The object of this study is snack technologies for various types of gluten-free breading for "Fast food" ERI format.

It has been determined that snacks are gaining more and more demand in restaurants of the "Fast food" format. From the point of view of a balanced diet, snack products for fast food are rich in cholesterol with increased amounts of sugar, salt, and gluten protein. In the course of technological testing, components for dry breading were selected: rice flour, extruded oatmeal and corn flakes, sesame seeds. For the manufacture of snacks, the main raw material was chosen – shrimp meat, poultry, soft cheese "Brie". To give the snacks more refined and rich tastes, spices were used: turmeric and ground paprika.

For the most part, the technologies are designed for freezing and subsequent heat treatment (deep-frying). According to this, the specificity of the development of two-layer breading was investigated, namely the development of the "Klyar" semi-finished product and dry breading. The composition of the "Klyar" semi-finished product includes cold-swollen starch "Cold Swell", which is able to quickly swell and form a colloidal suspension.

Due to the functional properties of starch "Cold Swell", the cycle "freezing – heat treatment" took place without significant heat loss. With a starch content of 3.5 % in the breading composition, during their cutting, homogeneity of the main product and breading was observed. Carrying out technological testing, it was determined that the starch content is 3.5 %, the losses during heat treatment are up to 8.0 %, thereby confirming that the properties of starch do not only bind but also hold moisture.

During the study of microbiological indicators, it was determined that frozen snacks are capable of withstanding long-term storage for up to 90 days at a temperature of 18...– 24 °C

Keywords: gluten-free breading, "Cold swell" starch, "Klyar" semi-finished product, two-layer breading, freezing

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DEVELOPMENT OF TECHNOLOGY OF SNACKS WITH DIFFERENT TYPES OF BREADING FOR FAST FOOD ENTERPRISES

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1. Introduction

Thanks to globalization, the fast-food food industry is developing rapidly. Globalization processes in the world have led to the emergence of a cosmopolitan form of food, which means an increase in the speed flow of food coming from other countries and continents: pizza, sushi, hamburgers, nuggets, etc. Fast food actively affects the taste receptors by increasing salt, sugar, fats, flavor enhancers and other additives, thereby attracting a large number of consumers.

One of the more popular group of meals among fast food is snacks. These products can most often be called hot appetizers but in establishments of the restaurant industry (ERI) of the "Fast food" format it has a more kerative name – snacks. Snacks in "Fast food" ERI have the form of food products that can be consumed by hand, that is, meals for a snack. The assortment range of snacks is as follows:

– nuggets, strips (natural or minced products made of meat, fish, poultry, seafood);

– vegetable snacks (French fries, potato balls, or deep-fried vegetable croquettes, etc.);

– milk-cheese snacks (cheese balls, croquettes from cottage cheese, etc.).

In ERI, the production of snacks is aimed at their long-term storage in the form of semi-finished products in a frozen state. During heat treatment (deep-frying), snack semi-finished products should be fully brought to a state of culinary readiness with appropriate qualities indicators.

To maintain the quality indicators of snacks, people most often pay attention to breading materials, which not only increase the organoleptic characteristics of snacks but also play a significant role in preserving the structural and mechanical properties of the product, in particular for snacks that freeze in advance.

The main task facing manufacturers is the selection of breading materials that are able to withstand sudden changes in temperature. In this case, these are food ingredients, which may include starch, pectin, combinations of mineral salts with polysaccharides.

In the fast-food industry, food additives that can stabilize products during the "freezing – heat treatment" cycle have become widespread, among which hydrocolloids of a

polysaccharide nature are the primacy in terms of variability of indicators.

The selection of these components is associated with many problems:

– most modified starches show stability during low temperatures, but they may have low organoleptic properties (rich starchy taste);

– the use of food additives of a polysaccharide nature (gums, carrageenan, alginic acids), which can exhibit technological functions in certain reactions with calcium or sodium salts;

– the selection of dry breading, which mainly consists of wheat flour or bread processing products, reveals very low stability during freezing storage. This is accompanied by the presence in them of native starches that undergo retrogradation during storage. The main problem is that flour breading has quite high taste advantages but low physiological properties (presence of gluten protein).

Thus, scientific research with the justification of new types of breading, which will have a gluten-free composition, as well as have stable properties for snacks during the "freezing-heat treatment" cycle, is relevant.

2. Literature review and problem statement

Around the world, fast food establishments that sell culinary products, in particular snacks with high quality indicators, are gaining momentum at a rapid pace [1].

Almost all snacks are subjected to heat treatment and are sold at a feeding temperature of 65–70 °C. To a greater extent, products such as snacks and French fries are fried using deep frying, thereby complementing its taste [2, 3].

Currently, there are problems in the technological flow of snack production.

The first problem is the stability of quality indicators (organoleptic, physical-chemical indicators) during the cycle "freezing – heat treatment". Semi-finished (s/f) frozen snacks undergo heat treatment, deep-frying where, during exposure to high temperatures of 180 °C and pressure, the surface layer of breading can exfoliate or deform. The occurrence of this problem can occur under conditions not only of the difference in low and high temperatures but also from the technological properties of breading materials. Most often, breading materials are represented by starch-containing raw materials, mainly bread crackers and wheat flour. Therefore, wheat starch in breadcrumbs and flour is not modified and at low freezing temperatures, will show low stable qualities, as well as flour proteins during frying exhibit smoke burning.

