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BLACK CHOKEBERRY POWDER AS AN IMPROVER FOR PASTA

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Abstract. In the course of the research, it has been studied how a dosage of black chokeberry powder effects on the quality of pasta made from flour with different gluten content. The studies used flour of standard quality and low-gluten flour. To reduce the gluten content in wheat flour, it was mixed with potato starch. As a result of "diluting" gluten with starch, its content decreased from 25 to 2.5%. The resulting mixtures were used to make pasta to which different quantities of black chokeberry powder were added. The effect of different doses of chokeberry powder on the gluten content of the mixtures obtained was determined by the experimental design 2^2 "with a star" in the Statgraphics Plus package. It has been established that with increasing the doses of chokeberry powder, there is a decrease in the gluten content and an increase in pectin substances. In the finished pasta, the mechanical strength and the amount of dry matter that passed to the cooking water were determined. According to the data obtained, a chart has been developed to determine the dosage of chokeberry powder and the amount of starch introduced that allow achieving the quality of pasta that conforms to the standard. Thus, introducing 5.0% of black chokeberry powder into flour containing about 18% of gluten will make it possible to obtain products with the strength 0.66 N and with less than 7.9% of solids passing into the cooking water. With flour of standard quality, adding 5% of chokeberry powder has a positive effect on the mechanical strength of pasta, increasing it by 20% compared to the check sample. Other quality parameters, including cooking characteristics, are within the permissible limits. Production tests were conducted in the open joint-stock company *Lidakhleboprodukt*. The quantity of black chokeberry powder added was 5%. The pasta was made on a Buhler production line with a capacity of up to 2000 kg per shift. The tests results have made it possible to develop technical specifications BY500134647.012-2018 "Pasta with the food additive *Aronia*" and the technological instruction BY 500134647.001-2019 "Production of pasta with the food additive *Aronia*."

Keywords: pasta, chokeberry powder, gluten, pectin substances, strength, cooking characteristics.

Introduction. Formulation of the problem

The quality of pasta products largely depends on the gluten content in flour. Dough is the strongest when flour contains 28–32% of crude gluten. The protein content of flour influences the products' water absorbing ability during cooking and the strength of the cooked products. Pasta products feature normal cooking characteristics if the crude gluten content in flour is 25 to 40%. If the gluten content in flour is reduced, then the time of cooking products until done is reduced, too, the cooked products become less strong, more water is absorbed, more dry matter passes into the cooking water, and the mass of a cooked product is more likely to stick together [1]. The less gluten is in flour, the worse the quality of the pasta made from this flour. That is why, it has been suggested to use raw ingredients that help improve the pasta quality. Black chokeberry powder can be such a raw material component, as it contains enough pectin substances.

To investigate more fully the effect chokeberry powder has on the quality of pasta products, it is worthwhile to use flour with different gluten contents. For this purpose, mixtures of wheat flour and potato starch were made: the gluten content was purposefully reduced in flour by "diluting" it with starch.

Analysis of recent research and publications

The starch is widely used in the pasta products industry. However, it is practically impossible to make pasta solely from starch, since native starch cannot form a dough structure which will allow the products, after pressing and drying, to retain the shape they have been moulded into [1]. To improve the dough formation process, it is suggested to gelatinise preliminarily part of the starch and add vegetable oil [2]; or use converted starches (cold pregelatinisation starch, hot pregelatinisation startch, and extruded maize starch) as structure forming components [3,4]; or use extruded maize starch in combination with vegetable oil [5].

