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IMPROVING THE COMPOSITION OF FORMED POTATO CHIPS WITH FUNCTIONAL PLANT ADDITIVES

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Abstract. The modern food concentrate industry in Ukraine is undergoing active transformation driven by changes in consumers' dietary habits and the growing demand for convenience foods that combine ease of consumption, a variety of flavors, and high nutritional value. The global trend toward healthy eating encourages manufacturers to develop functional products enriched with protein, vitamins, and dietary fiber while simultaneously reducing caloric content. Therefore, an essential condition for the production of highly competitive snack products is the improvement of their quality characteristics, nutritional and biological value, sensory properties and safety. Traditional potato chips are characterized by high energy value, as they contain up to 30-40% fat. In addition, deep-frying leads to the formation of lipid oxidation products and other undesirable compounds. This study presents a technological approach to improving the composition of formed potato chips by incorporating dietary fiber sources, namely psyllium (*Plantago ovata* seed husk) and a fiber mixture derived from milk thistle, pumpkin and flax seeds, as well as by replacing deep-fat frying with high-temperature baking as the dehydration method. Psyllium, which contains up to 86% dietary fiber, acts not only as a nutritional fortifier but also as an effective hydrocolloid and structure-forming agent. It was established that the addition of 3% psyllium or 5% of the fiber mixture, based on the weight of dry potato puree, is the most rational for forming a plastic, more cohesive mass suitable for shaping into flakes. Structural-mechanical studies confirmed the strengthening of the biopolymer framework of the potato dough: the ultimate shear stress in samples with additives increases by 1.1–1.24 times compared to the control sample. The optimal thermal processing conditions were experimentally substantiated: baking at 170-180 °C for 14-15 minutes allows the final moisture content of the chips to be reduced to 2.2-2.5% while providing a crispy porous structure with an attractive golden color. The use of psyllium increases the dietary fiber content by 58%, while the fiber mixture increases it by 41.6% compared with the control sample. The absence of aggressive hot fat during baking promotes better preservation of the structure of psyllium and fiber components, confirming their potential for use in dietary nutrition.

Keywords: food concentrates, potato snacks, high-temperature baking, dietary fiber, psyllium, fiber, structure, nutritional value.

Introduction. Formulation of the problem

The food concentrate industry of Ukraine demonstrates stable development due to the introduction of modern technological solutions aimed at improving product quality and expanding their range. Manufacturers are increasingly using natural raw materials and environmentally friendly packaging, which meets the current demands of consumers and the concept of sustainable development.

A significant factor in market development is the change in the eating habits of the population: the growing demand for quick snacks due to reduced time allocated for cooking. Under such conditions, snack products are becoming increasingly important due to the convenient consumption format, which can partially provide the body with essential nutrients. The level of snack consumption in Ukraine is about 1.5 kg per person per year, which is significantly lower compared to the countries of the European Union (5-6 kg) and the USA (about 10 kg). This indicates the presence of significant growth potential of the domestic market for this group of products. The key participants in the Ukrainian snack market are the companies "S.Group", "Snack Company

Zakhid", "Kraft Foods Ukraine" and "Technocom", which are actively developing marketing strategies and offering a wide range of well-known brands. Their activities are based on modern production technologies, which ensure a consistently high quality level of finished products [1].

A separate promising direction is the development of functional snack segment. The growing demand for products with increased nutritional value, particularly with a high content of protein, dietary fiber, vitamins and minerals, necessitates the development of new recipes. Such products are focused on meeting the needs of different groups of consumers and are aimed at maintaining cognitive and physiological functions of the body, which requires the active involvement of scientific research and technological innovations.

An important component of the salty snack market in Ukraine is the segment of potato and corn products, which includes potato chips, corn flakes, corn sticks and other extruded products. The average annual growth rate of this segment is estimated to be 8-9%, which indicates its sustainable development. Due to the variety of tastes and aiming at the youth audience, the position of corn snacks is strengthening, particularly nachos and extruded products, however, potato chips are the most popular among consumers [2].

Analysis of recent research and publications

Potato chips are popular snack foods and are usually made in the form of deep-fried thin potato slices. This group also includes molded potato chips, which are made from potato mass combined with starch, flour, spices and other auxiliary ingredients. The high energy value of such products is due to the significant content of fat and carbohydrates, and their regular consumption can negatively affect human health, increasing the risk of obesity, cardiovascular and gastrointestinal diseases.