Well-known manufacturers of the restaurant industry "McDonald's", "KFC", "Burger King" imply freezing snacks with special solutions containing hydrocolloids that can withstand both low and high temperatures.

Snack production is divided into several stages:

– the first stage: semi-finished products are initially blanched with the release of free moisture, but not brought to culinary readiness. The release of free moisture will further reduce the manifestation of ice glaze on the surface of the product;

– the second stage: the heat-treated semi-finished product is treated with liquid breading using hydro-colloidal solutions and immediately breaded in dry breading;

– the third stage: freezing [4, 5].

Based on this, it is determined that the main task of the manufacturer is the selection of hydrocolloids that are capable of forming a protective shell that can hold a dry layer of breading.

It should be emphasized that starches of chemical modification, which are able to withstand various technological factors, have become increasingly common. One of the critical factors that can influence is temperature extremes, during storage and heat treatment.

Analytical review of sources [5, 6] suggests that starches that have undergone acetylated oxidation are considered heat-resistant during low temperatures (–24 °C and below) and high temperatures (+220 °C). But, conducting experimental studies, it was determined that starches are custard (a type of gelling) and, moreover, their viscosity may increase during cooling.

Analyzing the formulation composition of the protective shell, which should cover the product during breading, revealed that it has the form of "Klyar" liquid dough. In [7], it is proposed to introduce tapioca starch, which has a striated modification, instead of wheat flour. Tapioca starch grains have an average particle size, that is, their gelling is faster than in native corn starch [8]. Thus, the production of batter with uniformly swollen starch grains occurs quickly, moreover, gels can be frozen, followed by defrosting without syneresis.

But in the course of research, it was determined that the viscosity of the liquid dough with their use can also increase, giving the shell a denser consistency.

The second problem is aimed at maintaining the influence of such trends as "Free from". Currently, the format "Free from" means the complete or partial removal of salt, sugar, gluten protein, and other substances from the diet. Therefore, based on this, "Fast food" ERI seek to change the concept to meals that do not contain gluten, or sugar, or have a low salt content. One of the conditions for reducing or completely eliminating the gluten protein for snacks is the selection of gluten-free breading [9].

Particular attention should be paid to breading because it is it that completes the process of giving the product a pleasant appearance. To ensure optimal storage conditions in the frozen state, there is a selection and use of breading materials.

Traditionally, breading to a greater extent should consist of flour or crushed crackers in combination with a Leeson or liquid dough.

Leading experts in the field of production of semi-finished products for fast-food use breading materials, which include flour mixtures, bakery products, food additives, in particular thickeners, preservatives, spices.

There are many scientific directions in the development of breading materials that have different functional and technological properties. For the most part, all areas are aimed at the production of breading materials with a complete absence of gluten in the composition.

The authors of [10] developed the technology of breading, the basis of which is a combination of dry powders from vegetables (tomatoes, sweet peppers) and bean flour. During the production of products, semi-finished products were first treated with a suspension based on sodium alginate, and then breaded. Of course, alginate gel shows heat resistance and does not lose its structure-forming properties. As for vegetable powders in breading, they can change color (bur-

ritos) during freezing, and bean flour is not heat-resistant during low and high temperature extremes. Therefore, this type of breading cannot be suitable for fast food products.

But in other works [11, 12], a new range of gluten-free breading is proposed, namely with the use of bean flour. However, rice flour was added to the composition, as well as dry powders from celery roots, parsley, thereby complementing the taste preferences of the product. The developed breading materials were used for frozen fish semi-finished products. It was investigated [13] that gluten-free breading does not affect changes in the physicochemical parameters of fish semi-finished products during refrigeration storage for 24 days. But this type of breading subsequently requires heat treatment at no higher than 160 °C (traditional frying) since deep frying (t=170–180 °C) can partially deform the product.

The possibility of preparing products using deep frying due to breading based on soy flour has been established [14]. This raw material has a positive effect on the technological process of deep-frying, namely the temperature regime. Soy flour positively manifests itself in the melanoid formation reaction, which passes faster than when using wheat flour or breading – due to a larger amount of protein, which makes it possible to reduce the frying temperature. This feature has a positive effect on deep fat, on its quality and duration of use. But it is impossible to completely call this breading gluten-free because wheat flour is added to the technology in a ratio of 3÷1 (since this raw material contains little starch).

The leaders in the market of breading materials, in combination with cereal raw materials, herbs, with the addition of spices, are TM "Pripravka", TM "Shchebpak", and others.

In the course of the analysis of the recipe composition of breading materials of TM "Pripravka" it was revealed that it includes a mixture of different types of flour, ground kernels of buckwheat, oatmeal, rice and corn grits. Also, manufacturers combine flavoring ingredients (dry mustard, garlic, honey, glucose syrup) with breading materials. Breadcrumbs for breading by TM "Szczebpak" contain dried crackers of wheat bread with the addition of turmeric, and the assortment also includes breadcrumbs with the addition of Caucasian spices. But to a larger degree, the breading materials presented can only be suitable for culinary products without prior freezing, or in home cooking.