Different scientists have suggested different methods to improve pasta quality. A pasta making method has been patented that involves mixing a corrective additive with water, followed by adding an enricher. As an enricher, milled or dried Scorzonera root is used [6]. Another pasta making method involves using an enrichment additive made from milled Amaranth and millet seeds, in combination with a corrective additive. Hemicellulose and ascorbic acid are used as corrective additives [7]. There is a method when dough is kneaded with wheat flour, a food enricher, and water with a corrective additive. The enricher is a product of processing amaranth (its grain and/or vegetable varieties), the corrective additive is a phosphate [8]. In Ukraine, there is patented pasta based on wheat flour, lupine flour (4–8% of it), and water. This pasta also includes 0.2–0.5% gelatin introduced as a colloidal solution [9]. In Kemerovo Technological Institute of Food Industry, turmeric has been suggested as a means to improve the nutritional qualities of pasta products. It enhances the visco-elastic properties of gluten, the strength and cooking characteristics of finished products [10]. There are also foreign studies of how to enrich pasta with proteins, vitamins, organic acids, dietary fibre, polyunsaturated fatty acids, and other substances. To this end, legumes, dairy products, vegetables, seaweeds, sprouted seeds, as well as calf liver and other products were introduced into the recipe [11]. To improve the quality of pasta, emulsifiers, mono and diglycerides, various organic acids, and antioxidants are introduced. These compounds effect on the plasticity of dough, thus facilitating the pressing process, increase the strength of dry products, improve their appearance and taste [12]. In Poland, it was studied how additives, egg powder, disodium orthophosphate, methyl cellulose, and ascorbic acid effected on the microstructure of pasta at different values of the intensity and temperature of kneading [13].

Using products obtained from processing fruit and berries has not become common practice in pasta production. An exception is the sea buckthorn, for it has been an object of some research. It can be recommended to include fat-free sea buckthorn meal into schoolchildren’s diet, and it is a healthy and dietary product for elderly people [14]. Sea buckthorn flour added to pasta makes it stronger and not so easily overcooked, gives it a nice creamy tint and a touch of sea buckthorn in the flavour and smell, and increases its biological value [15].

There have been suggestions to use chokeberry derivatives in flour-based products: bakery products, cookies, and muffins. Thus, black chokeberry nectar and fructose syrup included in the recipe of the bun *Gorodskaya* (10, 20, and 30% of the total amount of liquid in the dough) increase the substances of the flavonoid structure from 3.2 to 17.5 mg% in terms of a dry sample [16]. While studying how to use chokeberry powder in the production of indented shortbread cookies, the recipe of the cookie *Ryabinka* was developed containing 8.7% of the powder. The resulting products are highly nutritious and calorific, with a wide range of vitamins. Besides, they contain chokeberry pectins that neutralise toxins formed as a result of intestinal activity, bind and remove heavy metal salts from the body [17]. Powders from common viburnum and black chokeberry used instead of granulated sugar in muffins change their organoleptic and physico-chemical quality characteristics (moisture content, alkalinity, and water absorption). The optimum doses of black chokeberry and common viburnum powders when baking muffins are 5–10% and 5%, respectively [18]. Chokeberry, bilberry, and cranberry powders can be used to make bread from wheat flour. Studies have shown that the prototypes (with powders added in an amount of 1 to 5% by weight of flour), by their sensory and physico-chemical quality characteristics (moisture content 38.2–39.3%, acidity 2.8–3.2 degrees, porosity 64–68%), conform to the standard. Introducing the powders had its effect on the colour of the crumb, which acquired the tint of the powder used. The colour intensity varied with the dosage of the powder. Since food powders have a rich chemical composition, they can be used to enrich flour-based foods [19]. Besides, the chokeberry exhibits antioxidant and antiallergenic qualities. The high iodine content allows it to be used for thyroid disease. The berries help in the treatment of disorders of the gallbladder, kidneys, liver, gastrointestinal tract, and vascular system. Regular consumption of black chokeberries helps increase appetite, and reduces blood and intracranial pressure [20-22].

Having analysed the above, it can be assumed that chokeberry powder will have a positive effect on pasta products made from low gluten flour. However, there are no such data in the literature. So studying the effect of chokeberry powder on the quality of pasta made from flour with different gluten content is a topical task.

The **purpose** is to study the effect of different doses of black chokeberry powder on the quality of pasta made from flour with different gluten content.

