКАРСЬКИХ ВЛАСТИВОСТЕЙ ПШЕНИЧНОГО БОРОШНА ЗА ДОПОМОГОЮ КАРТОПЛЯНИХ ПРОДУКТІВ

Анотація

Найпоширенішим на сьогоднішній день в Україні є використання синтетичної групи технологічних добавок, що застосовують як на борошномельних заводах, так і у хлібопеченні, кондитерських комбінатах, тощо. Проте більш перспективною та природною, є група рослинних добавок. В статті проаналізовано вплив різних картопляних продуктів у кількості 4-10% та екструдатів різних злакових культур на якість борошняних виробів. Досліджена зміна властивостей пробної випічки порівняно з контрольним зразком.

В матеріалах статті наведено показники якості борошна пшеничного ТМ «Богумила» у порівнянні до вимог ДСТУ 46.004-99. Розроблено склад модельних сумішей пшеничне борошно : картопля у співвідношеннях 96...90 : 4...10, а також картопляного пюре і мезги 5-10 %. Для отриманих зразків визначені фізико-хімічні показники лабораторного випікання хліба. Проведено екструдування модельних сумішей зерна з сировою картоплею при температурі +100-120 °С і тиску пари 0,2 МПа. Екструдовані суміші пшениці з картоплею додавали до борошна пшеничного ТМ «Богумила» у кількості 5; 7,5 і 10% від маси борошна перед замісом тіста та здійснили пробне випікання хліба. Для отриманих зразків хліба провели оцінку за органолептичними та фізико-хімічними показниками. Досліджено зміни хлібопекарських властивостей борошна з додаванням аналогічних подрібнених екструдатів у різних пропорціях. Встановлено, що вміст крохмалю в екструдованих зразках збільшується з підвищенням в них рівня вологості і досягає мінімального значення при мінімальному вмісті картоплі та зерна розміром 1,6 і 0,6 мм.

Встановлено, що додавання 7,5 % сирової картопляної мезги та сирого 5 % картопляного пюре у хлібопекарське пшеничне борошно вищого сорту є оптимальним через найкращі показники якості виробів без значного погіршення традиційних органолептичних властивостей та дещо відстрочений термін черствіння. Екструдоване пшеничне борошно, отримане із суміші пшениці та картоплі, рекомендовано застосовувати у якості добавки до хлібопекарського пшеничного борошна у кількості не більше 7,5 %.

Ключові слова: хлібопекарські властивості, борошно пшеничне, картопля, картопляне пюре, картопляний сік, картопляна мезга, екструдат.

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