Based on the above scientific research, gluten-free breading has its advantages and disadvantages. One of the main drawbacks is the instability to withstand drops in low and high temperatures, due to the low protein content, so gluten-free breading is usually used for culinary products for not mass consumption.

However, manufacturers present many traditional breading materials for the production of culinary products of mass consumption on the market. These culinary products undergo deep freezing over –24 °C and long-term storage. Monitoring the breading materials, it was determined that they contain wheat flour, corn, modified starches, moisture-retaining salts, preservatives, as well as dyes, which further give the orange range of products.

One of the unresolved problems is the use of gluten-free breading that can withstand low temperature conditions (–18...–24 °C), or high (+200....+220 °C). Moreover, after different temperature differences, the dry breading layer should be evenly distributed, without deformations on the product, and when consumed, have a crispy crust. To solve this problem, it is necessary to form a layer of liquid breading, which would be able to form a protective layer for the main product and a base layer for sticking dry gluten-free breading.

3. The aim and objectives of the study

The aim of this study is to develop the technology of snacks with various types of gluten-free breading for establishments of the restaurant industry in the "Fast food" format, which will enable its implementation in the fast-food system.

To accomplish the aim, the following tasks have been set:

– to develop a formulation composition of dry breading;

– to investigate the influence of technological factors on the physicochemical properties of starches of the "Cold Swell" series;

– to propose and justify the technological scheme of production of snack products.

4. The study materials and methods

According to these requirements, a study of model systems (MS) was carried out during freezing and heat treatment – deep-frying (t=170–180 °C) (Table 1). Their composition includes:

– s/f "Boiled shrimp meat", s/f "Meat minced chicken", s/f "Brie cheese prepared", chicken eggs according to DSTU 5028:2008;

– drinking milk according to DSTU 2661:2010;

– starch of "Cold Swell" series, rice flour, flakes (oatmeal, corn), extruded, ground paprika, sesame seeds (white and black).

Determination of the effective viscosity of starch dispersions was carried out on a rotational viscometer of the type VPN-0.2 (Ukraine) [15].

Dynamic or effective viscosity was determined by (1):

$$\eta = k \cdot U \cdot T \cdot A, \quad (1)$$

k – constant of the measuring node, Pa/V;
U – voltage, V;
T – rotation period, s;
A – the coefficient of the measuring unit.

The shear rate γ was determined by (2):

$$\gamma = \frac{1}{T \cdot A}, \%. \quad (2)$$

The shear stress τ was determined by (3):

$$\gamma = k \cdot U. \quad (3)$$

Computer technologies were used in the work: Google search engines; scanning devices and optical recognition systems, in particular, Fine Reader 10.0 (USA); MS Office 2010 (USA).

Table 1

Composition of model systems

MS composition	Content, %					
	MS 1	MS 2	MS 3	MS 4	MS 5	MS 6
«Boiled shrimp meat» s/f	75...80	75...80	0	0	0	0
«Minced meat, chicken» s/f	0	0	80...83	80...83	0	0
«Brie cheese prepared» s/f	0	0	0	0	65...70	65...70
Chicken eggs	25.0	25.0	33.0	33.0	35.0	40.0
Milk	55.0	55.0	60.0	60.0	57.0	57.0
Starch «Cold Swell»	2.22	2.80	2.45	2.50	3.0	3.5
Rice flour	35.0	37.0	45.0	47.0	49.0	51.0
Oatmeal flakes, extruded	30.0	32.0	0	0	47.0	50.0
Corn flakes, extruded	0	0	53.0	55.0	0	0
Ground turmeric	1.5	1.5	0	0	0	0
Ground paprika	0	0	1.75	1.75	0	0
Sesame seeds white	0	0	0	0	1.5	1.5
Sesame seeds black	0	0	0	0	1.5	1.5

5. Results of the study of technological parameters of obtaining snacks with gluten-free breading with subsequent freezing

5. 1. Development of the formulation composition of dry breading for snacks

For the production of snacks that require long-term storage in a frozen state, followed by heat treatment, it is necessary to create a two-layer breading. The main task of two-layer breading is to preserve moisture as much as possible and reduce fat loss to ensure the juiciness of the product during freezing. Typically, two-layer breading consists of a liquid solution based on eggs, milk, flour (the "Klyar" semi-finished product), and dry flour breading.

During the development of dry breading for snacks, preference was given to plant materials that do not contain gluten. Also included are spices produced by industry in a dry form: turmeric, paprika, curry, sesame seeds, which have an incredibly powerful antioxidant ability.

As a liquid breading, we used the cold-swollen starch "Cold Swell". Starches of the "Cold Swell" series have several advantages over traditional soluble starches, namely: they better withstand temperature and mechanical stress, bind more water, give the product greater viscosity. When interacting with cold water, it has a viscous consistency, easily envelops the product, and creates the effect of sticking breading in a uniform distribution over the entire volume. At the same time, starch gel is heat-resistant, does not lose its structure-forming properties after heat treatment [16].