In this regard, modern scientific research pays considerable attention to the development of technologies for the production of potato chips with a reduced fat content or with a complete rejection of deep-frying [3]. It is known that prolonged heating of oil at high temperatures leads to the formation of lipid oxidation products, which deteriorate the quality of fat and reduce the nutritional value of the finished product. Therefore, control of frying quality indicators, particularly acid, peroxide and anisidine values, is a mandatory stage in assessing its suitability for use in the technology of chips. The mass fraction of fat in the finished product remains one of the key indicators of their quality [4].

Ultrasonic treatment of chips before frying has become one of the most promising methods for reducing the fat content in finished products. Acoustic cavitation creates microchannels in the structure of potatoes, which facilitates the release of moisture during frying. This reduces the time of heat treatment and creates a surface barrier that prevents the absorption of oil. The fat content in such chips is reduced by 22-30% compared to the control sample [5, 6].

One of the ways to reduce the fat content of chips is to use alternative technological solutions. Thus, the authors described a method for obtaining potato chips with fat content of less than 32%, which involves pre-washing potato slices in salt solutions, drying and infrared heating before heat treatment, and it is also possible to apply hydrocolloid coatings to the surface of the slices. The use of such approaches allows to reduce the amount of absorbed oil and, accordingly, reduce the energy value of the product [7, 8].

Edible gums, also known as hydrocolloids, can be used as food coatings or added to the recipe of chips, which can decrease fat content and moisture retention during deep frying. Studies [9] noted that the using edible coating of xanthan gum reduced oil absorption by up to 57% and improved the overall quality of fried potato chips in terms of taste, aroma and crispiness.

A separate important aspect affecting the safety of potato chips is the formation of acrylamide: a toxic compound formed in starchy foods during heat treatment at high temperatures. An increase in the temperature and duration of frying leads to a significant increase in the concentration of this substance, which can negatively affect the nervous, immune and reproductive systems of the body [10]. In order to reduce the formation of acrylamide, the various pre-treatments of potato ingredients have been proposed. Particularly, it has been found that soaking potato slices in water or suspension of *Aureobasidium pullulans* yeast helps reduce the level of acrylamide, especially when increasing the time of such treatment. Using pulsed electric fields before soaking enhances the effectiveness of reducing its formation, although the combination of several methods does not always have a pronounced synergistic effect. Additionally, enzymatic methods are considered promising, particularly the use of L-asparaginase, glucose oxidase, as well as the addition of lyophilized yeast and plant powders, which allows to control the level of acrylamide in the finished product [11, 10].

An innovative direction in the production of potato chips is vacuum frying, which provides a decrease in temperature and limits oxidative reactions. The results of studies have shown that vacuum frying contributes to better preservation of color, taste and aroma, decreases fat content, and also minimizes the formation of trans fatty acids compared to traditional atmospheric frying. At the same time, such chips may be less crispy, which requires further technological adjustment [12, 13].

The composition of the restructured potato dough has a significant impact on the quality and fat absorption of chips. It has been established that using different types of starch (wheat, corn, tapioca) changes the rheological properties of the dough, the gel structure and the mechanisms of moisture evaporation during frying. Particularly, the addition of wheat and corn starch allows to significantly reduce the fat

content in the finished chips by forming a stronger starch matrix [14]. The authors [15] considered the mechanisms of oil absorption during deep frying and noted that the modification of the product surface reduces the fat content. Surface dehydration of potato slices by pre-drying also contributes to a 54% reduction in the fat content in chips. Given the valuable mineral composition of potatoes, which can be lost during intensive heat treatment, using potato mixtures and raw materials with a reduced starch content is promising. Additionally, there is a possibility of enriching chips with prebiotic components, particularly lactulose, as well as biologically active CO_2 extracts, which allows to increase their functional value [16].

Modern trends in the development of the food industry are also focused on enriching snack products with dietary fibers, which perform important physiological functions in the human body. Given the deficiency of dietary fibers in the diet of the population, it is relevant to create molded potato chips with the addition of plant bran, vegetable powders and other ingredients that contribute to increasing the nutritional and biological value of the product while simultaneously reducing its calorie content [17].