To achieve this purpose, the following **objectives** were solved:

– preparing mixtures with different gluten content;

– making pasta products with the mixtures prepared and different quantities of black chokeberry powder;

– testing the mixtures to be used in cooking pasta, for their gluten and pectin content;

– measuring the mechanical strength of the finished pasta products, and determining the total dry matter that passed into the cooking water;

– mathematical analysis of the data obtained, and constructing a diagram to determine the quantity of chokeberry powder and starch that allows making pasta with the required quality parameters.

Research materials and methods

The objects of study were pasta made from mixtures of premium wheat flour and starch, with the addition of different quantities of chokeberry powder.

The work involved the use of premium-grade wheat flour produced by the open joint-stock company *Lidakhleboprodukt* (Republic of Belarus), premium-grade potato starch (open joint-stock company *Golshansky Krakhmalny Zavod*, Republic of Belarus), black chokeberry powder (limited liability company *TK Prestizh*, Russian Federation). The quality characteristics of the raw materials used are presented in Table 1.

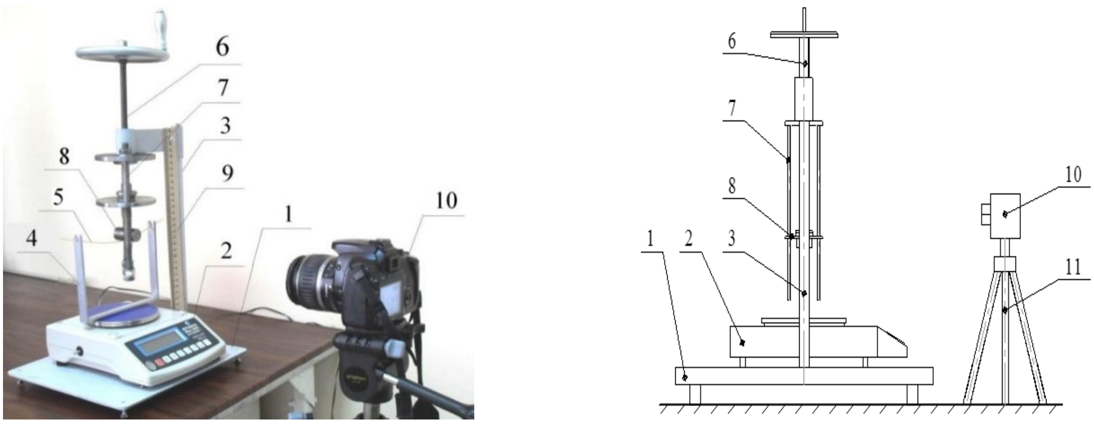
In the preparation of pasta, various ratios of wheat flour, starch, and chokeberry powder were used in accordance with the doses indicated in Table 2. In the laboratory, the dough for pasta was kneaded and compacted, the products were moulded with a laboratory screw extruder (Amitek), then cut and laid out on drying surfaces by hand, then dried in a laboratory dryer at 60°C until the moisture content was not more than 13%.

The quality characteristics of the raw materials and pasta were determined in accordance with the methods and techniques that are generally accepted in the pasta industry and are in effect on the territory of the Republic of Belarus. The pectin content and the sum of pectin substances were determined by gravimetric calcium-pectin analysis [23].

The mechanical strength of the pasta was determined in accordance with Patent for an Invention No. 21224 of the Republic of Belarus, IPC G01 N33/02, G01 N33/10 "Pasta strength measuring device". The device developed is shown in Fig. 1. Its features are a ruler and a digital video camera. The ruler allows measuring the flex of a pasta product, and the digital video camera captures the magnitude of the flex and the readings of the scales at the moment of breaking.

Table 1 – Quality characteristics of raw materials used

Quality parameters	Premium wheat flour (Standards of the Republic of Belarus 1666-2006)	Premium potato starch (State Standard 7699-78)	Black chokeberry powder (Technical Specifications 10.29.25-003-69275-64-2017)
Colour	White		Burgundy-coloured
Smell	Typical of this raw material, free of off-odour		
Taste	Characteristic of the raw materials, without off-flavours, not sour, not bitter		Sweet and sour, slightly astringent
Crunch	No crunch when chewed		
Moisture content, %	12.0	18.3	4.96
Acidity, deg.	3.0	8.7	–
Acidity, deg. in terms of malic acid	–	–	0.12
Ash content, %	0.45	0.32	1.49



a) b)

a) – overall view; b) – schematic view

Fig. 1. Pasta strength measuring device

1 – baseplate; 2 – electronic scales; 3 – stand; 4 – bracket support; 5 – pasta product; 6 – screw; 7 – guiding rod; 8 – pressing element; 9 – ruler; 10 – video camera, 11 – tripod