According to the research objectives, it is planned to develop snacks for ERI of the "Fast food" format, which will be pre-breaded, frozen, and then heat treated using deep-frying.

During the development of the range of snacks, the following assortment is presented:

– breaded shrimp meat – the name for snacks is "Appetizing seafood";

– minced chicken meat (type – nuggets, hereinafter referred to as nuggets) – the name for snacks "Delicious chicken";

– soft cheese "Brie" in breading – the name for snacks "Crispy brie cheese".

The main task of the selection of breading materials is not only the selection of raw materials according to taste preferences but also the production of snacks with appropriate quality indicators:

– density of fit of breading materials to the product;

– lack of separation of breading in the process of freezing, deep-frying, as well as selling (portioning).

During the selection of dry breading materials, the use of wheat flour, white bread or crackers containing gluten protein is completely excluded.

To obtain new types of breading, the selection of cereal raw materials and spices was carried out (Table 2). As a cereal raw material, rice flour, oatmeal, corn, which have undergone extrusion processing, were used. This treatment will make it possible to instantly absorb external moisture and retain it inside.

Table 2

Dry breading formulation project

No. of entry	Snack products in assortment:					
	Breaded shrimp «Appetizing seafood»		Nuggets «Delicious chicken»		Cheese «Brie» breaded «Crispy brie cheese»	
	Name of raw materials	Content, %	Name of raw materials	Content, %	Name of raw materials	Content, %
1	Rice flour	72.0	Rice flour	39.0	Rice flour	49.0
2	Extruded crushed oatmeal flakes	25.0	Corn flakes, extruded, crushed	57.0	Oatmeal, extruded, crushed	49.0
3	Turmeric	3.0	Ground paprika	3.0	Sesame seeds, white	1.0
4	–	–	Curry	1.0	Sesame seeds, black	1.0

Most often, many manufacturers use cereal raw materials (in their native state) in the form of crushed grains of corn, rice, oats. But in any case, during heat treatment, crushed grains, namely their surface aleurone layer, will not pass the stage of complete destruction (softening), which will lead to more rigid breading and worsen organoleptic performance. Therefore, extruded flakes were used, which to a greater extent will be easier to assimilate, as well as in the process of heat treatment will be brought to readiness.

For nuggets, cornflakes are predominant, which add a sweetish flavor to chicken meat, and the use of paprika, curry will only enhance the taste benefits of chicken and the color of the breading range.

For a more dessert taste of Brie cheese, a combination of rice flour and oatmeal is used, which especially emphasize cheese products. Also, to give a marketable look, sesame seeds are used, white and black.

5. 2. Investigation of the influence of technological factors on the physicochemical properties of starches "Cold Swel"

We plan to develop the development of batter for semi-finished products using cold-swelling starch "Cold Swell". To substantiate the starch content in batter, it is necessary to

investigate the temperature of starch gelling and the change in effective viscosity depending on content (Table 3, Fig. 1).

Table 3

Rheological characteristics of SS of experimental starch

Name of starch	Gelling parameters	
	Initial gelling temperature, °C	Maximum gelling temperatureï, °C
Native potato starch	67±2	73±2
Starch Cold Swell 3681	27±2	55±2
Starch Cold Swell 5571	32±2	57±2
Starch Cold Swell 5573	31±2	56±2

For research, starch suspension (SS) was used in an aqueous medium (t=20±2 °C). Potato starch (native) was taken as a control since in terms of the botanical composition, the starch of "Cold Swell" series is potato-based.

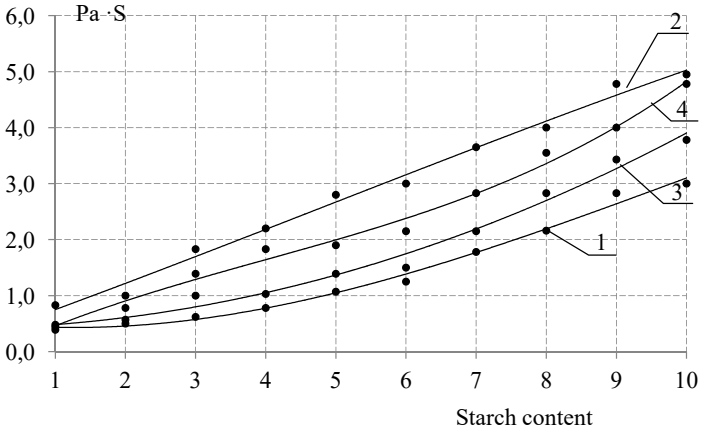

Fig. 1. Dependence of the effective viscosity of starch suspension on starch content: 1 — potato; 2 — potato Cold Swell 3681; 3 — potato Cold Swell 5571; 4 — potato Cold Swell 5573 (for $\dot{\gamma}$=50 s^{-1})

As can be seen from rheological studies, cold-swollen starches begin to swell at a temperature of 27±2 °C, it is visually observed that the SS using starch "Cold Swell" 3681 begins to thicken to a viscous-plastic consistency.