Psyllium is one of the most studied sources of dietary fiber. It is obtained from the husk of plantain seeds (*Plantago ovata*). The uniqueness of psyllium lies in the high content of soluble fibers (up to 70%), mainly arabinoxylans, which have high hydrophilicity. When in contact with water, they form a viscous gel-like mass, which is a natural enterosorbent that adsorbs and removes toxins from the body [18].

The gel-forming fraction of psyllium has an enveloping effect on the mucous membrane of the gastrointestinal tract, creating a protective barrier that promotes the fastest healing of wounds and erosions, eliminating discomfort during digestion. This allows it to be used as a functional ingredient to alleviate the symptoms of irritable bowel syndrome and correct the glycemic profile [19, 20].

Most of the beneficial health effects of psyllium are explained by the high content of soluble polysaccharides (mainly arabinoxylans), which are very important biologically active ingredients [21]. Since baked chips are not exposed to aggressive hot fat, the structure of psyllium fibers is better preserved and such products have a significantly lower glycemic index compared to conventional fried potato snacks. Studies [22] have also shown that adding hydrocolloids, including psyllium, has the effect of reducing the glycemic index of gluten-free bread.

Dietary fiber is a complex carbohydrate of plant origin. Due to the specific configuration of glycosidic bonds, it is not subject to enzymatic hydrolysis in the human small intestine. However, it is used for dietary purposes, as it serves as a prebiotic substrate for the microflora of the colon and regulates the rate of nutrient absorption [23].

Thus, the analysis of modern scientific research shows that the improvement of potato chip production technology is aimed at reducing the fat content and harmful heat treatment products, particularly acrylamide, as well as increasing the nutritional value of the finished product. The most promising areas are alternative methods of dehydration, pre-treatment of potatoes before frying, optimizing the composition of ingredients and enriching the chips with valuable components through functional plant ingredients, particularly to reduce the starch content and increase the proportion of indigestible carbohydrates. The implementation of these approaches allows to create competitive snack products with improved safety and quality properties that meet modern requirements for healthy eating.

Research objectives. The purpose of the study is to determine the feasibility of using functional additives of plant origin (psyllium and a fiber mixture) and dehydration of molded potato chips by high-temperature baking to improve the nutritional value of the product and reduce the negative impact of deep-frying.

To achieve this goal, the following tasks were set:

1. To investigate the effect of various sources of dietary fiber (a mixture of fiber from milk thistle, pumpkin and flax seeds and psyllium) on the structural and mechanical properties of semi-finished products and chips.

2. To establish reasonable parameters of high-temperature baking of molded potato chips with the added mixture of fiber or psyllium.

3. To establish the main physical, chemical and sensory properties of finished products.

4. To determine the nutritional and energy value of the developed products.

Research materials and methods

The materials used in the study were dry mashed potatoes formed into flakes (DSTU 4993:2008); potato starch (DSTU 4286:2004); table salt (DSTU 3583:2015); psyllium TM "Zdorovo" (TU U 10.8-42063780-001:2018) and a mixture of fiber from ground milk thistle, pumpkin and flax seeds TM "Dr. Fiber" ("Agrosilprom" LLC). Some of the research was conducted as part of a master's qualification work [24]. The water-binding capacity of the dry recipe mix for chips was determined by a method based on centrifugation of the dry mix suspension [25]. The ultimate shear stress of potato dough was studied by penetration method: an immersion of a cone with a 60° angle at the apex with a constant penetration force into the mass on an automated penetrometer AP-4/1. The hardness of chips was determined on a device developed at ONTU by pressing a stamp onto the surface of the products until the sample was destroyed. In this case, the force at which the sample collapsed was measured [26]. Physical, chemical and sensory properties of finished

products had to meet the requirements of DSTU 4608:2006 "Potato chips and snacks".

Sensory evaluation of the developed molded potato chips was carried out by an expert group of 15 members, who evaluated the samples by their shape, structure, taste, aroma and color. Sensory evaluation was carried out using the rating test method, in which pre-coded samples were rated on a five-point scale (1 - very low, 5 - very high).

Mathematical processing of experimental data was carried out using the MATSTAT program (number of experiment repetitions n=3, reliability P≤0.05).

As a control sample, a recipe for molded potato chips was chosen (52.3% dry mashed potatoes, 10.8% potato starch, 1.4% salt, 35.5% water), to which a fiber mixture was added in an amount of 3, 5 and 7% or psyllium in an amount of 2, 3 and 4% to the mass of dry mashed potatoes.