All the results of the experimental studies were statistically processed by finding a random error by Student's *t*-test (with the confidence probability 95%). To study the mutual influence of the input factors on the optimisation parameter (response function), we used the method of mathematical two-level two-factor experimental design (full factorial experiment, or FFE, of the type 2^2 "with a star") using the computer experimental design system STATGRAPHICS Plus for Windows. When using this design, the number of experiments increases: experiments are additionally carried out in the "star" points and in the centre of the design space, which allows a more complete estimation of the influence of the input factors on each optimisation parameter [24]. When making the design, the dosage of black chokeberry powder (in the range 2–8%) was taken as the input factor X_1, and the dosage of starch (in the range 20–80%) as the input factor X_2. In the "star" points, the dosage of chokeberry powder was 0.76 and 9.24%, of starch 7.57 and 92.43%, and in the centre of the design, 5.0% and 50.0% for chokeberry powder and starch, respectively. The optimisation parameters Y were the contents of gluten and pectin substances in the resulting mixture, as well as mechanical strength and the amount of dry matter that passed into the cooking water.

Results of the research and their discussion

When mixing wheat flour and starch in different proportions in the doses indicated in Table 2, mixtures with different gluten content were obtained. The amount of starch introduced and the gluten content are inversely proportional (Fig. 2). Adding starch to flour increases its share in the total mixture, thereby reducing the amount of protein substances. And this, in turn, leads to a lower content of crude gluten in the mixture. The addition of a small amount of starch does not significantly affect the gluten content, but with the maximum dosage of starch added, there is almost no gluten: its amount in the resulting mixtures decreases from 25 to 2.5%. This gluten content makes it possible to value most fully black chokeberry powder as a pasta improver when using flour which is "defective" or lacks gluten raw materials.

The data obtained (Fig. 3) show that adding up to 1% of black chokeberry powder has almost no effect on the amount of gluten.