It has been established that the regulation of starch content allows one to create starch suspensions:

– with the properties of liquid dispersions (from 1.0 % to 2.0 %);

– medium density dispersion (from 3.0 to 4.5 %);

– thick dispersions (from 5.0 to 10.0 %), which are fixed as parameters of the formulation composition of the semi-finished product "Klyar". The "Klyar" semi-finished product is a liquid breading that will form the first protective layer of breading.

According to these starch concentrations, it can be established that the potato starch "Cold Swell" 3681 with a content of 4.5 % can be used for batter (Table 4).

According to organoleptic indicators, starch-based SS «Cold Swell» has a neutral smell and taste, but when combined with dry breading, the product may also have an insufficiently pronounced taste. Therefore, to saturate the tastes, it is proposed to add egg products and milk. In the course of experimental studies, it was determined that the starch «Cold Swell» 3681 is also gelled in milk.

Table 4

Organoleptic indices of starch dispersions

Organoleptic indices of starch dispersions	Starch dispersion using starch by content 4.0...4.5 %		
	Cold Swell 3681	Cold Swell 5571	Cold Swell 5573
Appearance	Homogeneous viscous dispersion having a matte surface	Homogeneous viscous dispersion having a shiny surface	Homogeneous viscous dispersion having a loose surface
Consistency	Viscous-fluid, texture is short	Viscous-fluid, texture is long	Viscous-fluid, texture is long
Color	Transparent	Turbidity	Transparent
Smell	Neutral	Neutral	Neutral

During the development of snacks, one of the main factors is the study of the cycle "freezing – heat treatment (deep-frying)". The main requirements for the manufacturer during the development of snacks is the stability of breading, which should not exfoliate from the product. When deep-frying, breading on snacks should not deform or crumble. When selling, breading must stick to the product and have stable properties. According to these requirements, a study of model systems during freezing and heat treatment was carried out – deep-frying.

Organoleptic indicators of the developed model systems were evaluated by appearance, color, and smell.

From the studies, it was determined that with a starch content of 2.5 %, there is a decrease in the quality indicators of frozen model systems. Visually, this is accompanied by peeling of breading from the product, as well as the presence of cracks on the surface. With an increase in the starch content of 3.5 %, a denser protective layer is formed in the form of a gelled dispersion, which keeps dry breading on the surface of the product.

There is reason to consider it appropriate to carry out heat treatment after a freezing cycle or heat treatment of frozen semi-finished products.

To determine the starch content in model systems, the dependence of losses during freezing – heat treatment (deep-frying) was established. In the course of research, the starch content in MS was changed from 2.5 to 3.5 % (MS 1, MS3, MS 4), for MS 2, MS 4; MS 6 – the concentration was changed by 4.5 %. The dynamics of changes in heat losses are shown in Fig. 2. For the control sample, wheat flour was chosen as the breading material, in the content of 6.5 %.

In experimental studies, it was determined that starch losses of 3.5 % range from 8.3 to 5.5 % depending on the structure content of the main product, but these losses are not significant if they are compared with the control sample (13.5 %). For MS with a starch content of 4.5, minimal changes in heat losses are observed, which are 7.7...4.5 %.

In the course of organoleptic analysis, it was determined that MS that were breaded with a starch content of 3.5 % in the batter had a homogeneous distribution of breading without cracks, delamination. When cutting, the breading was not separated from the product, there was no cavity between the product and the breading. With a starch content of 4.5 % in the composition of batter, MS acquired a denser breading, which gave an unpleasant aftertaste, it was too starchy and bread, which clogged the natural taste of the main raw material.

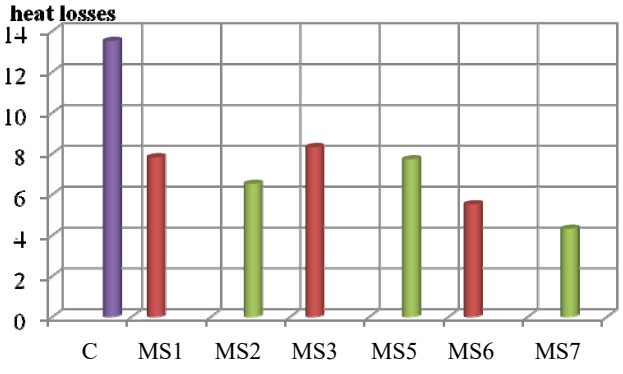

Fig. 2. Dynamics of changes in heat losses during the cycle "freezing – heat treatment (deep-frying) depending on the starch content in the s/f "Klyar": C – control (wheat flour, 6.5 %); MS1, MS 3, MS 5 – 3.5 % starch "Cold Swell", MS 2, MS 4, MS 6 – 4.5 % starch "Cold Swell"

Therefore, in the course of experimental studies, it is advisable to reasonably use starch "Cold Swell" in the composition of batter no more than 3.5 %.

5. 3. Development and justification of the technological scheme of snacks using gluten-free breading

At present, the restaurant industry has practically switched to raw materials and semi-finished products of industrial production. So, to obtain a batter, forming a formulation composition, skimmed milk is used. For microbiological safety, dry egg powder is used instead of fresh eggs. Dry egg powder was renewed with skim milk. Starch was suspended in milk at a temperature of 27±2 °C, for 10 minutes (Fig. 3).