Molded potato chips were manufactured by the following method. Dry mashed potatoes in the form of flakes were fed into a mixer, where potato starch, salt and, depending on the type of samples, fiber mixture or psyllium were added. The components were mixed for 5 min, and then room temperature water was added to the mixture with continuous stirring. Mixing was carried out until a dough mass of uniform consistency was obtained. Water was added in an amount that ensured a dry matter content of 55-62%. The mixing duration was 15 min. The resulting potato dough was left to stand for 10-15 min for complete hydration of the fibers in the additives and fed into a dough rolling machine for rolling into a ribbon with a thickness of no more than 0.8 mm. The formed ribbon was cut into individual square chips (40×40 mm). The chips were baked in an electric oven at a temperature of 180-190 °C for 10-11 min. The baked chips were cooled to a temperature of 25-30 °C and inspected to remove burnt and substandard particles.

In the studies, psyllium and a mixture of fiber from ground milk thistle, pumpkin and flax seeds were used as functional additives of plant origin, the chemical composition of which, according to the labeling, is given in Table 1.

Table 1 - Chemical composition of psyllium and a mixture of fiber per 100 g of product

Parameters	Psyllium	Fiber mix from ground milk thistle, pumpkin and flax seeds
Protein, g	2.5	28
Fat, g	0.5	12
Carbohydrates, g	4	18
Dietary fiber, g	86	40
Calories, kcal	162	298

Results of the research and their discussion

As a result of the conducted studies, the physical, chemical, structural and mechanical properties of semi-finished products (bulk mass, water-binding capacity of the recipe mixture, ultimate shear stress of potato dough) and finished products (moisture content, hardness) were determined.

The bulk mass reflects the density of the particles of powdered raw materials, and therefore quantitatively characterizes its ability to fill a unit of volume.

The results of studying the bulk mass of the chip recipe mixture showed that with increased amount of fiber and psyllium in the mixture, the bulk mass increases slightly. Thus, when adding 5% of fiber mixture, it increased by 4.4%, and when adding 3% psyllium, it increased by 2.4% compared to the control (Fig. 1). With a further increase in the amount of additives, the bulk density increases significantly, which is explained by the high dispersion and homogeneity of psyllium powder and the fiber mixture compared to potato flakes. This makes it possible to predict the behavior of the dough during kneading, increasing its density with the addition of the studied ingredients.

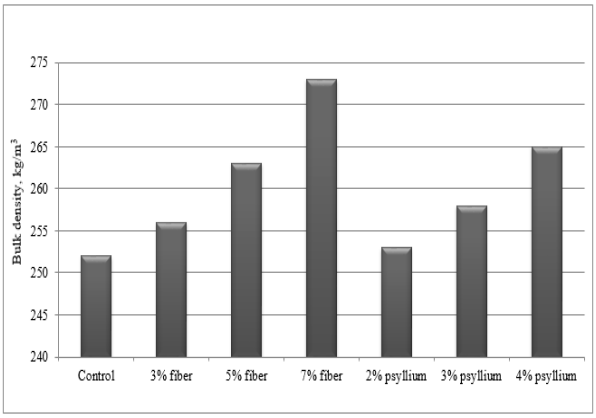

Fig. 1. Bulk density of the chip recipe mixture with fiber mixture and psyllium

The water-binding capacity is characterized by the adsorption of water with the participation of hydrophilic amino acid residues. At low humidity, hydrophilic groups form a monomolecular layer interacting with water molecules; at high humidity, a multilayer structure is formed around the protein globules with simultaneous penetration of water into the depressions and protrusions.

From the experimental data (Fig. 2) it follows that with increased amount of psyllium and the fiber mixture, the water-binding capacity of the chip recipe mixture increased proportionally. Thus, with the amount of fiber increased to 7% in the experimental samples, the water-binding capacity indicator increased 1.8 times compared to the control sample. When adding up to 4% of psyllium, the water-binding capacity of the recipe mixture also increased 1.75 times. The increase in the water-binding capacity of the mixture, in our opinion, is primarily due to the significant content of non-starch polysaccharides in the studied ingredients and may also be due to their high dispersion. The obtained dependences are consistent with the available research results, particularly those highlighted in [27].