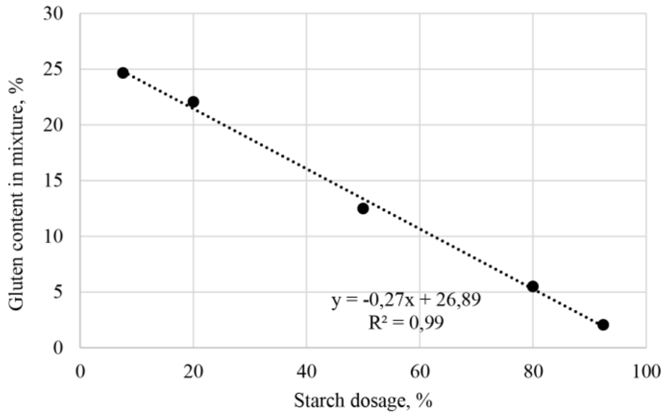


Fig. 2. Dependence of the gluten content in the mixture on the starch dosage

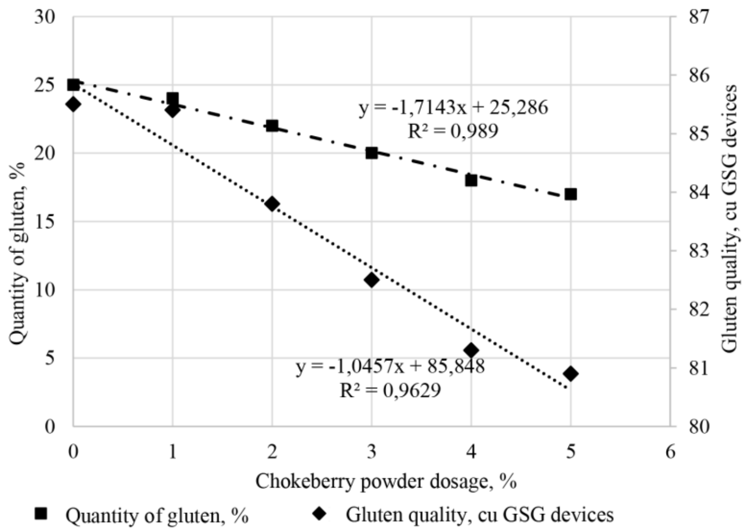


Fig. 3. Dependence of the quantity and quality of gluten on the chokeberry powder dosage

When more powder is added, the gluten content in the flour decreases, and when as much as 5% of powder is added, the amount of gluten is reduced by 1.25 times. All these changes are due to the fact that the composition of the food powder includes various acid-reactive substances, among them organic acids. And under high acidity conditions, gluten proteins do not swell, but are peptised, passing into a colloidal solution. At the same time, adding food powder strengthens gluten: the more food powder is added, the stronger gluten is. This is because in chokeberry powder, there are oxidising compounds which help the formation of disulphide bonds between the tertiary and quaternary structures of protein molecules, thereby strengthening the gluten network. Adding 1 to 5% of chokeberry powder improves the quality of gluten by 5.4%.

When making the experimental design, a design matrix was developed, which is presented in Table 2.

Table 2 – Design matrix to determine the content of gluten and pectin substances

	Input factors		Optimisation parameters		
	dosage of chokeberry powder, %	dosage of starch, %	gluten content in the mixture, %	content of pectin substances in the mixture, %	quantity of solids in the cooking water, %
1	5.0	50.0	10.81	3.32	8.08
2	2.0	20.0	21.58	1.36	9.52
3	8.0	20.0	18.66	2.15	8.49
4	2.0	80.0	1.0	1.38	18.55
5	8.0	80.0	0.2	2.14	15.8
6	0.76	50.0	13.43	0.52	6.03
7	9.24	50.0	9.66	5.86	11.62
8	5.0	7.57	19.34	3.3	8.72
9	5.0	92.43	0.2	3.29	19.43
10	5.0	50.0	10.75	3.31	8.53

The data of Table 2 make it clear that an increase in the proportion of chokeberry powder in the mixture results in a lower gluten content and a higher content of pectin substances. A decrease in the proportion of gluten is directly related to chokeberry powder (its effect on the quantity and quality of gluten has been mentioned earlier). Different contents of gluten and pectin in the mixture used for pasta production will effect on the quality of products.

During the statistical processing of the experimental data, regression equations with standardised variables were obtained that adequately describe the dependence of the considered parameters on the factors selected. The obtained mathematical dependences for the strength and quantity of solids that passed into the cooking water have the general form:

$$Y = 0.39 + 0.14 \cdot X_1 + 0.0012 \cdot X_2 - 0.018 \cdot X_1^2 + 0.00036 \cdot X_1 \cdot X_2 - 0.000071 \cdot X_2^2 \quad (1)$$

$$Z = 10.71 - 0.33 \cdot X_1 - 0.21 \cdot X_2 + 0.074 \cdot X_1^2 - 0.0048 \cdot X_1 \cdot X_2 + 0.0037 \cdot X_2^2 \quad (2)$$

where Y – strength of pasta, N;

Z – quantity of solids that passed into the cooking water, %;

X_1– dosage of chokeberry powder, %;

X_2– dosage of starch, %.

The Pareto chart visualises how each of the evaluated factors and their interactions effect on the strength of the products (Fig. 4).

Analysis of the Pareto chart makes it clear that the greatest influence on the strength is that of the interaction effect of the factor X_1 (X_1^2), and the factor X_1 itself (namely the chokeberry powder dosage). Besides, the influence of the factor X_2 (the starch dosage) is significant, too. As the values of the interaction effect X_1^2, factor X_1, and factor X_2 increase, the pasta strength decreases. This is because increasing doses of black chokeberry powder and starch result in a smaller proportion of gluten, which leads to a decrease in the bonding properties.