For "Appetizing seafood" breaded shrimp, rice flour was sifted. Oatmeal flakes are crushed to a powdery state and mixed with flour and turmeric.

For the production of nuggets "Delicious chicken", rice flour is sifted, corn flakes are crushed to a powder. All components are mixed together with ground paprika and curry.

During the production of Brie cheese "Crispy brie cheese", rice flour is sifted. Oatmeal flakes are crushed to a powder. Sesame seeds are sifted. Rice flour is mixed with crushed flakes and sesame seeds.

Summarizing the development of the technological process of production of s/f "Breading materials", technological developments were carried out and a technological scheme for the production of snack products was developed (Fig. 4).

For the production of shrimp "Appetizing seafood", we carried out mechanical and culinary processing of shrimp (blanching, cleaning, washing). The prepared shrimp were salted and moistened in batter until completely immersed, then the shrimp was breaded in dry breading with a fork or thorn.

The breaded shrimp was again dipped in batter and rinsed again in dry breading, then a thorn or fork was removed from the product and breaded until the breading was completely distributed. The breaded shrimp were laid out on the grates and headed for the shock freezing chamber.

According to the same method, preparations were carried out for chicken meat "Delicious chicken" and brie cheese "Crispy brie cheese". The meat of chickens or chicken was cleaned, crushed until a minced mass was obtained. The formed minced semi-finished products were breaded in the same way as shrimp. Brie cheese was inspected before breading and cut into triangles.

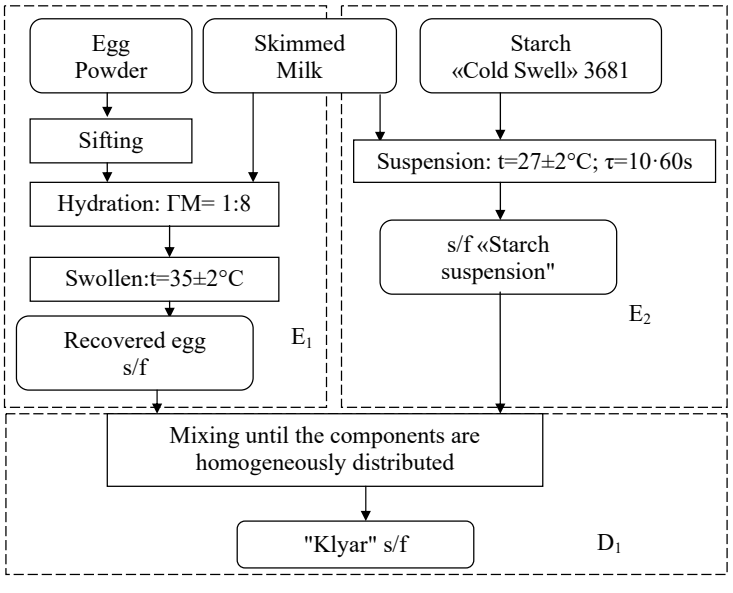

Fig. 3. Technological scheme of production of "Klyar" s/f

According to the developed technological process of production of snack products using new types of breading, the quality indicator of ready-made developed snacks was investigated (Table 5).

Table 5

Organoleptic indicators of developed snacks using new types of breading after the cycle of "freezing-deep-frying"

Organoleptic parameters	Characteristics for snack products		
	Shrimp «Appetizing seafood»	Nuggets «Delicious chicken»	Brie cheese «Crispy brie cheese»
1	2	3	4
Appearance	Snacks have the shape of a shrimp, during freezing and frying they have retained their shape, without cracks and swelling on the surface of the product	Snacks have the shape of rectangular or oval pieces, during freezing and frying they have retained their shape, without cracks and swelling on the surface of the product	Snacks have the shape of a triangle, during freezing and frying they have retained their shape, without cracks and swelling on the surface of the product
Consistency	Breading has a crunchy structure, during consumption or cutting, breading does not deform and fits snugly to the product. Minor cavities between the product and the breading sheath are allowed. The product is soft in the middle and brought to readiness		

Continuation of Table 5

1	2	3	4
Color	Golden with orange colors, uniformly distributed. No tanning	Golden, uniformly distributed. No tanning	Golden with orange colors, uniformly distributed. Interspersed with black and white sesame
Smell	Inherent, pleasant seafood and bread-breading, deep-fried. No extraneous odors	Inherent, pleasant to the bird and flour-corn breading, deep-fried. No extraneous odors	Inherent, pleasant brie cheese and breaded breading, deep-fried. No extraneous odors
Taste	Inherent in seafood with a sweetish aftertaste, without a foreign taste of oil and decomposition products	Peculiar to fried chicken, moderately salty, without a foreign taste of oil and decomposition products	Inherent in fried brie cheese, there is a slight taste of bitterness of moldy brie cheese, without a foreign taste of oil and decay products