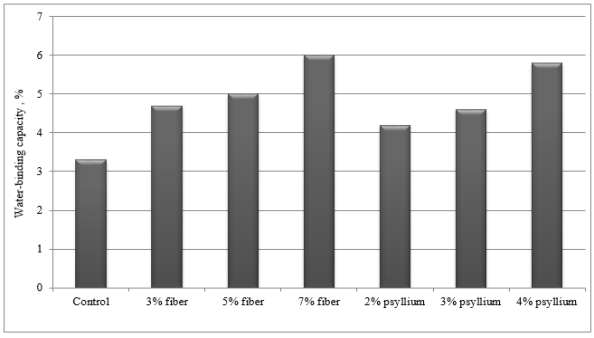

Fig. 2. Water-binding capacity of the chip recipe mixture

To establish the effect of the fiber mixture and psyllium on the structure formation of potato dough for chips, penetration studies were conducted. The results of studies of the ultimate shear stress of the test samples confirmed the strengthening of the biopolymer framework of potato dough (Fig. 3). With increased amount of the fiber mixture or psyllium in the potato dough, the strength properties of all the tested samples increased. The ultimate shear stress of the mass increased 1.24 times for the sample with 5% of the fiber mixture and 1.1 times for the sample with 3% of psyllium compared to the control. At the same time, the potato dough becomes more plastic and cohesive, such dough is easier to shape and roll into thin layers without breaks. When the amount of fiber mixture is increased to 7% and psyllium to 4%, the potato dough becomes excessively compacted (the ultimate shear stress increases by 205 Pa and 182 Pa, respectively), which makes it difficult to roll it out and form semi-finished products for baking.

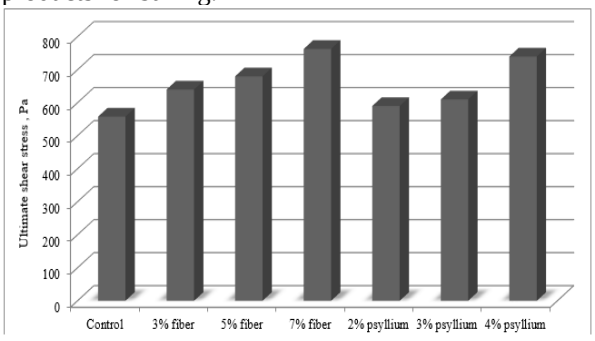

Fig. 3. Ultimate shear stress of potato dough with the mixture of fiber and psyllium

The amount of moisture in the product determines the consistency, texture and energy value. The stability of the product during storage, its transportability and suitability for further processing are closely related to the water content. Experimental data showed that with an increased amount of the fiber mixture and psyllium, an increased moisture content in finished products is observed. Thus, with the amount of the fiber mixture increased to 7% in the experimental samples, the moisture content was 42% higher, and with the amount of psyllium increased to 4%, the moisture content was 54% higher compared to the control sample (Fig. 4). Due to the high water-binding capacity of the hydrocolloid additives, the rate of moisture evaporation from the inner layers of the products during baking slows down, and the chips acquire a brittle, but not hard structure.

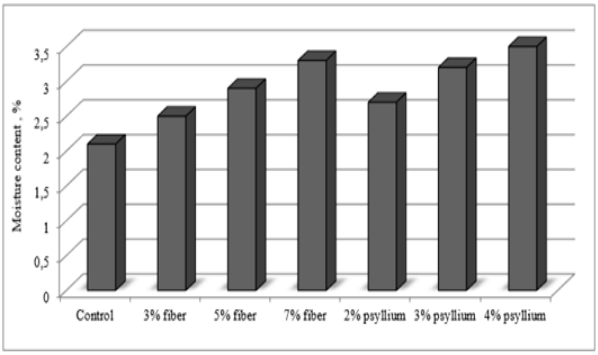

Fig. 4. Moisture content of molded potato chips with a mixture of fiber and psyllium

Excessive hardness and dryness are the main problems for fat-free potato chips prepared by high-temperature baking, which is confirmed by the data [28]. In this regard, the effect of adding fiber mixture or psyllium on the hardness of chips was investigated. The results showed that the hardness of the studied baked samples decreases, probably due to their higher moisture content (Fig. 5), the chips become more plastic. Thus, when adding 5% of the fiber mixture, the hardness decreases by 18.4%, and when adding 3% of psyllium by 10.5% compared to the control sample. This data is consistent with the results of studies [19], which found that adding 5-7.5% psyllium increases water absorption and reduces product hardness.