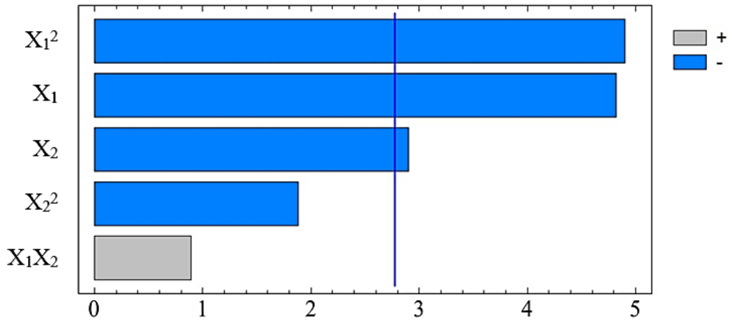


Fig. 4. Pareto chart for strength

This, in turn, reduces the strength. The intersection of the standardised effects of the vertical line, which represents the 95% confidence probability, means that the influence of the interaction effect X_1^2, factor X_1, and factor X_2 on the pasta strength is significant. The influence of the interaction effect X_2^2 is similar to the above-described: its increase results in a decrease in the pasta strength. And the combined action of two input factors leads to but a slight increase in the pasta strength. This is due to the presence of pectin substances in chokeberry powder, which form a linked structure with starch grains during pressing.

Fig. 5 shows the response surface – a graphical model for the regression equation (1).

For a deeper study of the effect of the input factors (black chokeberry powder dosage and starch dosage) on all optimisation parameters (pasta strength and amount of solids passing into the cooking water), it is reasonable to use the chart of lines of equal level.

Based on the data obtained, a diagram was constructed showing how the pasta strength and the amount of solids passing into the cooking water depended on the dosages of black chokeberry powder and starch (Fig. 6).

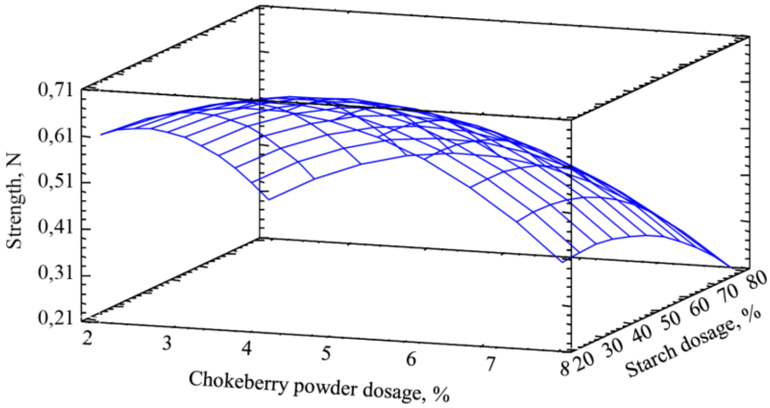


Fig. 5. Response surface for pasta strength

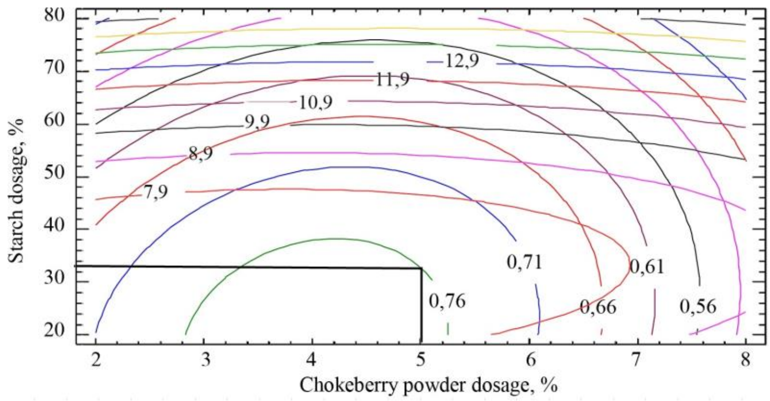


Fig. 6. Determining the strength and amount of solids depending on the doses of black chokeberry powder and starch

Using the diagram, it is possible to determine what dosage of chokeberry powder and what quantity of starch should be added to achieve the pasta quality meeting the requirements. So, adding 5.0% of black chokeberry powder with replacing 32.5% of flour with starch, which will make the gluten content in the mixture equal to 18% (Fig. 1), allows obtaining products with the strength 0.66 N and the amount of dry matter passing into the cooking water less than 7.9%.