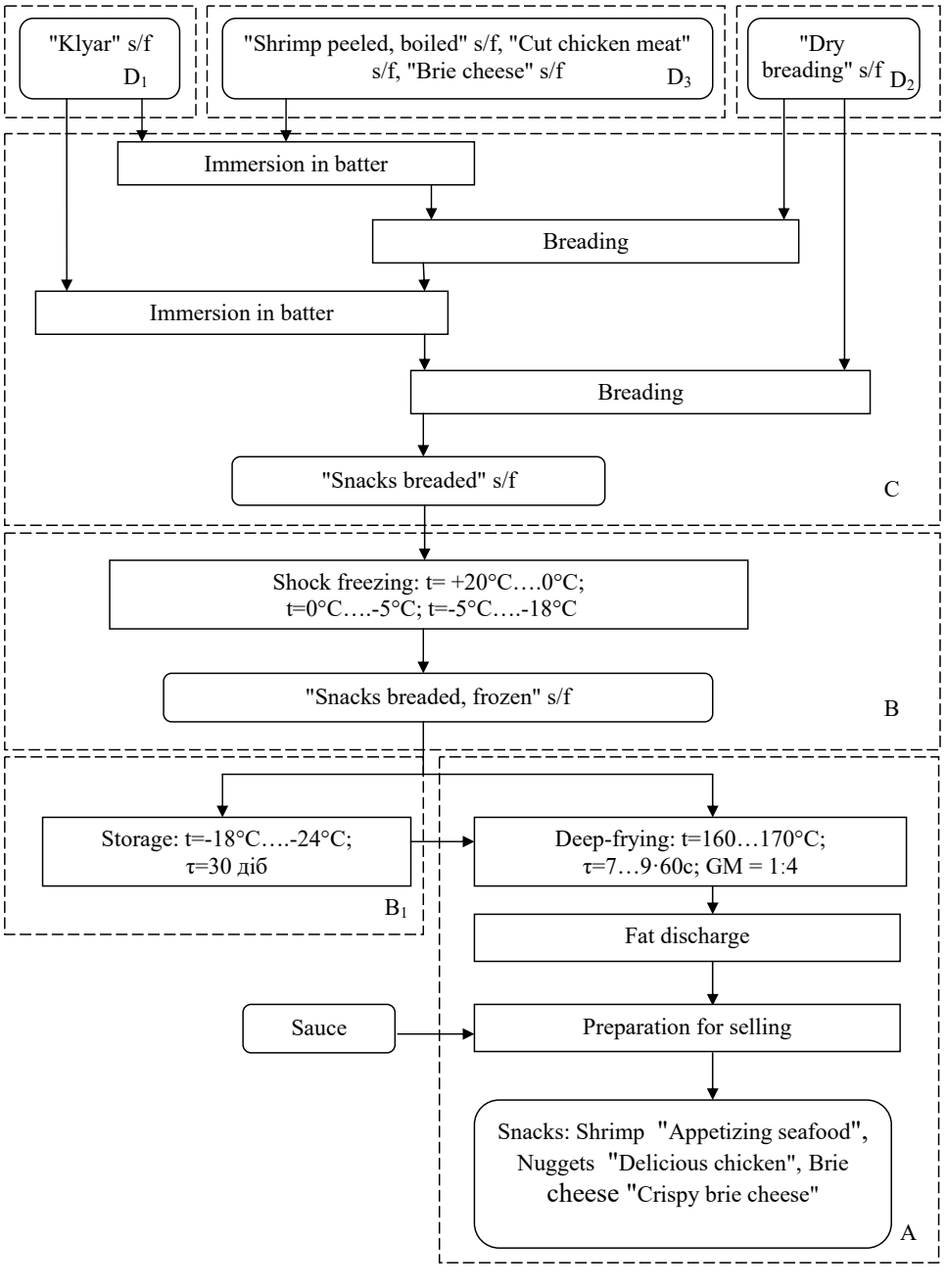

Fig. 4. Technological scheme of production of snack products using new types of breading

Microbiologic studies of developed snacks were carried out, which were stored for 30, 60, and 90 days in a frozen state at a temperature of –18....–24 °C. According to microbiological indicators, bacteria such as QMAFAnM were only one cubic meter of CFU/g, which is not significant from the standpoint of biological danger. Bacteria

of the E. coli group, pathogenic microorganisms were not detected.

As part of the study of safety indicators (microbiological indicators), it was determined that snacks developed using new types of breading can withstand long-term storage for up to 90 days in a frozen state at a temperature of –18...–24 °C.

6. Discussion of results of the study of technological parameters of obtaining gluten-free snacks with subsequent freezing

Justifying the technology of snacks using gluten-free breading, the following tasks were solved. The first task involved the selection of dry flour breading, which should not contain gluten protein.

Taking into account the rationale for dry flour breading, gluten-free extruded flakes were chosen, as well as rice flour, which has a neutral smell and taste (Table 2). The appropriate selection of dry breading was justified from a number of scientific studies [11, 12]. Thus, scientists who used a combination of rice flour with flour from beans or dry celery roots only added a specific taste, leaving traditional flavors.

However, carrying out a number of technological developments, this dry breading can only be used on a very wet base. This indicates that the proteins and polysaccharides of the dry mixture should swell, thereby evenly distributing the breading on the surface of the product.