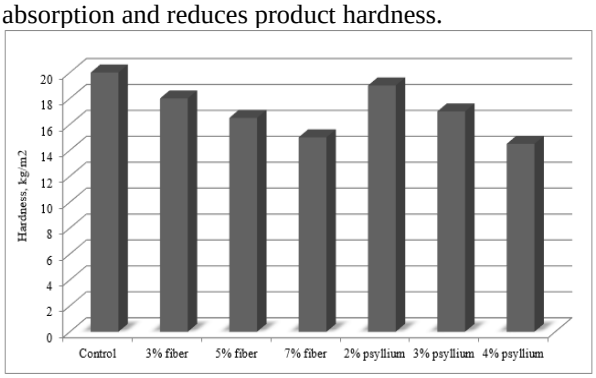

Fig. 5. Hardness of molded potato chips with fiber and psyllium

Given that decreased hardness of chips with fiber or psyllium can lead to the loss of crispiness, in further studies it was necessary to conduct a sensory assessment of the changes in the product quality.

Sensory characteristics include quality parameters that determine the consumer properties of products, such as shape, structure, taste, aroma and color. The sensory properties of molded potato chips with fiber mixture or psyllium were converted into relative units and presented in the form of diagrams.

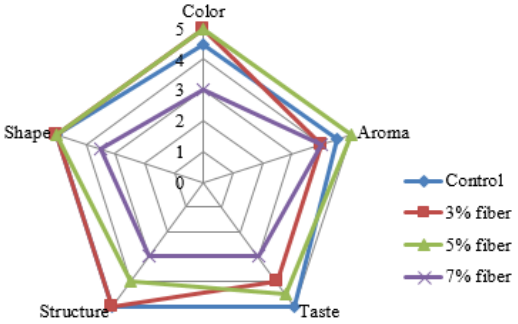

Fig. 6. Sensory properties of chips with fiber mixture

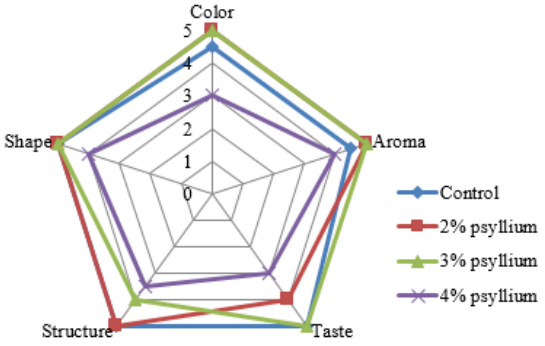

Fig. 7. Sensory properties of chips with psyllium

During research, it was found to be reasonable to add 5% of the fiber mixture (Fig. 6) or 3% of psyllium (Fig. 7) to the recipe of dry mashed potatoes. Products with this amount of functional plant additives have properties that meet the standards and are close in sensory characteristics to traditional chips. They have a pleasant aroma and potato taste, a porous structure, a uniform surface without cracks and a beautiful golden color, but their crispiness is somewhat reduced compared to the control sample. The amount of the fiber mixture or psyllium in these samples is selected in such a way that it does not deteriorate the structure and consistency of the potato dough, so that these samples can be easily given the correct shape that is retained during baking. Samples with a larger amount of the fiber mixture or psyllium have worse taste and aroma, a darker color with inclusions of additive particles, and an uneven surface.

Given the other taste properties and loss of crispiness of the studied products, it was necessary to adjust their baking parameters. Additionally, when baking potato chips, psyllium and fiber mixture, due to their high water-binding capacity, stabilize the polymer matrix of the dough, therefore, a slowdown in moisture loss was observed during baking, which increased the risk of chip deformation, the formation of cracks due to the lag of moisture diffusion to the surface layers, etc. Therefore, the introduction of these additives into the recipe of baked molded potato chips necessitates the correction of dehydration parameters relative to the control sample, which was baked at 180-190 °C for 10-11 minutes. The results of studies on the influence of baking parameters (temperature and baking time) for samples with 5% fiber mixture or 3% psyllium are presented in Table 2. It was discovered that the best quality is achieved at a temperature of 170-180 °C and a baking time of 14-15 min, which ensures a decrease in final moisture content to 2.2–2.5% and the formation of a stable, crispy structure with uniform porosity and attractive color. An increase in temperature and baking time above the recommended values is accompanied by a decrease in final moisture content, an increase in brittleness, and a dark color of baked potato chips, which is not desirable.