Thus, using 5.0% of black chokeberry powder allows obtaining good quality pasta from flour that is low in gluten.

In order to establish more fully how each recipe component influences the quality of pasta, the following product samples were manufactured:

– check sample made of wheat flour of premium quality:

– sample 1 made of wheat flour of premium quality with 32.5% of starch;

– sample 2 made of wheat flour of premium quality with the addition of 5% of black chokeberry powder;

– sample 3 made of wheat flour of premium quality with 32.5% of starch and 5% of black chokeberry powder.

The manufactured samples had a smooth surface, regular shape, and looked vitreous in the cross-section. They only differed in colour: the check sample was light beige, sample 1 whitish, and samples 2 and 3 were dark violet. The physical and chemical quality parameters, such as moisture content and acidity, were at the level 11.8–12.5% and 3.0–4.5 degrees, quite in compliance with the standard for these parameters. The mechanical strength of the check sample was 0.6 N, and that of samples 1, 2, and 3 0.43, 0.76, and 0.66 N, respectively. Such changes are due to the addition of black chokeberry powder, in particular, to pectin substances contained in it. The effect of pectin substances has been mentioned before.

The cooking properties of the pasta samples prepared have been determined, too. While cooked, all the pasta samples, except for sample 1, did not boil too soft, did not lose their shape, and did not stick together. When cooking sample 1, the structure of the product was destroyed, and the cooking liquid was cloudy with a lot of suspended particles. After cooking, the products obtained stuck together and formed a single big lump. Table 3 shows the cooking properties of the pasta under study.

Table 3 – Cooking properties of the pasta

Parameter	Check sample	Sample analysed		
		Sample 1	Sample 2	Sample 3
Cooking time until done, min	12.5	9	13	10
Mass growth factor	1.66	1.05	1.7	1.3
Solids that passed into the cooking water, %	6.05	10.65	6.9	7.5

Cooking time until pasta is done is the parameter that determines the time from putting the product into boiling water till the disappearance of the floury, undercooked layer. This parameter in the check sample and sample 2 remains practically unchanged. It means that chokeberry powder does not have a significant effect on it. The decrease in the cooking time in samples 1 and 3 is a result of a significant decrease in gluten (Table 2).

The mass growth factor is within the normal range (2 is the maximum). The check sample and sample 2 show almost the same values of this parameter. This is due to the fact that, on the one hand, the proportion of gluten decreases, and, therefore, the amount of absorbed water should decrease, too; on the other hand, the larger the chokeberry powder dosage, the higher is the content of pectin substances in pasta, which intensively absorb water during cooking. As these processes balance each other, the mass growth factor remains unchanged. The decrease in this parameter in samples 1 and 3 is also due to a decrease in the proportion of gluten and an increase in the proportion of starch: the latter absorbs far less moisture than protein does.

The amount of solids that passed into the cooking water in sample 2 is slightly larger compared to the check sample. This is because the powder contains a certain amount of extractive substances that pass into the water during cooking and thereby increase this parameter. In samples 2 and 3, the value of this parameter, compared with the check sample, is higher by 76% and 24%, respectively. This is because during pasta cooking, a small amount of gluten forms a “weak” framework of denatured protein. This framework cannot hold large amounts of substances in pasta, that is why, part of these substances passes into the cooking water. However, despite this, for all pasta samples except sample 1, the amount of solids that passed into the cooking water conforms to the standard (up to 10%).

As a result of the experiment, it has been established what effect black chokeberry powder has as a pasta improver. Moreover, chokeberry powder can be used both for low-gluten flour and for flour of standard quality.