Therefore, the second main task was to obtain the semi-finished product "Klyar". The semi-finished product "Klyar" is a viscous-thick mixture, which should take part in the formation of operation "Breading". Since snack semi-finished products must be frozen, the two-layer breading should serve as a protective layer against a number of technological factors. Conducting an analysis of scientific research, it was determined that in order to stabilize the breading, it is necessary to introduce modified starches that will swell immediately. However, too many cold-swollen starches [5–7], which have stable performance during the difference from low to high temperatures, can rapidly increase viscosity. Therefore, during the selection of criteria for choosing starches, attention was focused on starches of the "Cold Swell" series.

In the course of physical and chemical studies of starches of the "Cold Swell" series, it was revealed that they are cold-swollen. This indicates that at temperatures above 50 °C they have the form of a viscous suspension without signs of delamination (Table 3, Fig. 1). Carrying out the regulation of the studied starch suspensions, it was determined that for starch "Cold Swell" 3681 in content from 3.5 to 5.5 %, the suspension has a viscoelastic consistency without reversible changes (Table 4).

In the course of technological testing, which were aimed at heat treatment (deep-frying) of snacks after freezing, it was determined that in the process of frying, model systems with a content of 3.5 % and above retained burning breading with no visible signs of deformation.

However, for the formulation composition of two-layer breading, skimmed milk and egg powder were used. At the stage of obtaining the semi-finished product "Klyar", the egg powder was restored in milk and mixed with a starch suspension (Fig. 3). In accordance with this, it was predicted that milk, as a complex colloidal mixture, also egg powder as a source of protein, can affect the technological properties of batter when interacting with cold-swollen starch. Therefore, a study was conducted on changes in heat losses during deep-frying snacks in a frozen state.

During the study, model systems were presented in the form of a draft of snack recipes. For snacks, shrimp meat, chopped chicken meat, as well as soft Brie cheese were used. In the first case, starch was used for batter at a content of 3.5 %, in the second case with a content of 4.5 %.

Studies on changes in heat losses (Fig. 2) showed that losses for starch content of 3.5 % range from 8.3 to 5.5 %, and with a starch content of 4.5 % – 7.7....4.5 %. The percentages of losses for starch content of "Cold Swell" 3681 – 3.5 % are not high when compared with the heat losses of traditional deep-fried products. Moreover, according to organoleptic indicators, snacks fully met the quality criteria (Table 5). The surface layer of breading during frying was not deformed. When the section of the finished product did not reveal volumetric cavities between the breading and the main product.

Since snacks are supposed to be implemented in the "Fast food" ERI format, their storage and delivery (transportation) will be implemented in frozen form. In view of this, a study was conducted to substantiate the conditions and shelf life. It was determined that snacks with two-layer gluten-free breading can be stored for 90 days at a temperature of –18....–24 °C. This was confirmed by microbiological studies.

Thus, the development of snack technology with two-layer gluten-free breading, which includes starch of the "Cold Swell" series (Fig. 4) is relevant for physiological (lack of gluten) and practical-technological (stability of the technological process) properties.

However, the implementation of the technological process may contain the corresponding disadvantages. For example, the use of rice flour is quite expensive in terms of the cost-effectiveness of the technology. Therefore, in the technology of gluten-free breading, oatmeal or corn flour can be used, of course, its cost is not so expensive, but according to organoleptic indicators, snacks will have a specific flavor. Also, one of the significant drawbacks is deep frying, namely, during the Maillard reaction, glycation occurs (the formation of proteins and lipids of the corresponding type. In this regard, snack products that have deep frying are limited for the elderly, for people who suffer from obesity, etc. Therefore, in further studies of this direction, it is advisable to change the heat treatment – deep-frying for convection frying. One of the most relevant studies for the development of deep-frying snack technology may be the selection of oil, namely the complete absence of trans fats. It can be high-oleic oils, oils in combination with coconut oil, ghee (Ghi or Ghee), olive oil.

7. Conclusions

1. A project of the formulation composition of dry gluten-free breading for snacks has been developed. For the manufacture of snacks, used rice flour, extruded oatmeal and corn flakes, turmeric, cuzhut seeds. A prerequisite for extruded flakes was their grinding, which will give breading higher quality indicators.

2. The physical-chemical parameters of the "Batter" model systems using cold-swollen starch "Cold Swell" were investigated. It was determined that starch suspensions with a starch content of 3.5 % show a stabilizing effect during the cycle "freezing – heat treatment". Products after deep-frying retain their shape, breading does not exfoliate from the main product, and also does not undermine deformation.

3. In the course of technological testing, a technological scheme for the production of snack products and various types of gluten-free breading for ERI format "Fast food" was developed. The main raw material for snacks is shrimp meat – shrimp "Appetizing seafood", minced meat, chicken – nuggets "Delicious chicken", soft cheese of the "Brie" variety – "Crispy brie cheese". The main quality indicators (organoleptic indicators) of the developed snacks are investigated. All snacks fully corresponded to the indicators of quality.

Conflicts of interest

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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Data availability

All data are available in the main text of the manuscript.

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