Lowering the temperature and extending the baking time of the studied samples ensures gradual and uniform evaporation of moisture, the formation of a uniform, glossy surface, prevents thermal deformation and the appearance of cracks on the surface of the products. The use of psyllium hydrocolloids in baked products allows to imitate the texture of fried snacks by forming a porous structure, which is confirmed by studies [29]. Adding psyllium and a fiber mixture while simultaneously adjusting the baking parameters contributes to the formation of a brittle, but not hard structure of the finished products, which is typical for chips without added fat.

As a result of assessing the structural, mechanical, physical, chemical and sensory properties of molded potato chips, the feasibility of adding 5% of the fiber mixture or 3% of psyllium to dry mashed potatoes was proven, and technological parameters for high-temperature baking of molded potato chips without loss of their quality were established. Based on the research, recipes for baked molded potato chips “With fiber” and “With psyllium” were developed that can be recommended for manufacture. Considering that the developed technology for the production of molded potato chips does not require frying in oil, using studied ingredients will not significantly affect the production cost.

Adding psyllium or a fiber mixture to baked potato chips increases the nutritional value of the products (Table 3), transforming them from an “empty” carbohydrate snack into a source of prebiotic dietary fiber. The amount of digestible carbohydrates decreases; when using the fiber mixture, the protein content increases by 8.2%, dietary fiber by 41.6%, and the products are enriched with minerals, particularly calcium, magnesium, and vitamins A, B, and β-carotene. When using psyllium in the recipe, the dietary fiber content increases by 58%, and the fat content decreases by 2%, which is consistent with the data [30] that the introduction of psyllium into the composition of cookies led to a slight decrease in the percentage of fat and may be associated with an increase in the fiber and moisture content of the products. There is also a slight increase in the content of B-group vitamins. Consumption of 100 g of chips with psyllium will increase the degree of satiating the daily need for fiber to 27%.

Table 2 - The effect of temperature and baking time on the quality of baked potato chips with fiber mixture or psyllium

Baking temperature, °C	Baking time, min	Moisture content, %		Crispiness	Texture	Color
		5% fiber	3% psyllium			
160-170	11-12	3.0-3.3	3.0-3.5	Low	Soft, undercooked	Light
160-170	14-15	2.4-2.9	2.5-3.0	Medium	Moderately dense	Light gold
170-180	11-12	2.6-2.9	2.8-3.1	Medium	Even	Gold
170-180	**14-15**	**2.2-2.5**	**2.3-2.5**	**High**	**Crispy, evenly porous**	**Gold**
180-190	11-12	2.4-2.7	2.6-2.9	Medium	Brittle, with cracks	Dark gold
180-190	14-15	1.4-1.9	1.5-1.9	Very high	Excessively dry	Dark brown

Table 3 - Satiation of the daily requirement for macro- and micronutrients when consuming 100 g of potato chips

Nutrients	Daily norm	Nutrient content per 100 g of product, g			Satiation of the daily requirement when consuming 100 g of product, %		
		Control	3% psyllium	5% fiber	Control	3% psyllium	5% fiber
Protein, g	75	10.54	10.35	11.41	14.05	13.8	15.2
Fat, g	84	13.87	13.6	13.78	16.51	16.2	16.4
Carbohydrates, g	310	65.61	62.75	63.23	21.16	20.24	20.39
Fiber, g	25	4.3	6.8	5.09	17.2	27.2	20.4
Vitamins							
A, mcg	900	24.0	24.4	28.6	2.7	2.71	3.2
β-carotene, mg	5.0	2.0	2.03	2.28	40.0	40.6	45.6
B1, mg	1.2	0.30	0.312	0.336	25.0	26.0	28.0
B2, mg	1.3	0.90	0.925	1.02	69.2	71.2	78.5
B6, mg	2.0	0.40	0.412	0.452	20.0	20.6	22.6
Minerals, mg							
Ca	1000	88.4	88.87	104.0	8.84	8.89	10.40
Fe	10	2.9	2.86	2.76	29.0	28.6	27.6
Mg	400	138	137.2	150.1	34.5	34.28	37.52
P	700	331	326.0	314.5	47.3	46.6	44.9
K	4700	2265	2231	2152	48.2	47.5	45.8
Na	1300	1351	1331	1283	103.9	102.4	98.7
Energy value, kcal	2300	200.5	199.9	205.4	8.72	8.7	8.9