Approbation of results

A trial batch of pasta was produced in *Lidakhleboprodukt*. The pasta was manufactured from wheat flour and 5% of black chokeberry powder. Starch was not used to produce the trial batch of pasta (the use of starch was limited to laboratory studies in order to reduce gluten in flour). The products were manufactured on a Buhler production line with a capacity of up to 2000 kg per shift. The tests results have made it possible to develop technical specifications BY 500134647.012-2018 “Pasta with the food additive *Aronia*” and the technological instruction BY 500134647.001-2019 “Production of pasta with the food additive *Aronia*.”

Conclusion

During the research, it has been found how doses of black chokeberry powder effect on the quality of pasta made from flour with different gluten contents. It has been established that chokeberry powder can be used to produce pasta from flour of standard quality as well as from low-gluten flour. To reduce the gluten content in wheat flour, it was mixed with potato starch.

It has been determined that adding 5.0% of chokeberry powder to flour with a gluten content of about 18% is enough to make pasta that will comply with the standard. This quantity of powder will make it possible to obtain products with the strength 0.66 N and with less than 7.9% of solids passing into the cooking water.

When using flour of standard quality, the addition of 5% of chokeberry powder has a positive effect on the mechanical strength of pasta increasing it by 20% compared to the check sample. Other quality parameters are within the permissible limits.

Besides, the use of black chokeberry powder will make it possible to increase the nutritional value of pasta and expand the range of products at pasta enterprises of the Republic of Belarus.

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ПОРОШОК ЧОРНОПЛІДНОЇ ГОРОБИНИ ЯК ПОЛІПШУВАЧ ДЛЯ ВИРОБНИЦТВА МАКАРОННИХ ВИРОБІВ

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Аннотация. Вивчено вплив дозування порошку аронії чорноплідної на якість макаронних виробів з борошна з різним вмістом клейковини. У дослідженнях використовувалася борошно нормальної якості та борошно з низьким вмістом клейковини. Для зниження вмісту клейковини в борошні пшеничному, його змішували з картопляним крохмалем. У результаті «розведення» клейковини крохмалем її вміст знизився з 25 до 2.5%. Отримані суміші використовували для отримання макаронних виробів із внесенням різної кількості порошку аронії чорноплідної. Визначення впливу різних доз порошку аронії на вміст клейковини в отриманих сумішах здійснювалося за допомогою планування експерименту 2^2 «із зіркою» в пакеті StatGraphicsPlus. Встановлено, що зі збільшенням дозування порошку аронії відбувається зменшення вмісту клейковини і збільшення вмісту пектинових речовин. У готових макаронних виробах визначено механічну міцність і кількість сухих речовин, які перейшли у варильну воду. За отриманими даними розроблено діаграму для визначення дозувань порошку аронії і кількості внесеного крохмалю, при яких досягається, якість макаронних виробів, що відповідає вимогам стандарту. Таким чином, внесення 5.0% порошку аронії чорноплідної при утриманні клейковини в борошні близько 18%, дозволить отримати вироби з міцністю 0,66 Н та кількістю сухих речовин, які перейшли у варильну воду менш 7.9%. При використанні борошна нормальної якості, додавання порошку аронії в кількості 5% позитивно впливає на механічну міцнцість макаронних виробів, підвищуючи її на 20% у порівнянні з контрольним зразком. Інші показники якості, в тому числі і варильні властивості, знаходяться в межах допустимої норми. Проведено виробничі випробування на ВАТ «Лідахлібопродукт». Порошок аронії чорноплідної вносили в кількості 5%, макаронні вироби виготовляли на потокової лінії продуктивністю до 2000 кг в зміну фірми Buhler. За результатами проведених випробувань розроблено ТУ BY 500134647.012-2018 «Вироби макаронні з харчовою добавкою« Аронія »і ТІ BY 500134647.001-2019 «Технологічна інструкція з виробництва виробів макаронних з харчовою добавкою «Аронія».

Ключові слова: макаронні вироби, порошок аронії, клейковина, пектинові речовини, міцність, варильні властивості.

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