Conclusion

In the course of the conducted research, the influence of functional plant additives (a mixture of fiber or psyllium) on the structure of potato dough for molded chips was established. It was discovered that with an increased amount of additives, the ultimate shear stress of the mass increases 1.24 times compared to the control when adding 5% of the fiber mixture and 1.1 times when adding 3% of psyllium. At the same time, the dough becomes more plastic and cohesive, easier to roll into layers and mold.

The parameters for the heat treatment of potato chips with a fiber mixture or psyllium were experimentally substantiated. It was discovered that with the temperature of 170-180 °C and the baking time of 14-15 min, the final moisture content of the chips decreases to 2.2-2.5%, which ensures the formation of a stable crispy structure of the chips with uniform porosity and an attractive appearance.

A comprehensive assessment of the physical, chemical and sensory properties confirmed the technological and practical feasibility of adding 5% of the fiber mixture or 3% of psyllium to dry mashed potatoes in the recipe of molded chips. The use of functional plant ingredients (psyllium and fiber) in the technology of molded potato chips contributes to the expansion of the ingredient base for production, increasing the nutritional value of the finished product, as well as enriching it with dietary fibers with their characteristic prebiotic properties, vitamins and minerals.

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ВДОСКОНАЛЕННЯ СКЛАДУ ФОРМОВАНИХ КАРТОПЛЯНИХ ЧІПСІВ З ВИКОРИСТАННЯМ ФУНКЦІОНАЛЬНИХ РОСЛИННИХ ДОБАВОК

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Анотація. Сучасна харчоконцентратна галузь України перебуває на етапі активної трансформації, зумовленої зміною харчових звичок населення та зростаючим попитом на продукти швидкого харчування, які поєднують зручність споживання, різноманітність смаків та високу поживну цінність. Світовий тренд здорового харчування вимагає від виробників створення функціональних продуктів, збагачених білком, вітамінами та харчовими волокнами, при одночасному зниженні калорійності. Отже, необхідною умовою висококонкурентного виробництва снеків є підвищення їх якісних характеристик, харчової та біологічної цінності, органолептичних властивостей, безпечності готової продукції. Традиційні картопляні чіпси характеризуються високою енергетичною цінністю, адже містять до 30-40% жирів. Крім того процес їх обсмажування у фритюрі призводить до утворення продуктів окислення ліпідів та інших антипоживних речовин. У роботі представлено технологічне рішення щодо вдосконалення складу формованих картопляних чіпсів шляхом введення джерел харчових волокон: псиліуму (лушпиння насіння Plantago ovata) та суміші клітковини з насіння розторопші, гарбуза й льону і заміни способу дегідратації з обсмажування у фритюрі на високотемпературне випікання. Псиліум, який містить до 86% харчових волокон, відіграє роль не лише нутрієнтного збагачувача, а й ефективного гідроколоїда-структуроутворювача. Встановлено, що додавання псиліуму в кількості 3% або суміші клітковини в кількості 5% від маси сухого картопляного пюре є найбільш раціональним для формування пластичної, більш зв'язаної маси, придатної для формування у вигляді пластів. Структурно-механічні дослідження підтвердили зміцнення біополімерного каркасу картопляного тіста: гранична напруга зсуву в зразках із добавками підвищується у 1,1-1,24 рази порівняно з контролем. Експериментально обґрунтовано режими термічної обробки чіпсів, випікання при 170-180 °С протягом 14-15 хв дозволяє знизити кінцеву вологість чіпсів до 2,2-2,5% та отримати хрустку пористу структуру з привабливим золотавим кольором. Застосування псиліуму забезпечує підвищення вмісту харчових волокон на 58%, суміші клітковини - на 41,6% порівняно з контрольним зразком. Крім того, відсутність дії агресивного гарячого жиру під час випікання чіпсів сприяє кращому збереженню структури волокон псиліуму та клітковини, що підтверджує їх перспективність для дієтичного харчування.

Ключові слова: харчові концентрати, картопляні снеки, високотемпературне випікання, харчові волокна, псиліум, клітковина, структура, харчова цінність.

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